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THE

CANADIAN

NATURALIST AND GEOLOGIST.

VOL. VIII. DECEMBER, 1863. No. 6.

ART. XXVIII.—*A list of Animals dredged near Caribou Island, Southern Labrador, during July and August*, 1860; by A. S. PACKARD, JR.

The following results were collected during a stay of fifty days, with a party of six others, left by the Williams College (Mass.) Expedition to Greenland, in the summer of 1860.

Caribou Island is situated in the extreme N. E. corner of the Gulf of St. Lawrence, at the entrance of the straits of Belle Isle in lat. 51°.25, long. 57°.39. It is composed of sienitic rocks, and is the largest of many small islets which line the coast of Labrador between the Mecatinas and Bradore. Like many others, this island is situated directly opposite the mouth of a long narrow bay, or reach, two or three miles in extent, which receives a shallow impetuous stream. Salmon Bay, thus protected from the heavy swell of the Gulf, by the high cliffs of Caribou island, affords, with its deep muddy bottom, good anchorage, and a comparatively quiet harbor for the fishing vessels which yearly frequent it. It is connected on the west by a narrow ship channel with another exposed bay which receives Esquimaux River. On the east side, between the island and the mainland, is a narrow passage closed to navigation by a sand bar, where the fishermen draw their nets for capelin, lance fish, and young cod for bait. As the water deepens towards the gulf, the sand grows coarser, till farther out, where the strong current, sweeping down the Straits, carries off the fine sediment, the bottom is most curiously paved with polished and clean "cobble stones." This barren bottom is scattered over with patches of Desmarestia, Ptilota, and Agarum, which give shelter to Hyas, Chiton, Cynthia, and a few Echini. Three or four miles further out into the Straits, a long narrow ledge forms the "Bank," whose crown rises to within eighteen fathoms of the surface, and it is here that the Astrophyton abounds most. On this bank the Ptilota elegans and the Nullipora polymorpha were the only plants observed. Indeed I was struck with the poverty of this locality in sea weeds, compared with the mouth of the St. Lawrence river, as catalogued in a previous number of this journal.

The rocky shores exposed to surf from the Gulf did not seem to harbor any animal life, but a narrow, interrupted belt of sand and mud flats in Salmon Bay, with patches of *Zostera marina*, about six inches in length, exhibited a feeble assemblage of littoral animals compared with that of Maine, even. In the higher levels of the zone, whose whole extent was only six feet vertically, were *Littorina rudis*, *Rissoa minuta*, *Balanus balanoides* and *Jaera copiosa;* and below, *Mya arenaria*, *Macoma fusca*, *Mytilus edulis*, *Littorina littoralis*, *Tectura testudinalis*, and *Nereis*. In the pools on the flats, myriads of *Mysis* and *Crangon* occurred with Platessa and Cottus; under the rocks and seaweed, *Gammarus mutatus*, *Cancer borealis*, and occasionally *Homarus Americanus;* and on the fuci *Laomedea*, with *Dynamena pumila*.

The entire absence of any specimens of *Purpura lapillus* was inexplicable, though I searched for that shell. So also I did not find any species of *Idotaea*, though it is found at Anticosti, and I took it from seaweed floating a few miles off Cape Ray, Newfoundland. There were also no Planarians or Nemerteans observed between tide marks.

Another belt, extending a fathom or two below low water mark, was characterized by the three species of *Asterias*, *Solaster papposa*, *Echinus*, *Echinarachnius*, *Pecten tenuicostatus*, *Mesodesma Jauresii*, *Margarita helicina*, *Buccinum undatum*, *Pycnogonids*, *Cuma*, *Hyas aranea*, *Desmarestia* with *Spirorbis*, *Eupagurus*, two species, and *Agarum* with eggs of *Nudibranchs;* but no forests of *Laminaria* such as those in Maine, occurred around Caribou Island.

The muddy and sandy bottom of Salmon Bay in 15 to 20 fathoms was characterized by *Ophoiglypha nodosa*, *Pentacta calcigera*, *Nucula tenuis* and *expansa*, *Leda buccata*, *Thyasira Gouldii*, *Car-*

dium islandicum and *pinnulatum*, *Serripes Grœnlandicus*, *Macoma proxima*, *Turritella reticulata* and *erosa*, *Aporrhais occidentalis*, and the different species of *Bela*, with *Pectinaria Eschrichtii* and *Onuphis Eschrichtii*. These all occurred in the greatest abundance.

So also out on the Bank in fifty fathoms did the following, which are mentioned here at the risk of repetition, since they are of special interest in connection with the patches of Drift fossils found up and down the St. Lawrence, and in New England.

Tealia crassicornis?
Sertularia, &c.
Astrophyton eucnemis.
Ophiacantha spinulosa.
Eschara, Cellepora, and the species of Lepralia.
Hippothoa, Stomatopora &c.,
Anomia, two species.
Hypothyris psittacea.
Pecten islandicus.
Cardita borealis.
Astarte, two species.
Modiolaria decussata.
M. corrugata.
Glycimeris siliqua.
Mya uddevallensis.
Diadora noachina.
Margarita cinerea.
Admete viridula.
Trichotropis borealis.
Fusus tornatus.
Trophon scalariforme.

with *Spirorbis cancellata* and S. *vitrea*, *Vermilia serrula*, *Hippolyte spini*, *Chionoecetes opilio*. Dredging was carried on for about six weeks; from the middle of July to the last of August, during a season that proved to be the most boisterous and foggy that the inhabitants had experienced for twenty years.

Dr. William Stimpson has kindly identified the annelides and crustacea, so far as their state of preservation would allow, and given me aid in the determination of several other forms. I am under obligations to Theodore Lyman, Esq., Museum of Comparative Zoology, Cambridge, for naming the Ophiurians, and to Dr. Dawson, for identifying several species of Lepralia. I subjoin the names of some Foraminifera sent him in sand, &c., which he has furnished me.

Polystomella umbilicatula, Truncatulina lobata.
Miliolina seminulum (some very large and complex).
Biloculina ringens, Entosolenia globosa (var. *costata*).
Polymorphina lactea, Nonionina umbilicatula, Textularia variabilis, Nodosaria? Spiroloculina?

POLYPI.

Tealia crassicornis? Gosse. On stones 15–50 feet.

ACALEPHÆ.

Halecium muricatum Johnst. Frequent on the Bank. Its occurrence on our coast has not before been noticed.

Laomedea gelatinosa Johnst.? Frequent on fuci in the lower levels of the littoral zone. By no means so common as in Maine.

Dynamena pumila Lam. Occurs with the preceding.

Sertularia rosacea Johnst. Very abundant in 50 feet on the Bank.

Sertularia tricuspidata Alder. Exactly agrees with Alder's figure and description in the Annals Nat. Hist. Abundant on the Bank upon *S. rosacea.*

Campanularia verticillata Lam. Several specimens dredged on the Bank.

Lafoea ramosa Lam. Abundant,occurring upright and branching out from a common stout stalk, or creeping upon *S. rosacea* in 50 feet on the Bank.

Clava multicornis Pallas. On shells.

Hydractinia polyclina Ag. On an ascidian in 15 feet Salmon Bay.

Aurelia flavidula Per. and LeS. The young and mature were very abundant. The young were both yellowish and purplish.

Cyanea arctica Per. and LeS. This is the common species in the Gulf and about the Banks, and is rarely seen in retired bays where A. flavidula abounds. The fishermen experience much discomfort from handling fish lines entangled in the very long tentacula of this species.

Idyia roseola Ag. This is doubtless the species so common on this coast.

ECHINODERMATA.

Astrophyton eucnemis Müll. and Trosch.

One was hauled up by a fisherman 20 miles from land in about 80 feet. They are common and very large in 18 feet on the crown of the Bank.

Ophiacantha spinulosa Müll. and Trosch. Several from the Bank.

Ophiopholis aculeata Lütken. Most abundant among nullipores in 15 feet. A few were taken in dead pectens in 2 feet. Also from the Bank in 50 feet.

Ophioglypha nodosa Lyman. This species was especially abundant on a sandy bottom in Salmon Bay in 10 feet, and ranges from low water mark to 50 feet.

Solaster papposa Forbes. Occasionally taken with the dip-net a few feet below low water mark.

Cribella oculata Forbes. Among nullipores in 15 feet.

Asterias vulgaris Stm. (Asteracanthion rubens, M. and T.) Common just below low water mark. The largest specimens from 8-10 inches across.

Asteracanthion polaris M. and T. Occurring with and as common as the preceding, if not more so. Often taken, especially the young in 10-15 feet.

A. n. sp? Large specimens measuring 20 inches across frequently occurred in pools at low water mark. The color in life was a light greenish hue, mottled with reddish brown.

Toxopneustes drobachiensis Ag. (E. granulatus Say.) Specimens measuring four inches across were often taken at low water mark. It extends to 50 feet, at which depth it was dredged on the Bank frequently, where the specimens were uniformly small: but after a careful study I cannot see any permanent specific differences. I cannot see that it differs at all from individuals collected during the past summer at Eastport.

A specimen in my possession from Greenland seems to be very distinct from our Labrador and Maine species. The periphery is distinctly pentagonal. The whole shell is more elevated; while the sides of the shell are not so full and rounded as in our species, the ambulacral plates are not slightly depressed, nor that area so distinctly marked as in ours. The tubercles are fewer and proportionately larger; thus in the Greenland species there are 20 tubercles in a row along the narrowest interambulacral zone, in ours 28. In the broader interambulacral zone there are 15 papillæ in the Greenland species; in ours, 18. Moreover there are fewer flutings in the spines taken from either end of the shell than in our species.

Echinarachnius parma Gray. (E. atlanticus Gray). Abundant and large on sandy bottoms in 2–15 feet.

Psolus Fabricii Lütken. Two were taken in 15 feet on pebbles in Esquimaux Bay.

Pentacta calcigera Stm. (Cucumaria Koreni Lütken). One was taken in 15 feet sand, in Salmon Bay.

Pentacta frondosa Jaeger. One specimen was thrown upon the beach.

Chirodota laeve Grube. Very fine specimens, eight inches long, were abundant in 10 feet sand in Salmon Bay.

Eupyrgus scaber Lütken. Several were taken in 10 feet sand in Salmon Bay. It has not occurred so low down the coast before.

Polyzoa.

Tubulipora patina Johnst. Common.

T. hispida Johnst. Frequent on sertularians in 50 feet.

T. flabellaris Johnst?

Diastopora verrucaria M. Edw. (Millepora verrucaria O. Fabr.) Frequent in 50 feet. I have species from Greenland from which it does not differ, also from the Bay of Fundy.

Stonapora expansa n. sp. Creeping, flat, expanding; the branches widening at the origin of new ones, rugose. Cells in the young long, slender, erect, slightly recurved; arising singly, or in groups of two or three at irregular intervals along the branch. Old specimens broader, cells horizontal, apertures hardly raised above the surface, emarginated.

A small slender white species, the erect tubes in the young longer than the width of the branch. It differs from the European *A. major* in being broader and more expanded.*

Idmonea pruinosa Stm. Frequent from the Bank.

Hippothoa rugosa Stm. Abundant. All the polyzoa here enumerated are, unless otherwise stated, from the Bank, in 50 feet hard stony bottom, occurring on stones, shells, &c.

H. borealis D'Orb. (*H. divaricata* Lamx.?) Abundant.

H. expansa Dawson. Frequent. I have also dredged it at Mt. Desert, Me., in 15 feet.

Lepralia annulata O. Fabr. A group of three cells, with two spines on each side of the distal margin, occurred.

L. crassispina Stm. which I take to be the representative of the European *L. Peachii*, and which assumes its forms, was one of the most abundant species.

L. trispinosa Johnst., or an allied species was very abundant. It is also abundant in Maine, as far south as Portland.

L. pertusa Thomps. I cannot distinguish my specimens by any permanent characters from the British species occurring on a stone with *Crania anomala*. It is oval or broad oval, somewhat flattened or convex, punctured somewhat coarsely, with ridges separating the cells, which are arranged in no special order. Aperture round,

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* *S. compressa* n. sp. I have another narrow compressed, very convex species from Greenland. It is adherent, creeping, much rounded above. *Cells in a single alternating row, being short and thick, and opening a* little outwards; at the end of the branch much thickened and enlarged, giving rise to three or four cells. It varies in the size and relative distances of the cells. William Coll. Exp.

truncate behind, or with a broad shallow sinus. The ovi-capsules globose, subrugose, sub-punctate, much as in the British specimens. Found growing in purple patches. Length $\frac{1}{30}$ of an inch, half as broad as long.

What I take to be a second and larger form of this species has the cells large, oblong, oval, convex, being closely connected with the ones before and behind in radiating lines. The surface has coarse emarginatad punctures. In old specimens the punctures are so large that the surface is often but a network enclosing them Apertures round, slightly raised, with a deep narrow sinus, at the entrance of which are two denticles, one on each side, which often become obsolete. In some cells the surface is perfectly smooth, and only the marginal punctures present.

Specimens from Greenland do not differ. It is much larger than the preceding form, which is $\frac{1}{40}$ of an inch long, and arranged in more regular rows, and preserves better its oblong, oval, convex form. The ovi-capsules are emarginato-punctate, and proportionally smaller and smoother than in the preceding form.

I have also specimens on *Pecten islandicus* from the Newfoundland bank.

L. producta n. sp. (Fig. 1.) Cells oval, convex, coarsely punctate; in the young the punctures are emarginate, the base of the cell is produced and wedged in between adjacent ones. Aperture broad, round, with a moderately large and deep sinus in the young; in older cells, small, round, truncate behind, horse-shoe shaped; margin full, broad, unarmed, and when the cells are crowded, the margin in front expands upon the base of the cell in front. Cells arranged in lines, soon becoming very irregular, and partially radiating; forming white, but more generally purple patches. Length $\frac{1}{30}$ of an inch. Old specimens are flattened, granulated with marginal punctures; very rarely the aperture has a small sinus. It is the largest species observed. Frequent.

As in the preceding species, there are two forms which might easily be mistaken for as many species. The young cells are rounded, ovate, depressed and with emarginate punctures, while the apertures are sinuate. With the other form the species becomes the largest of the genus yet observed on this coast, being one thirtieth of an inch long. The cells are much thickened, convex, in outline often pyriform, owing to the elongation of the base of the cell; and the aperture is small and truncate behind.

In both forms the surface is more than usually rugose.

L. Belli Dawson. Frequent.

L. labiata Stm. One group of this singular species occurred.

L. lineata Hassell. Rare.

L. globifera n. sp. Cells large, flat, white, the surface somewhat raised around the small round aperture, which has a slight sinus. Behind the sinus is a minute perforated conical avicularium. Ovi-cell large, globose, with a few emarginated coarse punctures. Cells in radiating lines, with ridges running between them. The ovi-capsules are more crowded in the centre of the patch, not being present in the inner cells. Frequent, forming frosty white patches. It often encrusts Celleporæ, where the ovi-cells are much crowded, and the ridges between the radiating rows of cells obsolete. I have dredged it in the Bay of Fundy.

Stimpson's *L. candida*, very common in the Bay of Fundy, did not occur in my collection.

Membranipora pilosa Johnst. Especially abundant encircling fronds of Desmarestia just below low-water mark.

M. lineata Busk.

M. Lacroixii Busk? I cannot distinguish these two species from Greenland specimens.

M. solida n. sp. (Fig. 2.) Cells large, flat, solid, oval angulated, often presenting a six sided figure as is common in the genus. Margin raised, simple, very broad and without spines. Aperture occupying one half of the upper surface, transversely broad, oval, with a broad deep sinus; the posterior half of the upper valve is thin, convex subrugose, with a small, triangularly perforate, conical avicularium, situated at the posterior end of the upper surface. Cells arranged in lines, or in quincunces, or more often irregularly. The cells are not so crowded as in the other species. To the naked eye it looks like bleached patches of old worn Lepraliæ.

Beania admiranda n. sp. Cells very large, erect, oval smooth, base produced, sessile. Growing in tufts, the cells arranged in contiguous series, the new cells arising on each side of the aperture of the parent cell. Aperture raised, circular, surmounted by two long stout truncate spines, which are succeeded on the opposite side by two rows of long obtuse spines nearly meeting across the hollow formed by the two ridges on the back of the cell. Compared with *B. mirabilis* of the British coast, this is a much stouter species, growing in low spreading, but not creeping tufts. There are from 6 to 8 pairs of large obtuse spines which meet across the cell; being fewer in number, and longer and stouter than in *B. mirabilis*. More important differences exist in the diameter of the cell being greatest at the distal or anterior third of the cell, where in the British species it is thickest posteriorly; and in our species the aperture opens near the end of the cell. It occurred rarely on Pecten in 50 feet.

Cellularia Peachii Johnst.? With the preceding. Rare.

Menipea ternata Busk? Rare.

M. fruticosa n. sp. (Fig. 3.) This fine species grows an inch in height, with large wide branches, dividing dichotomously. The cells are large and long, being attenuated downwards. Above they are truncated, with four spines, two upon each side, and invariably with an outer projecting spine, when the others are absent. The upper valve is long, oval and sunken; aperture transversely linear, closed by a square incomplete lid. Cells contiguous, arranged in two alternating rows, with two or three median ones before the origin of the branches. The avicularia have long beaks, and are arranged sparsely at the base of the median cells. Long vibracula arise near the front of a few lower valves. The ovi-capsules are globose and smooth. It is more nearly allied to *M. cirrata* of Europe than any other species, though very distinct. It is a common species, and occurs in Greenland, from whence I have a specimen.

Scrupocellaria Americana, n. sp. This species is closely allied to *S. scruposa*, with specimens of which, collected by Dr. Stimpson on the English coast, I have compared it. With much the same habit, our species is twice as large and much more solid. There are the same relative proportions in the form and size of the cells, but in our species the avicularia are smaller in proportion to the cell, and there is but a single spine surmounting this appendage, the lip of the orifice being unarmed, while in *S. scruposa* two spines are very constantly present on the inner side of the cell. The lids or upper valves, which in my specimens are raised from the coenoecium by the relaxation of the muscles, are convex, and somewhat rugose, owing to several slight transverse lines. The ovi-cells are smooth and globose. It is not unfrequent on the Bank.

Caberea Hookeri Busk? One species presents some differences from the British specimens in my possession collected by Dr. Stimpson; and also from Mr. Busk's figures. It is abundant in Labrador, and on the coast of Maine as far as Casco Bay.

Halophila borealis n. sp. (Fig. 4.) This species agrees well in its generic character with *H. Johnstoniæ* Gray from New Zealand, though differing specifically among other respects in being multiserial. The coenoecium forms soft and flexible horn colored tufts an inch in height. The cells in mature specimens are arranged in several contiguous series and are very long, subclavate, truncate, widening a little above, with sometimes a slight spine on the outer angle. The aperture is transversely linear and closed by a slightly sinuate lid. The ovi-capsules are globular and nearly smooth. The upper valves are so thin that in dried specimens it readily contracts and the lid and linear aperture are effaced, and the cell then appears as if it possessed a large, broad, oval aperture, covered by a thin lid.

A single branch consisted in one example of eight rows of cells. A single isolated cell closely resembles a cell of *Flustra truncata*, showing the near relationship of this genus to the Flustradæ. But one tuft of this interesting species occurred in 50 feet associated with *Beania admiranda*, on a fragment of Pecten.

Flustra truncata Linn. Frequent.

F. membranacea Linn. Abundant.

F. Murrayana Busk. 10–50 feet. Abundant. A common species in Maine.

Cellepora pumicosa Ellis. Frequent on sertularians.

Celleporaria surcularis n. sp. Grows two or three inches high, branching dichotomously, the ends of the branches somewhat truncated. Cylindrical, base two or three lines in thickness, surface rough. Cells crowded, of unequal size, erect, conical. Aperture small, with a slight sinus. In the young conical communities, the cells stand out more from the axis; apertures large, round, with a slight, often obsolete, sinus. Surface of the cells coarse, irregular and deeply punctured, often arranged in irregular series running down the sides from the aperture. The terminal cell large and conical. In old species the sinus is sometimes enlarged with two denticles at its entrance. In section the cells are irregularly oval, scattered thickly over the axis and periphery.

Abundant on stems and cells in company with Escharæ.

Dr. Stimpson has placed in my hand specimens belonging to this species, collected by Dr. Hayes in Northern Greenland, and by McAndrew in Manseroe Sound, Finmark. European authors have confounded this arctic species with *C. cervicornis* of the Mediterranean sea, from whence it was originally described by Pallas.

Eschara lobata Lamx. This species Lamoureux describes as growing in radiating patches, always adhering to the surface of objects, and collected near the Bank of Newfoundland. Cells oblong, oval, convex; each end is connected with the cell in front and behind, with a few larger emaginate punctures. Aperture round with a shallow broad sinus. Just behind the aperture a small perforated conical eminence, which in old specimens bears a large avicularium, with long sharp pointed beaks gaping widely; or when absent the cone is large, covering the upper surface of the cell, and furrowed with descending ridges. In communities with ovicapsules, the surface of the cell itself cannot be seen; the capsules are globular, sublunate in form, with emarginated-punctures; the aperture large, often truncate behind. Cells arranged in linear series with intervening ridges.

Occurs spreading over dead Cardium and Serripes in 10-20 feet Salmon Bay, or in 50 feet on the Banks. I have taken it in the Bay of Fundy from low water mark at Eastport to 20 feet.

It is very different from a thin, flat, membranaceous, inverted cup-shaped species that inhabits Massachusetts Bay.

E. elegantula D'Orby. The coenoecium of this fine species grows several inches high in erect branching masses, the branches expanding flat and spreading at the ends. Cells broad, oval flattened, somewhat produced at the base; surface smooth, sub granulated. Aperture round, with a broad shallow sinus. Young cells often margined with a row of large punctures. In old communities the ovi-cells are narrow-oblong, very convex, semi-cylindrical, the cylinder-like avicularia projecting over the aperture, and perforated with a large operculated aperture. Towards the end of the branches, the cells are somewhat cylindrical bearing narrow globular ovi-capsules, which are emarginate-punctured. This is near Busk's *E. saccata* which came either from Norway or Finmark. It differs however from his figure; and his rather unsatisfactory description does not aid me in determining the species.

Common on the Bank in company with Cellepora. I have specimens also from the Newfoundland Banks. Dr. Stimpson has also specimens collected in Northern Greenland by Dr. Hayes in his last expedition.

Myriozoum subgracile D'Orby. (Fig. 5.) (Millepora truncata Linn. Fabr. F. G.) Frequent with the other species.

Fabricius' description applies well to this species. It grows two or three inches high, branching dichotomously; branches cylindrical, smooth, while at irregular distances slightly contracting,—

passim annulis angustioribus—Cells immersed; apertures round with a very narrow deep sidnus, those at the end of the truncate branches have the *figuram calcei equini* of Fabricius' description. The surface between the cells is deeply and irregularly punctured. A transverse section of a branch shows about twelve oval cells separated by thin walls, arranged around the solid axis of the stem.

This species approaches somewhat Busk's *Eschara teres*, Ann. Nat.Hist., 1856, but it seems to have a more regular form; the oval cells shown in a transverse section are not so much produced towards the central axis of the stem; while it differs wholly from the *teres* in the punctures dotting thickly the whole surface between the cells, instead of there being a single row surrounding the aperture as usual in the genus. *Millepora truncata* is a Mediterranean species, and as represented by Lamoureux, is a much larger and very different form from the two species above mentioned. On the Bank in 50 feet; with the preceding species.

TUNICATA.

Leptoclinum. A species of compound ascidian was abundant in somewhat pellucid masses surrounding branches of nullipores in 15 feet.

Ascidia callosa Stm. Dr. Stimpson has identified this and the species of *Pelonaia*. It is profusely abundant in the Bank in 50 feet growing to a very large size, and affords shelter to various worms, Sipunculi and Modiolariæ, besides serving as a base of attachment to Sertularia, &c.

Cynthia pyriformis Ratke. Several were taken up alive on beaches after storms. Fishermen haul them ashore in their nets.

C. sp. A specimen occurred on *Ascidiacallosa*. It is whitish, smooth, low conical, base expanding.

Pelonaia arenifera Stm. Several occurred in 15 feet sand.

Boltenia oviformis Sav. A young specimen, that I refer to this species was taken on the Bank. It is much more hirsute than the two Maine species.

BRACHIOPODA.

Hypothyris psittacea King. Frequent on hard and sandy bottoms in from 10–50 feet.

LAMELLIBRANCHIATA.

Anomia ephippum Linn. Abundant, though small. On nullipores.

A. aculeata Gm. In from 10–50 feet.

Pecten tenuicostatus Migh. (P. magellanicus Lam.) Is most abundant on a sandy bottom at a fathom's depth. The young were only dredged in 15 feet. The inhabitants call them "pussels" and often eat them. We can bear testimony to the delicacy and rich flavor of this shell fish.

A species of boring sponge, which grows two inches or more in height, its roots boring worm-like galleries in the shell, hastens the decomposition of dead shells very greatly.

P. islandicus Müll. Common in 10–50 feet on a sandy or rocky hard bottom. Valves are occasionally thrown up on beaches.

Limatula sulculus Leach. Several dredged in 15–50 feet sand and gravel.

Nucula tenuis Turton.

N. expansa Reeve. Occurred abundantly with the preceding. Dr. Stimpson has identified our specimens as being this before doubtful species.

Yoldia sapotilla Stm. A few occurred in 10–15 feet.

Leda buccata Stp. Abundant. Does not differ from Greenland specimens.

Crenella glandula Turton. Abundant.

Modiolaria corrugata Stm. In 50 feet.

M. laevigata Gray. With the preceding.

M. discrepans Müll. A valve two inches long was taken from the stomach of cod caught on the Bank.

Mytilus modiolus Linn. Not common.

M. edulis Linn. Abundant.

Alasmodonta arcuata Baines? I was told that a fresh water mussel was common in Salmon River. This must be the same shell that Professor Chadbourne informs me is very abundant in the streams of Newfoundland.

No Cyclades or any other fresh water mollusca were found in the countless pools of the mainland; though a more thorough search than I could make must reveal some forms.

Cryptodon Gouldii Phil. Very large and abundant; a few in 50 feet.

Cardita borealis Conr. Bank 50 feet.

Astarte semisulcata Leach. *A. elliptica* Brown. Bank 50 feet Abundant.

A. Banksii Leach. Frequent with the two preceding shells

Cardium islandicum Chemn. Very abundant and large in Sal mon Bay.

C. pinnulatum Conr. Very common, and as large as usual; with the preceding species.

Serripes grœnlandicus Beck. This is a very abundant species, and is a very constant companion of Cardium islandicum, occurring in a mixed sand and mud bottom in 10--20 feet, where it grows to an enormous size.

It varies considerably when old, some specimens being triangular and flattened, with the beaks placed far anteriorly, while other shells are ventricose, oval, with the beaks very central. The young all agree in being short and high, very thick and in having the large swollen beaks placed nearly in the middle of the shells. Some specimens from Greenland differ very much from the Labrador shells in being very triangular, not much longer than high, and having the beaks small and flattened, and placed far anteriorly. Were there not others approaching very closely to some Labrador forms, these characters would easily separate the *grœnlandicus* into two representative species.

Tapes fluctuosa Sby. One valve from the Bank.

Mactra solidissima Chemn. One valve was given me, which was taken three miles inland from the mouth of Esquimaux River on a sand beach.

M. polynema Stm. (M. ovalis Gould.) Rarely thrown up on beaches.

Mesodesma Jauresii Joannis. It is thrown up very abundantly on beaches, of a very large size.

Macoma fusca Stm. Common between tide marks.

M. sabulosa Stm. (T. proxima.) Very large and abundant in 15 feet Salmon Bay.

Solen ensis Linn. Rarely taken. Young dredged in 15 feet.

Thracia Conradi Couth. One small specimen was dredged.

T. myopsis Beck. A fine large specimen was dredged in 10 feet mud.

Pandora trilineata Say. A few specimens occurred in 15feet sand.

Pandorina arenosa Möll. One valve was taken with the preceding among nullipores in strong sand, 15 feet.

Cyrtodaria siliqua Daudin. In from 15–50 feet Mostly on hard stony bottoms.

Mya truncata Linn. The short obliquely truncated variety-*uddevallensis* if it should not be considered a distinct species, occurred on the Bank.

M. arenaria Linn. Abundant.

Saxicava rugosa Linn. Common in 10--50 feet Limestone pebbles are often fished up from the Gulf, which are bored into in every direction by these shells, which are then become short and much thickened.

GASTEROPODA.

Clione limacina Phipps. (Clio borealis Brug.) Seen frequently floating near the surface in calm weather.

Proctoporia ? sp. A species with an expanded foot was taken in 50 feet on the Bank. It was not discovered until immersed in alcohol, and is undistinguishable, though it differs from anything in New England, approaching rather Fabricius' figure of *P. fusca.* No other species of Nudibranchs, were found, though the ova frequently occurred in round masses on sea weeds in the *Laminarian* zone.

Cylichna alba Lovèn. Several large specimens with a thin brown epidermis, and differing in no respect from one from Green-. land, occurred in 10–15 feet mud and sand.

Philine lineolata Stm. Frequent, with the preceding.

Chiton marmoreus Fabr. From low water to 50 feet.

C. albus Linn. Several in 50 feet.

Tectura testudinalis Müll. Largest and most abundant at low-water mark. The young were dredged in 15 feet.

Diadora noachina Gray. Several in 10–50 feet.

Scissurella crispata Flem. Dr. Dawson has detected this species in sands examined for Foraminfera, as also the following species.

Adeorbis costulata Stm.

Margarita cinerea Gould. Grows largest on sandy bottom in 50 feet.

M. undulata Sby. and Brod. Common in 15–20 feet sand.

M. helicina Möll. Common, 2–15 feet.

Rissoa minuta Stm. One dead specimen occurred above high water mark.

Rissoa castanea Möll. R. exarata Stm. 15 feet sand.

Lacuna vincta Turt. The plain and banded varieties were common.

Littorina vestita Gould. *T. vestitus* Say L. rudis Gould.

L. palliata, Gould. *L. littoralis,* F. and H. Both these species occurred abundantly and with variations, as in Maine.

Scalaria grœnlandica Perry. A fragment only occurred.

Turritella erosa Couth. Abundant.

T. reticulata Migh. Very abundant, occurring with the preceding in 10–50 feet, but most abundant in 15 feet mud. Salmon Bay.

T. acicula Stm. One individual in 50 feet hard bottom.

Menestho albula Möll. The young were frequent in 2–15 feet sand.

Lamellaria perspicua Lovén. 15 feet sand and mud.

Natica heros Say. Two young dead shells were found at high water mark.

N. clausa Sby. Frequent in 15 feet.

Bela violacea Stm. (Pleurotoma violacea Migh. and Adams.) 18 feet. Both this and the *bicarinata* Couth., which Dr. Stimpson considers but a variation of the *violacea*, were frequent in 20 feet sand.

B. decussata Stm.

B. scalaris, (Defrancia scalaris Möll., Ind. Moll. Grön. Fusus turricula Gould.)

The European *B. turricula*, as observed by Mörch, is very different from the American representative. On a comparison of our shell with several specimens of the *turricula*, we find that the shoulder on each whorl that gives the shell its turreted appearance, is situated more in the middle in *B. scalaris*. The *turricula* has twelve longitudinal ridges on each whorl, being fewer and proportionately larger than in our species which has seventeen. Our species seems also to be a larger shell. It agrees well with Möller's *D. scalaris* to which he refers *turricula* Gould

B. Woodiana Möll. Fusus harpularius Gould.

One specimen was dredged with the preceding nave also two specimens of it from Greenland. It is a shorter and thicker shell than *B. scalaris*, in which the first whorl is as long as the remaining ones together. In this species the first whorl is longer than the rest. The canal is shorter and the aperture rounder. The longitudinal ridges are the same in number, but are less prominent, while the revolving lines are much coarser, giving the surface a reticulated appearance.

B. pyramidalis Stm.

These species of Bela occurred in sand and mud 15 feet Salmon Bay. B. decussata was the most abundant species.

Buccinum labradorense Reeve. Icon. Conch., pl. 1, fig. 5. Most abundant just below low water mark. Fine specimens 3½ inches long were frequent; their egg capsules in large bunches were often deposited at low water mark. This species represents the European *B. undatum*.

B. scalariforme Müll. One specimen on the bank.

B. cretaceum Reeve, Icon. Conch., Monogr. Bucc., pl. 14, fig. 112. Shell fusiform, slender, nearly three times as long as broad. Aperture oval, ending in a rather long, broad, oblique canal. Inner lip regularly curved; the columella projecting into the aperture at the base of the canal; from this projection a slight ridge runs back to the other end of the aperture, following the curve of the inner lip. Whorls 9, convex, especially on the upper two thirds. Spire much prolonged, acute. 21 longitudinal ridges, smooth and rounded. On the first whorl the ridges disappear on the lower two thirds, where the minute revolving lines are more minute than elsewhere. Aperture within, light chocolate, darker in the young, in which the revolving lines are more distinct. Length $\frac{21}{20}$ in., breadth $\frac{8}{10}$ in.

The slender and fusiform shape, and greater length of the spire than is found in other northern species, will distinguish it. The young and old were dredged alive in 10 feet mud and sand, Salmon Bay. Dr. Stimpson informs me that he has seen specimens from the Newfoundland Banks. It seems to be identical with Reeve's species, of which he gives no locality.

Fusus tornatus Gould. A large specimen, tenanted by a hermit crab, was dredged in 50 feet.

Trichotropis borealis B. and S. Frequent in 10–50 feet.

Admete viridula Stm. Thick heavy specimens, an inch in length, were dredged in 40-50 feet.

Trophon scalariforme Stm. Large specimens from the Bank.

Bulimus harpa Say. One dead shell was found in moss. The only Helicid found.

CEPHALOPODA.

Ommastrephes. A squid, the fishermen informed me, sometimes comes ashore in swarms, or is fished up from deep water.

ANNELIDA.

Sipunculus n. sp. It is very different from *S. Bernhardus*, being larger, proportionately thicker, while the anterior third is suddenly rounded and cylindrical. Found between Ascidiæ on a hard bottom in 50 feet.

Cerebratulus n. sp. Occurred with two other species of nemerteans, in 10 feet mud.

Spirorbis spirillum Lam.

S. nautiloides Lam.

S. vitrea Stm.

S. porrecta Stm.

S. cancellata Fabr.

S. glomerata Müll., Fabr. F. G. Large, round, smooth, aperture round, sinistrose, raised slightly from the whorl beneath. The adult shell is not flattened out beneath upon the surface of objects, but nearly free.

Diameter of the tube $\frac{1}{10}$ in., of the whole shell $2\frac{1}{2}$ tenths. The largest species observed occurring on the edges of Cardum in 10 feet mud, but more abundantly in company with the preceding species in 50 feet hard bottom. Other specimens are a little smaller, but with a slight ridge on the upper surface, occurred with it. I have a specimen of this form also, from Greenland, together with the slightly curved and flattened convex young shells.

S. quadrangularis Stm. With the preceding species.

Vermilia serrula Stm. Abundant with the preceding.

Pectinaria Eschrichtii Rathke. Very abundant and large, especially in 10 feet mud on fish offal thrown overboard from fishing vessels. One was taken at low water mark.

Terebella n. sp. 50 feet Bank.

Siphonostomum plumosum Müll., 10 feet mud.

Cirrhatulus n. sp.

Nephthys coeca Fabr.

Heteroneis arctica Oersted. One specimen was found swimming on the surface.

Eteone sp.

Nereis pelagica Linn.

Nereis n. sp. Allied to *denticulata*, and like that found in mud between tide marks.

Lepidonote cirrata Oersted. 10–50 feet.

L. punctata Oersted.

CRUSTACEA.

Cytherina Mullerii? In 15 feet gravel.

Cytherina sp.

Daphnia? A very large species, two tenths of an inch in length is abundant in fresh water pools. It is not the *D. retispina* of Greenland.

Phoxichilidium sp. At a little below low water mark.

Nymphon grossipes Kroyer. In 50 feet Bank.

Coronula diadema. On the grampus.

Balanus balanoides Linn.

B. porcatus Da Costa.

Cuma sp. A little below low-water mark.

Jaera copiosa Stm. Common near high-water mark.

Aega sp. On the belly of cod.

Unciola irrorata Say.

Anonyx sp. In 15 feet gravel.

Anonyx sp.

Ampeliscus pelagica Stm.

A. Eschrichtii Kr.

Gammarus purpuratus Stm. In 10 feet mud and sand.

G. mutatus Liljeborge. (G. pulex). Occurs as in Maine.

Mysis spinulosus. In swarms in tidal pools. The sea trout feed on it.

Hippolyte spini. (H. Sowerbyi Leach). Frequent in 10--50 feet

Crangon vulgaris Fabr. Very large and abundant.

Argis lar Owen. This fine species occurs rarely in 10 feet mud.

Homarus Americanus M. Edw. Common.

Eupagurus pubescens Stm.

E. Kroyeri Stm. Both species from below low-water mark to 50 feet.

Hyas coarctata Leach.

Hyas aranea Leach. Both species common.

Chionocetes opilio Fabr. A number were taken from stomachs of cod from the Bank.

Cancer borealis Stm. Common under sea weed.

To make the list of species of this region as complete as possible, I add the following radiata from Newfoundland, on the authority of Lütken.*

Astrophyton eucnemis M. and T.; *Ophiura Stuwitzii* Lütk.; *Ophioglypha nodosa* Lyman—(*Ophiura nodosa* Lütken.); *Solaster papposus*, *S. endeca; Asteracanthion polaris* M. and T., *A. Grœnlandicus* Stp.; *Echinus Dröbachiensis*, small specimens and *Psolus Fabricii.*

Also the following mollusca from the Grand Bank, mentioned by Dr. Gould:

Solecuartus fragilis, *Machaera nitida*, *Panopaea Norvegica*, *Glycimeris siliqua*, *Mya truncata*, *Mactra ponderosa*, *polynema* Stm., *Mesodesma deauratum*, *Astarte lactea*, *Venus* (*Tapes*) *fluctuosa*, *Aphrodite Grœnlandica*, *Mytilus discrepans*, *Pectend. islandicus*, *Natica clausa*, *N. flava*, *Scalaria Grönlandica* *Fusus ventricosus*, *F. tornatus*, *F. scalariformis*, *Aporrhais occidentalis*, *Buccinum Donovani*, *B. ciliatum*. Also a few species

* Uebersicht über Grönland's Echinodermata.

from Labrador, mentioned by Dr. Mighels. Bos. Jour. Nat. Hist., Vols. 1 and 4 : *Cardium pinnulatum*, *Nucula rostrata*, (*N. bucata?*) *Mytilus pectinula*, *M. Minganensis*, *Margarita acuminata*, Sby., *M. varicosa*, *Fasciolaria ligata*, *Fusus islandicus.*

Woodward also mentions *Astarte crebricostata*, *Cyprina islandica*, *Machæra costata*, *Buccinum undulatum* Müll., *B. Labradorense* Reeve, *B. cyaneum*, *Lacuna*——, and *Ommastrephes todarus* d'Orb., as coming from Newfoundland. Sowerby, in the "Thesaurus," figures *Terebratella Labradorensis.* Troschel in Wiegmann's Archiv., 1846, describes *Anaperus cigaro*, and *Orcula Barthii* collected at Okkak in northern Labrador.

Professor Chadbourne informes me that *Pecten tenuicostatus* and *Alasmodonta arcuata* are very abundant and characteristic shells in Newfoundland.

Reeve (Icon. Conch. Monog. Fusus, pl. 21, fig. 89) figures and describes *Fusus pullus*, which was collected at Newfoundland by Mr. Jukes.

Lamouroux, in his "Exposition Methodique des Polypiers," has figured and described several species of Polyzoa collected by Captain Laporte upon or near the Bank of Newfoundland: *Loricaria Americana*, of which *Gemellaria dumosa* Stm., seems to be a synonym; *Eucratea appendiculata*, and *Eschara lobata*, besides one Acaleph, *Lafoea ramosa.*

Gemellaria Americana d'Orb., *Eschara retiformis* Ray, (= E. foliacea Lamk), *Eschara lobata* Lamarck, *Eschara elegantula* d'Orb., *Celleporaria incrassata* d'Orb. (Cellepora incrassata Lamarck), *Celleporina ramosissima* d'Orb., *Biflustra aculeata* d'Orb., *Ornithoporina avicularia* d'Orb., Hudson's Bay. *O. dilatata* d'Orb., *Semieschara lamellosa* d'Orb., *Hippothoa borealis* d'Orb., *Hippothoa robertina* d'Orb., *Cellepora* sp. (none described), *Reptocelleporaria tuberosa* d'Orb., *Repteschareliina borealis* d'Orb., *Multescharellina aculeata* d'Orb. var., *Membranipora partita* d'Orb., *Reptoflustrella Americana* d'Orb., *Cridia appendiculata* d'Orb. (= Eucratea appendiculata Lamx.), *Myriozoum subgracile* d'Orb., *Fasciculipora Americana* d'Orb., *Idmonea angustata* d'Orb., *Reptotubigera confluens* d'Orb., *Entalopora Gallica* d'Orb., *Diastopora latomarginata* d'Orb., *Tubulipora verrucaria* Edwards, *Proboscina serpens* d'Orb., *Proboscina latifolia* d'Orb., *Berenicea prominens* Lamx.

Mr. Verrill has identified specimens of a polyp in the collections of the Essex Institute, (Salem, Mass.) brought from the Grand

Bank of Newfoundland, as *Alcyonium rubiformis* Dana, (Ehr. sp.)

I have permission to introduce in this connection:

A List of the Invertebrata collected at Anticosti and Mingan Islands, by Messrs. A. E. Verrill, A. Hyatt, and N. S. Shaler, in 1861, who have allowed me to make this use of the names given below. The specimens are deposited in the Museum of Comp. Zoology at Cambridge, Mass. The list of radiates and the accompanying notes were furnished me by Mr. Verrill.

Polypi.

Metridium marginatum E. and H., (Actinia marginata Les.)? Several young actiniæ were dredged in 8 feet, at Ellis Bay, Anticosti, adhering to rocks, which appeared to belong to this species. No other polyps were obtained at these islands. At Gaspé, C. E., Prof. Dawson obtained this species, and has described and figured it very accurately,* (Actinia dianthus ?). With it he also found *Actinia carneola* Stimp. In Chedabucto Bay on the southern side of Breton Island, N. S., we dredged an abundance of *Alcyonium carneum* Ag., in 10 feet rocky bottom, associated with a variety of hydroids. This is the most northern locality yet known for the species, its range being southward to Cape Cod.

Acalephae.

Pleurobrachia rhododactyla Ag. Very abundant about East Point, Anticosti, in July.

Idyia roseola Ag., East Point, Anticosti. Very abundant the first of July.

Bolina alata Ag. Near Fox Bay, Anticosti. Very abundant June 29.

Cyanea arctica Per. and LeS. Anticosti. Common. Young about 1 inch in diameter were taken at Fox Bay, June 28.

Aurelia flavidula Per. and LeS. Eastern end of Anticosti. Common. Young ones ½ inch in diameter were taken at Salmon River Bay, July 2.

Haliclystus auricula Clark. (Lucernaria auricula Rathke, non Fabricius.) Near S. W. Point, Anticosti. Very abundant on *Chorda filum*, Aug. 14, at low water. Another species of Lucernaria was taken, but the specimen was lost.

Cosmetica sp. A beautiful species of this genus, about 3 inches in diameter, with large tentacles about two inches long and half an inch apart, was found in great abundance, June 25, at Entry Island, in

* Canadian Naturalist and Geologist, vol. 3, p. 401.

the caverns excavated in the high cliffs of red sandstone by the sea.

Hydractinia polyclina Ag. Anticosti and Mingan. Common.

Sertularia polyzonias Johnst. Niapisca Is. Mingan. In 15 feet rocky bottom.

S. argentea Johnst.	"	"	"
S. rosacea Johnst.	"	"	"
Eudendrium sp.	"	"	"
Clytia olivacea Lamx.	"	"	"
Thuiaria thuja Johnst.	"	"	"

Plumularia falcata Lamx. Anticosti.

ECHINODERMATA.

Pentacta frondosa Jæg. Anticosti, near Ellis Bay. Not common. A fine young specimen was found among rocks at low water.

Chirodota lævie Grube. Anticosti, near Ellis Bay. Several specimens were found under rocks at low water.

Echinus drobachiensis Müll. Anticosti and Mingan Is. Very common in 20–30 feet, rocky bottom.

Echinarachnius parma Gray. (E. atlanticus Gray). A few small specimens were dredged at Mingan.

Asteracanthion polaris M. and T. S. W. Point and Heath Point, Anticosti. Common among rocks just below low-water mark. Also dredged in 15 feet rocky bottom at Mingan Is.

Asteracanthion sp. A form with longer rays and sharp spines was obtained at Gaspé, C. E.

A. Grœnlandicus Stp. A single specimen was dredged in 15 feet rocky bottom off Ellis Bay, Anticosti.

Cribella oculata Forbes. Heath Point. Common.

Ophiopholis aculeata Lütken. Anticosti and Mingan Is. Very common in 10--15 feet rocky bottom. Cod-fish were often caught having their stomachs filled with this species.

Ophioglypha robusta Lyman. A single specimen dredged in 20 feet, rocky bottom, off Table Head, Anticosti.

Astrophyton Agassizii Stimp. A specimen of this species, obtained near Gaspé, C. E., was presented by Rev. I. A. Tallman.

POLYZOA.

Tubulipora patina Johnst. Anticosti.

Diastopora verrucaria Fabr. sp.

Membranipora Lacroixii? Sav. All these species occur at Mingan in 15 feet.

Lepralia annulata Fabr.
L. trispinosa Johnst.
L. hyalina Johnst.
L. Belli Dawson.
L. pertusa Johnst.
L. paucispina Stimp.
Eschara lobata Lamk.
Myriozoum subgracile d'Orb.

D'Orbigny in the Paleontologie Française, Terrain cretácés 1850-52, has described a large number of Polyzoa from the Bank of Newfoundland, a list of which is here given :

BRACHIOPODA.

Hypothyris psittacea King. One specimen occurred at Anticosti in 20 feet, rocky bottom.

LAMELLIBRANCHIATA.

Mytilus edulis Linn. Anticosti.
Saxicava arctica Desh. Anticosti.
Mya arenaria Linn. Anticosti.
M. truncata Linn. Anticosti.

These four species, together with *B. Labradorense* and *P. lapillus* and *Cancer irrorata*, were all that occurred during a walk along the shores of the island for 12 miles. Owing to the freshness of the water, there was a remarkable paucity of littoral animals noticed.

Pecten islandicus Müll. Mingan, 20 feet.
Crenella glandula Turton. Anticosti, 20 feet.
Cardita borealis Conr. Mingan, 20 feet rocky.
Cardicum islandicum Chemn. Mingan, 20 feet rocky, abundant.
Serripes Grœnlandicus Beck. With the last; large and abundant.

GASTEROPODA.

Doris sp. Not described.
Chiton marmoreus Fabr. Mingan.
Margarita undulata Sowb. Mingan.
M. cinerea Gould.
M. helicina Müll. Anticosti, abundant.
M. varicosa Mightes. Mingan Is. 20 feet rocks, common.
Turritella erosa Couth.
Aporrhais occidentalis Beck.
Lacuna vincta Turton. Anticosti.
Littorina vestita Gould.
L. palliata Gould.
Purpura lapillus Lam. Anticosti. Not very common.

Buccinum Labradorense Reeve. (B. undatum Gould). Anticosti. Not very common.

Fusus tornatus Gould. Mingan Is. 20 feet rocky. One large dead shell.

Bela Woodiana Möll. Mingan, 20 feet rocky.

Physa heterostropha Say. Occurred on the south side of Anticosti in great abundance.

Limnæa. A species was common in ponds at Anticosti.

Vitrina pellucida Drap.? Common at Anticosti and Mingan.

Succinea obliqua Say. Common at Anticosti and Mingan. Fright Island, and Niapisca Island.

S. avara Say. Frequent at Mingan under drift stuff, boards, and rocks near the shore, where all the terrestrial species mentioned from Labrador occur. But those mentioned from Anticosti were found all over the island, in the interior as well as on the shore.

Pupa badia Adams. Abundant at Fright Is., Mingan.

Bulimus lubricoides Stm. Common at Niapisca Is., Mingan.

Helix chersina Say. Frequent at Fright Is.

H. nemoralis Linn. Both the plain and striped varieties were found on plants at Anticosti.

H arborea Say. Common at Niapisca Is.

H. minuta Say. Common at Anticosti.

H. striatella Anthony. Abundant at Fright Island and Niapisca Island.

Limax campestris Binney. Frequent at Anticosti.

At Entry Island, one of the Magdalen group, in the centre of the island under boulders, occurred and in the usual abundance, *Helix nemoralis, arborea, lineata, striatella, electrina,* and *Bulimus lubricoides.*

At Chedabucto Bay *Pandorina arenosa*, young shells, alive, *Margarita acuminata* and *Nassa trivittata* were dredged by the same party.

ANNELIDA.

Omatoplea Stimpsoni Girard. Anticosti, 15 feet rocky bottom.

Nereis sp., allied to *denticulata.* Anticosti.

Lepidonote cirrata Oersted. Anticosti.

L. punctata Oersted. Anticosti and Mingan.

CRUSTACEA.

Hippolyte aculeata Fabr.

H. polaris Sabine.

H. Fabricii Kroyer.

H. Gaimardii M. Edw.

Argis lar Owen. This and the four preceding occurred at the eastern end of Anticosti in 20 feet rocky bottom.

Homarus Americanus M. Edw. Common.

Eupagurus pubescens Stimp. Anticosti, 20 feet common.

Cancer borealis Stimp. Common.

Hyas aranea Leach. Common.

Gammarus mutatus Leidy. Low water, abundant.

Idotea new sp. Low water and 10 feet, common.

Caprella. Two species, 20 feet, common.

Calliope lævinscula. Magdalen Isles. Abundant at the surface of the water in the caverns under eroded cliffs.

Themisto sp. Anticosti, common.

Pandalus annulicornis Leach. Anticosti, 15 feet.

Argis lar Owen. Mingan, 15 feet Niapisca I.

Homarus Americanus M. Edw. (Lobster.)

Hyas aranea Linn. At Ellis Bay, Anticosti, in 8 feet rocks.

Cancer irrorata Say. Anticosti.

These articulata were identified by Dr. Stimpson.

Crangon boreas has been brought from Labrador by H. R. Storer, M.D.

Though the above lists of species are imperfect, yet they seem to afford very satisfactory evidences that there are three distinct assemblages of marine invertebrates intermingled on the coast of southern Labrador. We can easily separate from the list, as foreign to this coast, three species of molluscs; viz. *Pandora trilineata, Natica heros*, and *Rissoa minuta*. These shells were rare, and of small size, though on the coast of New England they are large and abundant.

By the aid of "The Invertebrata of Massachusetts," by Dr. Gould, and a list of invertebrates found by Mr. Robert Bell, Professor of Natural Sciences, in Queen's College, Kingston, about the mouth of the St. Lawrence and the coast of New Brunswick, published in the Canadian Naturalist and Geologist; together with a list of the shells of Halifax by Mr. Willis, and Stimpson's Invertebrates of Grand Manan, we are enabled to trace the fauna peculiar to the coast from Cape Cod to ova Scotia, as it reappears again in the Eastern shores of the Gulf of St. Lawrence, about Prince Edward's Island, at Gaspé, and extends up the river St. Lawrence towards Quebec.

Some of the following shells do not occur at Grand Manan, but seem to be as abundant on the shores of Canada as in Maine:

Leda limatula.
Mytilus plicatulus,
Venus mercenaria.
Lyonsia hyalina.
Ostræa virginiana.
Crepidula plana.
" *fornicata.*
Rissoa minuta.
Natica heros.
" *triseriata.*
Nassa trivittata.

Mr. Bell observes that *Natica heros* is "large and abundant." *Mytilus plicatulus* and *Venus mercenaria* were "from the Gulf.". The last mentioned species occurs abundantly in Casco Bay. *Eupagurus Bernhardus*, which does not occur in Labrador, was frequent. *Aporrhais occidentalis* occurred very rarely at Gaspé, as it does on the coast of Maine.

The occurrence of the large long oyster so common at Prince Edward's Island, and which is found in such immense heaps at Newcastle, Me., upon the banks of the Sheepscot River, in whose waters it still lives, though in diminshed numbers, indicates similar oceanic conditions existing on those two shores, which are separated by the colder waters of the Bay of Fundy.

The occurrence of *Astrophyton Agassizii* at Gaspé, which is replaced in Labrador by *A. eucnemis*, is interesting as showing that the echinoderm faunæ of those localities are also distinct. The island of Anticosti, judging by its land shells and vegetation and the presence of *Idyia roseola*, *Bolina alata*, and *Pleurobrachia rhododactyla*, belongs to New Brunswick.

This fauna was stated by Dr. Gould to extend from Cape Cod to the Newfoundland Banks from the study of the mollusca alone. It was afterwards, by Forbes, termed the "*Boreal*" province, and he considered Cape Breton its most northern limit.

In 1852, Dana* established under the name of the "Nova Scotian Province," a crustacean fauna, embracing an extent of nine hundred miles, reaching from "Cape Cod to the Eastern Cape of Newfoundland;" and in 1857, Lütken † likewise proposed for the same region an echinoderm fauna, which he calls the "Acadiske Provinds," merely changing Dana's name for the more ancient title of that Province.

They all agree in bringing down the Arctic or polar fauna to intermingle with the Acadian fauna at the northern limits of the latter. But with a better knowledge of the polar fauna, which is presented in the lists of Greenland invertebrates by Reinhart, Mörch, Lütken, and others,‡ we are led to the conclusion that there is an in-

* Crustacea of the U. S. Exploring Expedition.
† Uebersicht über Grönland's Echinodermata.
‡ Naturhistoriske Bidrag til en Beskrivelse af Grönland. Kjobenhavn, 1857.

termediate fauna inhabiting the seas of Labrador and Newfoundland.

A large portion of the polar species have not yet been discovered south of Greenland; and the following species are characteristic of Labrador and the Banks of Newfoundland:

Cyrtodaria siliqua.	*Machæra nitida.*
Asterias n. sp?	*Margarita acuminata.*
Anaperus cigaro.	" *varicosa.*
Orcula Barthii.	*Natica flava.*
Terebratella Labradorensis.	*Aporrhais occidentalis.*
Pecten tenuicostatus.	*Fusciolaria ligata.*
Alasmodonta arcuata.	*Buccinum cretaceum.*
Mesodesma Jauresii.	*Fusus ventricosus.*

Ommastrephes todarus.

The littoral species of south-eastern Labrador agree well with those of Maine. The two species of *Littorina* present the same variations, and the *Macoma fusca* occurs in the same abundance. These three mollusks are replaced in Greenland by representative species; as regards the latter, Dr. Stimpson has separated this species from *Tellina Grœnlandica* Beck; and my own specimens from Greenland are plainly distinct. The genus Mesodesma, which does not occur in Greenland, is represented by two species in Labrador and the Grand Banks. The fresh water *Alasmodonta arcuata*, which is so abundant throughout Newfoundland, and in Nova Scotia, New Brunswick, and the eastern half of Maine, which is included in what was formerly called "Acadia," also characterizes this fauna. In the deep water species there is a greater similarity to the polar fauna, but many species of Buccinum and Fusus described from the frozen seas, which have not been found to the southward, show plainly a different fauna adapted to those climatic conditions. Most of the species enumerated in the preceding list extend around Cape Breton to Halifax and the Banks lying off Nova Scotia, and predominate at the mouth of the Bay of Fundy; but along the coast of Maine they become reduced in size and numbers before reaching the mouth of the Penobscot. The fauna also reappears on St. George's Banks, and very probably on Jeffries Bank, and the occurrence of *Eupagurus pubescens** and *Cardita borealis*, a very abundant Labrador and Greenland shell, off the coast of New Jersey, indicates that the cold arctic current impinges upon that coast. How far northward of Newfoundland this fauna extends is not now known. The charts show the existence of an im-

* Forbes' Natural History of the European seas, p. 53.

menseshoal to the northward of that island, which with the opposite coast of Labrador is no doubt occupied by this fauna. Returning down the coast we find it following very closely the line of floating ice as laid down in the charts. It includes the Mingan Islands, partially embracing Anticosti, and then sweeps around towards Cape Breton, there meeting the warmer waters of the Gulf Stream.

Thus, south of Labrador, it is apparently a *shoal* fauna, and we would propose for it the name of the *Syrtensian Fauna*, indicative of the physical features that limit its bounds.

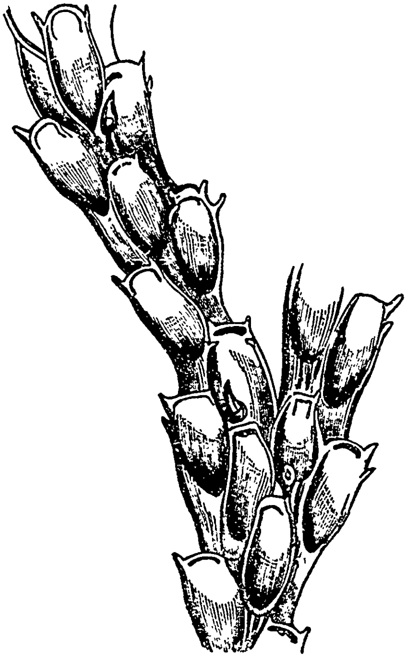
This fauna seems to have its equivalent upon the European side of the Atlantic in Finmark, where Lövén* records the discovery of several new species of Mollusks and other invertebrates. The climatic conditions are very similar, and the insect fauna and the flora correspond very exactly with the insects and plants of Labrador.† Indeed, there is apparently a belt of faunæ intermediate between the boreal province on both sides of the Atlantic on the one hand, and the circumpolar province, which touches upon the southern point of Greenland, includes Iceland, and spreads out so as to include Finmark and the neighboring islands. Dr. Gould, in noticing the distribution of our mollusks, mentions the fact that "about 20 species may be regarded as intermediate, being found most frequently by fishermen about the Banks, Newfoundland, and the islands intervening between Greenland and England. (Invertebrates of Massachusetts, p. 316).

Thus with our present knowledge we can approximate very nearly to the southern limits of this *shoal* fauna, and trace the isolated patches situated upon the cold and unprotected elevations, which rise in the warmer seas of New England; but our imperfect information respecting the range northward of its most characteristic species, does not allow us to speak with much certainty how far up the eastern coast of Labrador these species extend, or whether those few species, which reach Greenland and occur there rarely, may not be considered as foreigners to the soil. For example: of *Apporhais occidentalis*, which is so profusely abundant in the Straits of Belle Isle, Mörch reports but a fragment from Greenland. This is analogous to the occurrence of

* Identified by Dr. William Stimpson.

† In a communication to the Boston Society of Natural History, "Proceedings," 1863, Mr. S. H. Scudder has intimated that there is an insect fauna peculiar to Eastern Labrador, and in conversation with the writer, has also spoken of the close analogy, which the insects of Labrador bear to those of Lapland.

PLATE I.



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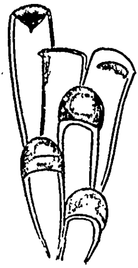

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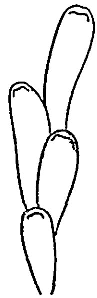
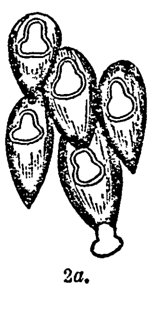


4 *a*

2.

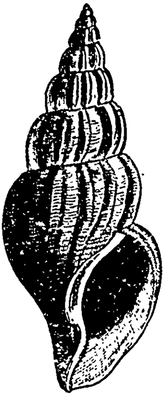


2*a*.

2 M. solida. 3 M. fruticosa.

4 H. borealis.

PLATE II.



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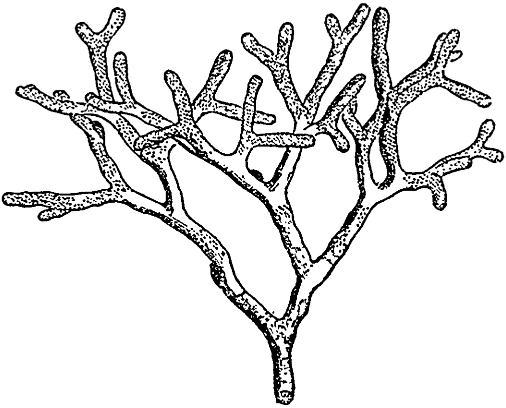

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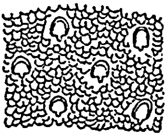


5a.

1.

1 L. producta.

5 M. subgracile.

6 B. cretaceum.

Cardita borealis on the New Jersey coast, where it is certainly an alien.

In the absence of requisite data concerning the distribution of marine life in the arctic and subarctic seas, we shall be very materially aided by tracing the course of the yearly isothermal lines; and more especially for our purpose that area of the Atlantic ocean comprised between the line of 40° and 32°. The line of 40°, according to Professor Henry*, begins in America at the Northern portion of Nova Scotia. This agrees well with Gould's and Forbes' designation of Cape Breton, as being the dividing point between the Acadian and Arctic provinces. The line of " 32° indicates the boundary of the region within which the average temperature is below the freezing point. It will be seen at a glance, that, instead of being circular in its outlines, it has the form of an irregular elongated ellipse, the greater diameter of which is across the pole, from the southern extremity of Hudson's Bay, to the south of Lake Baikal, in Siberia." Upon the map accompanying the report, the line is made to pass through the lower third of the eastern coast of Labrador, dividing Cape Farewell from the remaining portion of Greenland, and touching Europe at Finmark in the vicinity of Nordland, one of the most southern of the Lofoden Islands. Thus to the north it shuts out a vast circumpolar region, including the northern portion of Hudson's Bay, with all of Baffin's Bay; and upon the European side it includes Spitzbergen and Nova Zembla. We are therefore confirmed in our opinion formed before meeting with these meteorological facts, that this elliptical area embraces a belt of faunæ of a subarctic character; and in the supposition that the fauna of Labrador and the Newfoundland banks has an European equivalent fauna in Finmark, occupying an extent of perhaps some 400 miles along the coast from Nordland to a point somewhere beyond Cape North.

Brunswick, Maine, Aug. 1863.

EXPLANATION OF THE FIGURES.

Pl. s. I. II. Fig. 1. Lepralia producta Pack.
" 2. Membranipora solida Pack.
" 3. Menipea fruticosa Pack.
" 4. Halophila borealis Pack.
" 5. Myriozoum subgracile D'Orby.
" 6. B ccinum cretaceum Reeve.

* Meteorology in its connection with Agriculture. Patent Office Report on Agriculture, 1856.

ART. XXIX.—*Note on the Foot-prints of a Reptile from the Coal Formation of Cape Breton.*

Since the publication of my memoir on the "Air-Breathers of the Coal Period," my friend Richard Brown, Esq., of Sydney, Cape Breton, has favoured me with a photograph of a series of footprints from the Sydney Coal-field. They occur in a bed of rippled sandstone, and are sufficiently distinct to render it certain that they indicate the existence of a reptile as yet unknown to us by other remains.

The slab exhibits with some distinctness three foot-prints of the right side, and less distinct traces of the left feet. The feet are short and broad, the fore foot as large as the hind foot, the toes short, broad and deeply impressed in the sand. Four toes are distinctly marked in both fore and hind feet, and there are uncertain traces of a fifth. The stride is considerably greater than the breadth of the body. The toes are somewhat turned inward. The figure is reduced one fourth, so that the animal must have been rather larger than *Dendrerpeton Acadianum,* with shorter toes and broader body.

These foot-prints are quite different in form from those previously found by Sir W. E. Logan, Dr. Harding, and the writer. They more nearly resemble those figured by Dr. King and Mr. Lea from the carboniferous of Pennsylvania; and may have been produced by an animal generically related to that which has left the traces named *Sauropus primævus* by the latter author. For this reason, until we shall obtain some knowledge of the animal from more definite remains, I propose for it the name of *Sauropus Sydnensis.* The specimen was discovered by Mr. Brown, and is now in his collection.

These footprints add a ninth species to the reptilian fauna of the Coal Formation of Nova Scotia, and are the first traces of this kind discovered in the Cape Breton Coal-field.

J. W. Dawson.

Art. XXX.—*Synopsis of the Flora of the Carboniferous Period in Nova Scotia;* by J. W. Dawson, LL.D., F.R.S., F.G.S., &c., Principal of McGill College.

The following list includes the plants in the collection of the writer, and in collections submitted to him by several geological friends; as well as those previously catalogued by Mr. Bunbury, in Sir Charles Lyell's Travels, and in the Journal of the Geological Society, and by Mr. R. Brown and the author, in the list appended to "Acadian Geology."

The present synopsis was not prepared so much for immediate publication, as in aid of the writer's investigations of the characteristic plants in the numerous coal beds at the South Joggins, and of the conditions of formation of those beds; but as some time may elapse before the publication of these researches, and the want of a list of the known species is much felt by those engaged in the study of the carboniferous rocks, it has been thought advisable to print it in the present form.

The new species are accompanied by short characters; but many of the details which might have been given are omitted for the sake of brevity. The collectors of the specimens examined are mentioned in every case, when known to the author. The part of the carboniferous system in which the species occur has also been stated; and as some confusion has lately arisen from the use of the term "sub-carboniferous," by authors, it is proper to state that the name "*Lower coal formation*" in this paper is equivalent to "sub-carboniferous" of Dana; that "*Middle coal formation*" denotes that part of the system over the Marine Limestones and holding the principal coal beds; and that "*Upper coal formation*" is applied to the newer part of the system over the productive coal measures.* These three members are, to a

* These groups are indicated in the following pages by the initials L. C., M. C., U. C.

certain extent, distinct in their flora. Any minor differences which exist in subordination to these main divisions, will be fully detailed in the memoir on the coal beds of the Joggins already referred to.

I have included in the list such plants from New Brunswick as are known to me. Those from Grand Lake in that Province are I believe on the horizon of the middle coal formation, though tending to the upper. A collection formed by Sir W. E. Logan at Baie de Chaleur, in beds of the lower and probably middle coal formation, includes also some species which in Nova Scotia are more characteristic of the upper coal formation. This apparent mixture of plants of different horizons, may be a consequence of the comparatively small thickness of the New Brunswick coal formation.

In the present unsettled state of the species of coal plants, it is with much diffidence that I venture to publish this list, which will without doubt admit of many corrections and improvements, even in the memoir on the formation of the Nova Scotia coals, with which I propose to follow it. I have, however, endeavoured to avoid adding to the load of synonyms, and have in all doubtful cases leaned to the side of identity with known species rather than to that of giving new names. I may add, that the increase of my collection has enabled me to reunite many specimens which I had regarded as representatives of distinct species. But for the large number of specimens which I have been enabled to examine, I should certainly in the case of several variable species, as for example *Alethopteris lonchitica* and *Lepidodendron corrugatum*, have erred in this way. I am constantly more and more convinced that no satisfactory progress can be made in fossil botany without studying the plants as they occur in the beds in which they are found, or in large numbers of specimens collected from those beds, so as to ascertain the relation of their parts to each other.

Dadoxylon, Unger.

Large quantities of drifted coniferous trunks are found in the sandstones of the coal formation in Nova Scotia; but, after sliceing more than one hundred specimens, the following are the only species I can distinguish. It is to be observed, however, that the different states of preservation of these trunks render their study and comparison very difficult.

1. *Dadoxylon Acadianum*, s. n.

M. C. Joggin, Port Hood, Dorchester. J. W. D.;

Large trees, usually silicified or calcified, with very wide wood-cells, having three or more rows of small hexagonal areoles, each enclosing an oval pore; cells of medullary rays one-third of breadth of wood-cells, and consisting of twenty or more rows of cells superimposed in two series. Rings of growth indistinct.

2. *D. materiarium*, s. n.

M. and U. C. Joggins, Malagash, Pictou, &c., J. W. D. Glace Bay, H. Poole. Miramichi, G. F. Matthew.

Wood-cells less wide than those of the last; two to rarely four rows of hexagonal discs. Medullary rays very numerous, with twenty or more rows of cells superimposed in one series. Rings of growth slightly marked. Approaches in the character of its woody fibre to *D. Brandlingii*; but the medullary rays are much longer. Some specimens show a large sternbergia pith with transverse partitions.* Vast numbers of trunks of this species occur in some sandstones of the Upper Coal formation.

3. *D. antiquius*, s. n.

L. C. Horton, Dr. Harding.

Wood-cells narrow, thick-walled, two or three rows of pores, Medullary rays of three or four series of cells with twenty or more superimposed, nearly as wide as the wood-cells. Rings of growth visible. This species would belong to the genus *Palæoxylon* of Brongniart, and is closely allied to *D. Withami* L. and H., which like it occurs in the Lower Coal measures.

4. *D. annulatum*. s. n.

M. C. Joggins, Sir W. E. Logan. J. W. D.

Wood-cells with two or three rows of hexagonal discs. Medullary rays of twenty or more rows of cells superimposed, in two series. Wood divided into distinct concentric circles, alternating with layers of structureless coal representing cellular tissue or very dense wood. A stem six inches in diameter has fourteen to sixteen of these rings, and a pyritised pith about one inch in diameter. This is probably generically distinct from the preceding species.

ARAUCARITES, Unger.

Araucarites gracilis, s. n.

U. C. Tatamagouche., J. W. D.

* Canadian Naturalist, 1857.

Branches slender, 0·2 inch in diameter, with scaly, broad leaf bases. Branchlets pinnate, numerous, very slender, wit small acute, spirally disposed leaves.

SIGILLARIA, Brongt.

Under this name I include four sub-genera, viz., (1). *Favularia* of Sternberg, of which *S. elegans* is the type; (2). *Rhytidolepis* of Sternberg, of which *S. scutellata* is the type; (3). *Sigillaria* proper, of which *S. reniformis* is the type; (4.) *Clathraria*, Brongt, of which *S. Menardi* is the type.

To these may perhaps be added *Asolanus* of Wood (Proc. Phila. Ac. Sci.), though most of the specimens of Sigillaria destitute of ribs are only portions of old trunks of the ribbed species. With these sub-genera I would place *Syringodendron* and *Calamodendron* as members of the gymnospermous family *Sigillariaceæ*. *Stigmaria* may be retained as a provisional genus, to include roots not connected with the trunks.

1. *Sigillaria* (*Favularia*) *elegans*, Brongt.

M. C., Joggins, J. W. D.; Sydney, R. Brown: abundant, especially in the roofs of coal seams. *S. Hexagona* includes old trunks of this species. Young branches have scars of an elliptical form like those of *S. Serlii*.

2. S. (*Fav.*) *tessellata*, Brongt.

M. C., Joggins and Pictou, J. W. D.; Sydney, R. Brown.

3. *S.* (*Rhytidolepis*) *Scutellata*, Brongt.

M. and U. C., Joggins, Lyell, J. W. D.

4. *S.* (*Rh.*) *Schlotheimiana*, Brongt.

M. C. Joggins, Lyell, J. W. D.

5. *S.* (*Rh.*) *Saullii*, Brongt..

M. C. Sydney, R. Brown; Joggins, Lyell, J. W. D.

6. *S. Brownii*, Dawson (Jl. Geol. Socy., vol. X.)

M. C. Joggins, J. W. D.

7. *S. reniformis*, Brongt.

M. C. Joggins, Lyell, J. W. D., Sydney, R. Brown.

8. *S. levigata*, Brongt.

M. C. Sydney, R. Brown; Joggins, J. W. D.

9. *S. planicosta*, s. n.

M. C. Sydney, R. Brown.

Scars half hexagonal above, rounded below, lateral vascular impressions elongate, central small punctiform. Ribs $1\frac{1}{10}$ inch broad, smooth externally, longitudinally striate on ligneous surface. Slight transverse wrinkles between the scars, which are distant from each other about an inch. Allied to *S. levigata*, but with very thin bark.

10. *S. catenoides*, s. n.

M. C. Joggins, J. Smith. Sydney, R. Brown.

Cortical surface unknown, ligneous surface with puncto-striate ribs $1\frac{1}{10}$ inch in breadth and with single oval scars half an inch long, and an inch distant from centre to centre. A very large tree. Perhaps, if its cortical surface were known, it may prove to be a large *Syringodendron*.

11. *S. striata*, s. n.

M. C. Joggins, J. W. D.

Ribs prominent, coarsely striate, 0·35 inch wide. Scars nearly as wide as the ribs, rounded hexagonal, one inch distant; lateral vascular marks narrow, central large. On ligneous surface scars single, round, oblong; bark very thin.

12. *S.* ———

M. C. Joggins, J. W. D.

A small erect stem, somewhat like *S. flexuosa*.

13. *S.* (*Clathraria*) *Menardi*, Brongt.

M. C. Sydney, R. Brown; N. C. Pictou, J. W. D.

14. *S.* (*Asolanus*) *Sydnensis*, s. n.

M. C. Sydney, R. Brown.

Ribs obsolete; cortical and ligneous surfaces striate; vascular scars two, elongate longitudinally, and alike on cortical and ligneou surfaces; scars 1·1 inch distant, in rows 0·6 inch distant.

15. *S. organum*, L. and H.

M. C. Sydney, R. Brown.

16. *S. elongata*, Brongt.

M. C. Sydney, R. Brown.

17. *S. flexuosa*, L. and H.

M. C. Sydney, R. Brown's list, in Acadian Geology.

18. *S. pachyderma*, L. and H.

M. C. Sydney, R. Brown's list.

19. *S.* (*Fav.*) *Bretonensis*, s. n.

M. C. Sydney, R. Brown.

Like *S. tesseleata*, but areoles more hexagonal, bark thin and smooth on both sides, and furrow above the scars arcuate, and with a central punctiform elevation.

20. *S. eminens*, S. N.

M. C. Sydney, R. Brown.

Like *S obovata,* Lesqx. but with narrower ribs, and larger and less distant areoles, each with a slight groove above.

21. *S. Dournaisii,* Brongt.

M. C. Joggins, J. W. D.

22. *S. Knorrii,* Brongt.

M. C. Sydney, R. Brown.

SYRINGODENDRON, Brongt.

Obscure specimens, referrible to a narrow-ribbed species of this genus, occur in the lower carboniferous beds at Horton and Onslow.

STIGMARIA, Brongt.

Stigmaria ficoides, Brongt.

Under this name I place all the roots of *Sigillariæ* occurring in the carboniferous rocks of Nova Scotia. They belong, without doubt, to the different species of sigillaroid trees, but it is at present impossible to determine to which; and the specific characters of the Stigmariæ themselves are, as might be anticipated, evanescent and unsatisfactory. The varieties which occur in Nova Scotia, discarding mere differences of preservation, may be arranged as follows;

Variety (*a*) Areoles large, distant; bark more or less smooth. This is the most common variety, and extends throughout the coal formation.

" (*b*) Areoles large, separated by waving grooves of the bark.

" (*c*) similar, but ridges as well as furrows between the areoles; var. *undulata* of Göeppert.

" (*d*) Areoles small, separated by waving grooves.

" (*e*) Areoles moderate, in vertical or diagonal furrows separated by ridges; var. *sigillarioides* of Göeppert.

" (*f*) Areoles small, bark finely netted with wrinkles or striae.

" (*g*) Areoles surrounded by radiating marks, giving a star-like form; var; *stellata* of Göeppert. The only specimen I have seen was found by Dr. Harding in the lower carboniferous coal measures of Horton

" (*h*) Areoles small or obscure and n.requent. Surface covered with fine uneven striae. My specimens were collected by Mr. Brown in the middle coal measures at Sydney

Variety (*i*) Areoles narrow, elongate, bark smooth or striate.

" (*k*) *alternans*, with areoles in double rows on broad ribs separated by deep furrows. Probably old furrowed roots.

" (*l*) *knorroides*, prominent bosses or ridges instead of areoles. These are imperfectly preserved specimens.

The varieties (*a*) (*b*) (*c*) (*e*) (*i*) have been seen attached to trunks of Sigillariæ of that group distinguished by broad and prominent ribs, *Sigillaria* proper of the above arrangement. Stigmariæ, like Sigillariæ, are exceedingly abundant in the middle coal measures, and are comparatively rare in the lower carboniferous and newer coal formations.

CALAMODENDRON, Brongt.

1. *Calamodendron approximatum*, Brongt.

M. C. Sydney, R. Brown; M. C. Joggins, Pictou, J. W. D.; Coal Creek, C. B. Matthew.

This plant is evidently quite distinct from *Calamites* proper. The calamite-like cast is a pith or internal cavity, surrounded by a thick cylinder of woody tissue consisting of scalariform vessels and woody fibres with one row of round pores; external to this is a bark of cellular and bast tissue. The structure appears to be allied to that of *Sigillaria*, and is one of the most common in the beds of bituminous coal.

2. *C. obscurum*, s. n.

M. C. Sydney, J. W. D.

This is a calamite-like fragment found in a block of Sydney coal, in the state of mineral charcoal. The external markings are obscure but the structure is well preserved. It differs from the last in having large ducts with many rows of pores, or reticulated, instead of scalariform vessels.

CYPERITES, L. and H.

Cyperites, ———

Middle and upper coals, everywhere.

These elongate linear leaves have two or three ribs and the central band between the ribs raised above the margin: one species has been seen attached to *Sigillaria Sclotheimiana*.

The leaves of *Sigillaria elegans* are different, being as broad as the areoles of the stem and with several parallel veins.

ANTHOLITHES, Brongt.

I include under this name spikes of inflorescence, or of fruits, usually showing buds or scaly floral leaves, and sometimes ovate fruits which may be young *Rhabdocarpi* or *Trigonocarpi.* I have not seen them attached to stems; but their associations would lead me to suppose that they may have belonged to *Sigillaria* or *Calamodendron.* Stems of Sigillaria of the groups *Rhytidolepis* and *Favularia* have rings of abnormal scars at intervals, which may have borne such spikes of fruit. No such marks are seen on the stems of other sub-genera of *Sigillaria,* which probably bore fruit at their summits.

1. *Antholithes rhabdocarpi,* s. n.

M. C. Grand L., C. F. Hartt.

Stem short, interruptedly striate, with two rows of crowded ovate fruit, and traces of floral leaves. Fruits half an inch long striate longitudinally, attached by short peduncles.

2. *A. pygmaea,* s. n.

M. C. Joggins, J. W. D.

Rhachis 1 inch thick, rugose; two rows of opposite flowers, each showing four lanceolate striate floral leaves, two outer and two inner.

3. *A. squamosa,* s. n.

U. C. Pictou, J. W. D.

Rhachis thick, coarsely rugose, with two rows of closely placed cones or scaly fruits.

4. *A.* ——— s. n.

M. C. Joggins, J. W. D; Sydney, R. Brown.

Indistinct, but apparently different from those above described.

TRIGONOCARPUM, Brongt.

1. *Trigonocarpum Hookeri,* Dawson. Geol. Journal, Vol, 17.

M. C. Mabou, J. W. D.

2. *T. Sigillariæ,* s. n.

M. C. Joggins, J. W. D. Ovate, ½ inch long; testa smooth, or rugose longitudinally, acuminate, two-edged. Found in erect trunks of *Sigillariæ,* in large numbers.

3. *T. intermedium,* s. n.

M. C. Joggins, J. W. D. Allied to *T. olivæformis,* but larger and more elongated.

4. *T. avellanum,* s. n.

M. C. Joggins, J. W. D. Sydney, R. Brown.

Allied to *ovatum,* L. & H.; three-ribbed, size and form of a filbert.

5. *T. minus*, s. n.

M. C. Joggins, J. W. D. Half the size of *T. Hookeri*, and similar in form.

6. *T. rotundum*, s. n.

M. C. Joggins, J. W. D. Small, round ovate, slightly pointed.

7. *T. Nœggerathi*, Brongt.

Newer coal formation, Pictou, J. W. D.

The *Trigonocarpa* are very abundant in some beds of the Middle coal formation. Most of them are fruits of *Sigillariæ*, some of them perhaps of conifers.

RHABDOCARPUS, Goep. and Berg.

1. *Rhabdocarpus* ——— s. n.

M. C. Joggins, J. W. D. Ovate, acuminate, less than half an inch long.

2. *R. insignis*, s. n.

U. C. Pictou, J. W. D.; 1·5 inch long, ovate, smooth, with about 7 ribs on one side, and the intervening surface obscurely striate. The nature of this fossil is perhaps doubtful, but if a fruit it is the largest I have seen in the coal formation.

CALAMITES, Suckow.

1. *Calamites Suckowii*, Brongt.

M. C., Sydney, R. Brown; Joggins, Lyell, J. W. D.; Grand Lake, C. F. Hartt. U. C. Pictou, J. W. D. Coal Creek, C. B. Matthew.

This species is one of the most common in an erect position. It has verticillate branchlets with pinnate linear leaflets.

2. *C. Cistii*, Brongt.

M. C. Joggins, J. W. D.; Sydney, R. Brown; Grand Lake, C. F. Hartt; Bay de Chaleur, Logan. Coal Creek, C. B. Matthew.

Often found erect. Its leaves are verticillate, simple, linear, striate, apparently one-nerved and 3 inches long.

3. *C. cannæformis*, Brongt.

M. C., Joggins, Lyell, J. W. D.; Sydney, R. Brown.

4. *C. ramosus*, Artis.

M. C. Joggins, J. W. D. Sydney, R. Brown; possibly a variety of *C. Suckowii*.

5. *C. Voltzii*, Brongt—(irregularis, L. and H.)

M. C. Joggins, J. W. D.

Often erect. Has large irregular adventitious roots.

6 *C. dubius*, Artis.

M. C. Sydney, R. Brown; Joggins, J. W. D., Logan; U. C. Pictou, J. W. D.

7. *C. Nova Scotica*, s. n.

M. C. Joggins, J. W. D.

Ribs equal, less than a line wide, striate longitudinally. Joints obscurely marked and with circular areoles separated by the breadth of 3 to 4 ribs. Bark of moderate thickness.

8. *C. nodosus*, Schlot.

M. C. Sydney, R. Brown: Grand Lake, C. F. Hartt.

This species has long slender branchlets, with close whorls of short rigid leaves.

9. *C. arenaceous?* Jaeger.

This species is mentioned with doubt in Lyell's list.

EQUISETITES, Sternberg.

Equisetites curta, s. n.

M. C. Sydney, R. Brown.

Short thick stems, enlarging upward and truncate above, joints numerous, sheaths as long as the joints, with unequal acuminate keeled points. Lateral branches or fruit with longer leaf-like points. Has the characters of *Equisetites*, but its affinities are quite uncertain.

ASTEROPHYLLITES, Brongt.

1. *Asterophyllites foliosa*, L. and H.

M. C. Joggins, J. W. D; Sydney, R. Brown.

2. *A. equisetiformis*, L. and H.

M. C. Sydney, R. Brown; Pictou, J. W. D.

3. *A. grandis*, Sternberg.

M. C. Grand Lake, C. F. Hartt; Bay de Chaleur, Logan; Sydney, Bunbury.

The specimens resemble this species, but are not certainly the same. Logan's specimens have terminal spikes of fructification.

4. *A.* ———

A species with tubercles (fruit) in the axils is mentioned in Lyell's list as from Sydney. I have not seen it, but have a specimen from Mr. Brown similar to *A. tuberculata*, Sternberg, which may be the same.

5. *A. trinervis*, s. n.

M. C. Sydney, R. Brown.

Main stem smooth, delicately striate, with leaves at the nodes. Branches delicately striate, with numerous whorls of linear nearly straight leaves, 0·5 inch long, twenty or more in a whorl, and showing two lateral nerves in addition to the median nerve. This and No. 2 would be placed by some authors in *Annularia.*

ANNULARIA, Sternberg.

Annularia galioides, Zenker.

M. C. Grand Lake, C. F. Hartt; U. C., Pictou, J. W. D.; Bay de Chaleur, Logan; Sydney, R. Brown.

SPHENOPHYLLUM, Brongt.

1. *Sphenophyllum emarginatum*, Brongt.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt; Bay de Chaleur, Logan; Pictou, J. W, D.

2. *S. longifolium*, Germar.

U. C. Pictou, J. W. D., M. C. Sydney, R. Brown.

3. *S. Saxifragifolium*, Sternberg, Bay de Chaleur, Logan.

Elongate, much forked variety, closely allied to *S. bifurcatum* Lesquereux.

4. *S. Schlotheimii*, Brongt.

M. C. Sydney, Bunbury.

5. *S. erosum*, L. and H.

M. C. Sydney, Bunbury.

The two last species are regarded by Geinitz as varieties of *S. emarginatum.* A specimen of the last named species in Sir William Logan's collection shows a woody jointed stem like that of *Asterophyllites*, giving off branches at the joints. These again branch and bear whorls of leaves. The stem shows under the microscope a single bundle of reticulated or scalariform vessels like those of some ferns, and also like those of *Tmesipteris* as figured by Brongniart. This settles the affinities of these plants, as being with ferns or with *Lycopodiaceæ.*

PINNULARIA, L. and H.

1. *Pinnularia capillacea*, L. and H.

M. C. Sydney, R. Brown.

2. *P. ramosissima*, s. n.

M. C. Joggins, J. W. D. More slender and ramose than the last.

3. *P. crassa*, N. S.

L. C. Horton, C. F. Hartt. Branching like *P. capillacea* but much stronger and coarser.

All these are apparently branching fibrous stems or roots, of soft cellular tissue with a thin outer bark. Perhaps they are roots of *Asterophyllites*, or perhaps branchlets of an aquatic plant.

Genus Noeggerathia, Sternberg.

1. *Noeggerathia*———— ? s. n.

Bay de Chaleur, Sir W. E. Logan. A remarkable fragment of a leaf, with a petiole nearly three inches long, and a fourth of an inch wide, spreading abruptly into a lamina one side of which is much broader than the other, and with parallel veins running up directly from the margin as from a marginal rib. It appears to be doubled in at both edges, and is abruptly broken off. It seems to be a new species, but of what affinities it is impossible to decide.

2. *N. flabellata*, L. and H.

M. C. Sydney, R. Brown.

Cyclopteris. Brongt,

Including *Cyclopteris* proper and sub-genera *Aneimites* Dn. and *Nephropteris*, Brongt.

1. *Cyclopteris heterophylla*, Göeppert.

M. C. and U. C. Joggins, J. W. D.

2. *C.* (*Aneimites*) *Acadica*, Dawson, (Journ. Geol. Soc., Vol. 17.)

L. C. Horton, C. F. Hartt; Norton Creek, N.B., G. F. Matthew.

Stipe large, striate, branching dichotomously several times. Pinnæ with several broadly obovate pinnules grouped at the end of a slender petiolule, and with dichotomous radiating veins. Fertile pinnæ with recurved petiolules, and borne on the divisions of the main petiole near their origin. This plant might be placed in the genus *Adiantites*, Brongt., but for the fructification, which allies it with such ferns as *Aneimia*. It has a very large frond, the main petiole being sometimes three inches in diameter, and two feet long before branching. Flattened petioles have sometimes been mistaken for *Cordaites* and *Schizopteris*. It is a characteristic plant of the Lower coal measures.

3. *C. oblongifola*, Göeppert.

U. C. Pictou, J. W. D.

A little larger and coarser than Göeppert's figure.

4. *C.* (*Nephropteris*) *obliqua*, Brongt.

M. C. Sydney, R. Brown; Grand Lake, C. F. Hartt.

5. *C.* (? *Neuropteris*) *ingens*, L. & H.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt.

6. *C. oblata*, L. & H.

M. C. Sydney, R. Brown.

7. C. *fimbriata*, Lesquereux.

M. C. Sydney, R. Brown.

8. C. *hispida*, s. n.

M. C. Sydney, R. Brown.

Pinnate; pinnules obovate, diminishing in size toward the point, decurrent on the petiole, veins slender, distant, forking several times; under surface covered with stiff hairs.

NEUROPTERIS. Brongt.

1. *Neuropteris rarinervis*, Bunbury.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt; Bay de Chaleur, Logan.

2. *N. perelegans*, s. n.

M. C. Sydney, R. Brown.

Resembles *N. elegans*, Brongt., but has narrower pinnules and nerves less oblique to the mid-rib.

3. *N. cordata*, Brongt. (and var. *angustifolia*.)

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.

The ferns referred to this species are identical with *N. hirsuta* of Lesquereux. They abound in the Middle and Upper coal-formation, and have larger pinnules than any of our other ferns. A single terminal pinnule in my collection is five inches long. The surface is always more or less hairy.

4. *N. Voltzii*, Brongt.

N. C. Pictou, J. W. D.

A single imperfect specimen, like this species but uncertain.

5. *N. gigantea*, Sternb.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt; U. C. Pictou, J. W. D.

6. *N. flexuosa*, Sternb.

M. C. Sydney, R. Brown; Joggins, J. W. D.

7. *N. heterophylla*, Brongt.

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.

9. *N. Loshii*, Brongt.

Bay de Chaleur, Logan.

10. *N. acutifolia*, Brongt.

M. C. Sydney, Lyell's list.

11 *N. conjugata*, Goept.

M. C. Sydney, Brown's list, Ac. Geol.

12 *N. attenuata*, L. & H.

M. C. Sydney, l. c.

13. *N. dentata*, Lesqx.

M. C. Sydney, R. Brown.

14 *N. Soretii*, Brongt.

M. C. Sydney, R. Brown.

15. *N. auriculata*, Brongt.

M. C. Sydney, R. Brown.

16. *N. Cyclopteroides*, s. n.

M. C. Sydney, R. Brown.

Pinnate; pinnules contiguous or overlapping, obliquely round-ovate, attached at the lower third of the base, nerves numerous, spreading from the point of attachment. Allied to *N. Villiersi* Brongt.

ODONTOPTERIS, Brongt.

1. *Odontopteris Schlotheimii*, Brongt.

M. C. Sydney, R. Brown; Bay de Chaleur, Logan; U. C. Pictou, J. W. D.

2. *O. antiqua*, s. n.

L. C. ? Hebert R., J. W. D.

Tripinnate, petioles slender, pinnules oblong, obtuse, not contiguous. Terminal pinnules much elongated, venation obscure.

3. *O. Sub-cuneata*, Bunbury.

M. C. Sydney, R. Brown.

DICTYOPTERIS, Gutb.

Dictyopteris obliqua, Bunbury.

M. C. Sydney, R. Brown.

LONCHOPTERIS, Brongt.

Lonchopteris tenuis, s. n.

M. C. Sydney, R. Brown.

Pinnate or bipinnate, pinnules contiguous at base, nearly at right angles to petiole, oblong, elongate, obtuse. Network of veins very delicate. Allied to *L. Brierii*, Brongt., but with smaller more elongate pinnules and finer veins.

SPHENOPTERIS, Brongt.

1. *Sphenopteris munda*, s. n.

M. C. Grand Lake, C. F. Hartt.

Like *S. Dubuissonis*, Brongt., or *S. irregularis*, Sternberg, in habit; but the pinnules are obovate, decurrent and few-veined.

2. *S. hymenophylloides*, Brongt.

M. C. Sydney, R. Brown; U. C. Joggins, J. W. D.

3. *S. latior*, s. n.

M. C. Grand L., C. F. Hartt; U. C. Pictou, J. W. D.

Petiole forking at an obtuse angle, slender, tortuous, divisions bipinnate. Pinnæ with broad rounded confluent pinnules.

Veins twice forked, with Sori in the forks of the veins. In habit like *S. latifolia*, Brongt., and *S. Newburyi* and *S. squamosa*, Lesqx.

4. *S. decipiens*, Lesquereux.

M. C. Sydney, R. Brown.

5. *S. gracilis*, Brongt.

M. C. Joggins, J. W. D.; Grand L., C. F. Hartt.

6. *S. artemisifolia*, Brongt.

M. C. Grand L., C. F. Hartt; Sydney, R. Brown.

7. *S. Canadensis*, N. S.

Bay de Chaleur, Logan; Sydney? R. Brown.

General aspect like *S. Hoeninghausi*, but secondary pinnules with a margined petiole and oblong pinnules divided into five to three obtuse points. It is not unlike *S. marginata*, from the Devonian of St. John.

8. *S. Lesquereuxii*, Newberry.

M. C. Sydney, R. Brown.

9. *S. Microloba*, Guttbier.

M. C. Sydney, R. Brown.

10. *S. Obtusioloba*? Brongt.

M. C. Baie de Chaleur, Logan.

PHYLLOPTERIS, Brongt.

Phyllopteris antiqua, s. n.

M. C. Sydney, R. Brown.

Pinnate; petiole thick, woody, pinnules oblong, pointed, attached by middle of base; midrib strong extending to the point, giving off very oblique nerves which have obliquely pinnate nervules not anastomosing. A remarkable frond, which, if not the type of a new genus, must belong to that above named.

ALETHOPTERIS, Sternberg.

1. *Alethopteris lonchitica*, Sternberg.

M. & U. C. Joggins, J. W. D.; M. C., Sydney, R. Brown; Grand L., C. F. Hartt.

Very abundant throughout the Middle and Upper coal formation, and so variable that several species might easily be founded on detached specimens.

2. *A. heterophylla*, L. & H.

L. C. Parrsboro', A. Gesner.

3. *A. grandini*, Brongt.

M. C., Sydney, R. Brown

4. *A. nervosa*, Brongt.

M. C., Sydney, R. Brown; Bay de Chaleur, Logan; U. C., Pictou, J. W. D.

5. *A. muricata*, Brongt.

M. C., Joggins, Bathurst, Lyell; U. C., Pictou, J. W. D.

6. *A. pteroides*, Brongt. (*Brongnartii*, Göeppert.)

L. or M. C., Bathurst, Lyell's list.

7. *A. Serlii*, Brongt.

M. C., Sydney, R. Brown; Bay de Chaleur, Logan.

8. *A. grandis*, s. n.

Bay de Chaleur, Logan.

Bi-pinnate; pinnæ broad, contiguous, united at the base; veins numerous, once forked, not quite at right angles to the midrib. Upper pinnæ having the pinnules confluent so as to give crenate edges. Still higher the apex of the frond shows distant decurrent long pinnules with waved margins. A very large and fine species of the type of *A. Serlii* and *A. Grandini*, but much larger and different in details. Its texture seems to have have been membranaceous, and fragments from that part of the frond where the long simple pinnules are passing into the compound ones might be mistaken for an *Odontopteris*.

PECOPTERIS, Brongt.

1. *Pecopteris arborescens*, Schlot.

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.; Wallace, Dr. Creed.

Seems to have been an herbaceous species with a very strong petiole. It occurs in an erect position in a sandstone on Wallace R.

2. *P. abbreviata*, Brongt.

M. C. Sydney, R. Brown; Salmon R., U. C., Pictou, J. W. D.

Very common both in the Upper and Middle coal formation.

3. *P. rigida*, s. n.

U. C. Pictou, J. W. D.

Similar to *arborescens*, but much smaller and with finer nerves.

4. *P. unita*, Brongt.

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.

Certain pinnules of a frond are sometimes swollen as if covered with fructification below; and in this state they resemble *P. arguta*, Brongt. The sori are seen in other specimens, and are large, round, and covered with an indusium as in *Aspidium*.

5. *P. plumosa*, Brongt.
M. C. Sydney, R. Brown.
6. *P. polymorpha*, Brongt.
M. C. Sydney, R. Brown.
7. *P. acuta*, Brongt.
M. C. Pictou, J. W. D.
8. *P. longifolia*, Brongt.
In Bunbury's list from Sydney.
9. *P. tœniopteroides*, Bunbury.
M. C. Sydney, R. Brown.
10. *P. cyathea*, Brongt.
M. C. Sydney, R. Brown.
11. *P. œqualis*, Brongt.
M. C. Sydney, R. Brown.
12. *P. Sillimani?* Brongt.
In Lyell's list from Sydney.
13. *P. villosa*, Brongt.
M. C. Pictou, Lyell's list.
14. *P. Bucklandii*, Brongt.
M. C. Sydney, Brown's list.
15. *P. oreopteroides*. Brongt.
M. C. Sydney, Brown's list.
16. *P. decurrens*, Lesqx.
M. C. Sydney, R. Brown; has pinnules more crowded, decreasing towards the apex., but may be a variety,
17. *P. Plunckenetii*, Sternb.
M. C. Sydney, R. Brown.

BEINERTIA, Göeppert.

Beinertia Göepperti, s. n.

M. C. Grand L., Hartt; Bay de Chaleur, Logan; U. C. Joggins, J. W. D.

Bi-pinnate, pinnæ broad, contiguous, obtuse, with thick pinnules. Pinnules above rounded, below obovate. Midrib thick, oblique, dividing above into a tuft of irregular hair-like veins.

HYMENOPHYLLITES, Göeppert.

Hymenophyllites pentadactyla, s. n.

M. C. Sydney, R. Brown. In general habit like *Sphenopteris microloba*, Göept, but with pinnules divided into 4 to 7 obtuse cuneate lobes, each with one vein.

PALÆOPTERIS, Geinitz.

1. *Palæopteris Hartii*, s. n.

M. C. Grand L., C. F. Hartt.

Stem or leaf bases transversely wrinkled with delicate lines, scars transversely oval, slightly appendaged below, vascular scars confluent. Breadth, 1.4 in. Length, 0.6 inch.

2. *P. Acadica*, s. n.

U. C. Pictou, J. W. D.

Stem or leaf bases longitudinally striated. Scars transverse, flat above, rounded and bluntly appendaged below; vascular scars in a transverse row; breadth of scars 0.7 inch; length 0.5 inch.

CAULOPTERIS, L. & H.

Several small erect stems at the Joggins seem to be trunks of ferns but are too obscure for description.

PSARONIUS, Cotta.

Trunks of this kind must be rare in the Nova Scotia coal fields. A few obscure stems surrounded by cord-like aerial roots have been found, and probably are remains of plants of this genus.

MEGAPHYTON, Artis.

1. *Megaphyton magnificum*, s. n.

M. C. Joggins, J. W. D.

Stems large, roughly striate longitudinally; scars contiguous, orbicular, deeply sunk, nearly three inches in diameter, and each with a bilobate vascular impression, two inches broad and an inch high.

2. *M. humile*, S. N.

M. C. Sydney, R. Brown.

Stem 2·5 inches in diameter; leaf scars prominent, flattened and broken at the ends, 1 inch wide. Surface of the stem marked with irregular furrows and invested with a carbonaceous coating. An internal axis nearly two inches in diameter, with a coaly coating, sends off obliquely thick branches to the leaf scars. This is a very remarkable specimen, and throws much light on the structure of *Megaphyton*. Unfortunately the minute structures are not preserved.

Genus LEPIDODENDRON, Sternberg.

1. *Lepidodendron corrugatum*, Dawson. Journal Geol. Society, Vol. XV.

L. C. Horton, C. F. Hartt, J. W. D.; Norton Creek, &c., N. Brunswick, G. F. Matthew.

Areoles elongate, ovate, acute at both ends, with a ridge along the middle, terminating in a single elevated vascular scar at the upper end. In certain states the vascular mark appears in the middle of the areole. In young branches the areoles are contiguous and resemble those of *L. elegans.* In old stems they become separated by spaces of longitudinally wrinkled bark; in very old stems these spaces are much wider than the areoles.

Leaves linear, one inch or more in length, usually reflected, one-nerved.

Cones (Lepidostrobi) terminal, short cylindric, with numerous short acute triangular scales.

Structure of stem—a central pith with a slender cylinder of scalariform vessels, exterior to which is a thick cylinder of cellular tissue and bast fibres, and a dense outer bark.

Variety *verticillatum* has the areoles arranged in regular decussate whorls instead of spirally. This difference, which might at first sight seem to warrant even a generic distinction, is proved by specimens in my possession to be merely a variety of phyllotaxis.

This species is eminently characteristic of the Lower carboniferous coal measures; and has not yet been found in the Middle coal formation. Fragments of bark resembling that of this species occur in the coal formation of Bay de Chaleur, along with leafy branches of *Lepidodendron*, which resemble those of this species, though I believe distinct.

2. *L. Pictoense*, s. n.

M. C. Sydney, R. Brown; Pictou, H. Poole and J. W. D.; Grand Lake, C. F. Hartt.

Areoles contiguous, prominent, separated in young stems by a narrow line, long oval, acuminate, breadth to length as 1 to 3 or less, lower half obliquely wrinkled, especially at one side. Middle line indistinct. Leaf scar at upper end of areole, small, triangular, with traces of three vascular points, nearly confluent. Length of areole about 0.5 inch.

Leaves contracted at base, widening slightly and gradually contracting to a point, ribs three, central distinct, lateral obscure, length 1 inch.

Cones borne on sides of smaller branches, small, oval, obscurely scaly.

In habit of growth this species resembles *L. elegans*, for which imperfect specimens might be mistaken. It abounds in the Middle coal measures.

3. *L. rimosum*, Sternberg.

M. C. Sydney, R. Brown; Joggins, J. W. D.

4. *L. dichotomum*, Sternberg, (*L. Sternbergii*, L. & H.)

M. C. Sydney, R. Brown; Joggins, J. W. D.; L. C. Horton, J. W. D.

5. *L. decurtatum*, s. n.

M. C. Pictou, J. W. D.

Areoles approximate or separated by a shallow furrow, rhombic, ovate, obliquely acuminate below, nearly as broad as long, wrinkled transversely, especially on the middle line, which appears tuberculated, vascular scar rhombic, twice as broad as long, with three approximate vascular points. In some flattened specimens the line separating the areoles is indistinct, and the scars appear on a transversely wrinkled surface without distinct areoles.

6. *L. undulatum*, Sternberg.

M. C. Sydney, R. Brown, Joggins and Pictou, J. W. D.; U. C. Joggins, J. W. D.

Possibly several species are included under this name, but they cannot be separated at present.

7. *L. dilatatum*, Lindley and Hutton.

M. C. Joggins, J. W. D.

8. *L.* ——— like *tetragonum*, Göept.

L. C. Horton, J. W. D.

Obscurely marked, but a distinct species, unless an imperfectly preserved variety of *L. tetragonum*. The areoles are square with a rhombic scar at the upper corner of each.

9. *L. binerve*, Bunbury.

M. C. Sydney, R. Brown.

10. *L. tumidum*, Bunbury.

M. C. Sydney, R. Brown.

I think it probable that this species belongs to the genus *Lepidophloios*, but I have not seen a specimen.

11. *L. gracile*, Brongt.

M. C. Sydney, R. Brown.

In Brown's list in Ac. Geology. Probably a variety of the next.

12. *L. elegans*, Brongt.

M. C. Sydney, R. Brown.

In Bunbury's and Brown's Lists.

13. *L. plumarium*, L. and H.

M. C. Sydney. In Brown's List.
14. *L. selaginoides*, Sternb.
M. C. Sydney. In Brown's list.
15. *L. Harcourtii*, (Witham.)
M. C. Sydney. In Brown's list.
16. *L. clypeatum ?* Lesqx.
M. C. Sydney, R. Brown; U. C., Joggins, J. W. D.
17. *L. aculeatum*, Sternberg.
M. C. Sydney, R. Brown.

HALONIA. L. & H.

Halonia ?———

A specimen probably referrible to this genus from Grand Lake, in the collection of C. F. Hartt.

LEPIDOSTROBUS. Brongt.

1. *Lepidostrobus variabilis*, L. & H.
M. C. Sydney, R. Brown; Pictou and Joggins, J. W. D.
The most common species.
2. *L. squamosus*, s. n:
M. C. Grand Lake, C. F. Hartt.
Two to three inches long, 1 inch thick, scales large, broadly trigonal, acute. Allied to No 6, but larger.
3. *L. longifolius*, s. n.
Long-leaved like *Lepidodendron longifolium*, L. and H.
Middle Coal-formation, Joggins, J. W. D.
4, *L.*———
Acute trigonal leaves, small.
Middle Coal-formation, Joggins, J. W. D.
5. *L.*———
Round with obscure scales and remains of long leaves.
Lower Coal Measures, Horton, J. W. D.
6. *L. trigonolepis*, Bunbury.
M. C. Sydney, R. Brown.

LEPIDOPHYLLUM. Brongt.

1. *Lepidophyllum lanceolatum*, L. & H.
M. C. Joggins; U. C. Pictou, J. W. D
2. *L. trinerve ?* L. & H.
U. C. Joggins, J. W. D.
Two-nerved or three-nerved like *L. trinerve*, L. & H. but narrower. Both th above are parts of *Lepidostrobi*.

3. *L. majus?* Brongt.
M. C. Sydney, R. Brown.
4. *L.*———
Broad ovate, short, pointed, one nerved, half an inch long.
Upper coal formation, Pictou.
5. *L. intermedium*, L. & H.
M. C. Sydney, R. Brown's list.

Halonia, Lepidostrobus and Lepidophyllum, including only parts of *Lepidodendron and Lepidophloios*, are to be regarded as merely provisional genera.

LEPIDOPHLOIOS, Sternberg.

Under this genus I include, on the evidence of numerous specimens, those plants known under the names *Ulodendron*, L. & H., *Bothrodendron*, L. & H., and *Lomatofloyos*, Corda, and in part *Halonia, Lepidostrobus* and *Lepidophyllum*. These trees have more or less elevated areoles or leaf-bases, rhombic in outline, and terminated by rhombic scars, bearing long, narrow, one-nerved leaves. The fruit consists of large strobiles borne on the sides of the stem and branches. The internal structure presents a large cellular pith, a slender cylinder of scalariform vessels, a very thick cellular and corky bark, and a dense rind or epidermis. They appear to have branched seldom and dichotomously, and are nearly related to *Lepidodendron*. They are abundant in the Middle coal formation.

1. *Lepidophloios Acadianus*, s. n.

M. C. Joggins, Salmon, R., Pictou, J. W. D.; Sydney, R. Brown.

Leaf-bases broadly rhombic or in old stems regularly rhombic prominent, ascending, terminated by very broad rhombic scars having a central point, and two lateral obscure points. Outer bark laminated or scaly. Surface of inner bark with single points or depressions. Leaves long, linear, with a strong keel on one side five inches or more in length, cone-scars sparsely scattered on thick branches, either in two rows or spirally, both modes being sometimes seen on the same branch. Scalariform axis scarcely an inch in diameter in a stem five inches thick. Fruit, an ovate strobile with numerous acute scales covering small globular spore cases. This species is closely allied to *Ulodendron majus* and *Lepidophloios laricinum*, and presents numerous varieties of marking.

2. *L. prominulus*, s. n.

M. C. Joggins, J. W. D.

Leaf-bases rhombic, pyramidal, somewhat wrinkled at the sides, truncated by regularly rhombic scars, each with three appproximate vascular points.

3. *L. parvus*, s. n.

U. C. Pictou ; M. C. Joggins, J. W. D. ; M. C. Sydney, R. Brown

Leaf-bases rhombic, small, with rhombic scars broader than long, vascular points obscure. Leaves linear, acute, three inches or more in length, with a keel and two faint lateral ribs. Cones large, sessile.

4. *L. platystigma*, s. n.

M. C. Sydney, R. Brown ; Joggins, J. W. D.

Leaf-bases rhombic, broader than long, little prominent. Scars rhombic, oval, acuminate, slightly emarginate above, vascular points two, approximate or confluent.

5. *L. tetragonus*, s. n.

M. C. Joggins, J. W. D.

Leaf-bases square, furrowed on the sides. Leaf scar central with apparently a single central vascular point.

DIPLOTEGIUM, Corda.

Diplotegium retusum, s. n.

M. C. Joggins, J. W. D.

The fragments referrible to plants of this genus are imperfect and obscure. The most distinct show leaf bases ascending obliquely, and terminating by a retuse end with a papilla in the notch. Some less distinct fragments may possibly be imperfectly preserved specimens of *Lepidodendron* or *Lepidophloios*.

KNORRIA.

Nearly all the plants referred to this genus, in the carboniferous rocks are, as Göeppert has shown, imperfectly preserved stems of *Lepidodendron*. In the Lower coal formation many such knorria forms are afforded by *L. corrugatum*.

Knorria Sellonii, Sternberg.

M. C. Sydney, R. Brown.

This appears different from the ordinary *Knorriæ*. Its supposed leaves may be aërial roots. It has a large pith cylinder with very distant tabular floors like Sternbergia.

CORDAITES, Unger, (*Pycnophyllum*, Brongt.)

1. *Cordaites borassifolia*, Corda.

M. C. Pictou, H. Poole ; Grand L., C. F. Hartt, ; Sydney, R.

Browr; Joggins, Onslow, J. W. D.; Bay de Chaleur, Logan. Very abundant in the Middle coal formation.

2. *C. simplex*, s. n.

M. C. Grand R., C. F. Hartt; U. C. Pictou: J. W. D.

Leaves similar to the last in size and form, but with simple equal parallel nerves. It may be a variety; but is characteristic of the Upper coal formation.

CARDIOCARPUM, Brongt.

1. *Cardiocarpum fluitans*, s. n.

M. C. Joggins, J. W. D.

Oval, apex entire or notched. Surface slightly rugose. Nucleus round ovate, acuminate, pitted on the surface, with a raised mesial line.

2. *C. bisectatum*, s. n.

M C. Grand Lake, C. F. Hartt.

Nucleus as in the last species, but striate. Margin widely notched at apex, and more narrowly notched below.

3. *C.* like *marginatum*.

M. C. Joggins, J. W. D.

4. *C.* Allied to *C. latum*, Newberry.

M. C. Pictou, H. Poole.

These Cardiocarpa are excessively abundant in the roofs of some coal seams; and the typical ones must have been samaras or winged nutlets. They must have belonged to phaenogamous plants, and certainly are not the fruits of *Lepidodendron*, though some of the spore-cases of this genus have been described as *Cardiocarpa*. These I propose to place under the provisional genus *Sporangites*.

SPORANGITES, Dawson.

1. *Sporangites papillata*, s. n.

M. C. Joggins, J. W. D.

I propose the provisional generic name of *Sporangites* for spores or spore cases of *Lepidodendron*, *Calamites* and similar plants, not referred to the species to which they belong. The present species is round, about one inch in diameter, and covered with minute raised papillæ or spines. It abounds in the roof of several of the shaly coals in the Joggins section, and especially in one in group XIX of that section.

2. *S. Glabra*, s. n.

About the size of a mustard seed, round and smooth. Exceedingly abundant in the lower carboniferous coal measures of Horton Bluff, with *Lepidodendron corrugatum,* to which it possibly belongs. A similar spore-case, possibly of another species of *Lepidodendron,* occurs rarely in the Middle coal formation at the Joggins.

STERNBERGIA, Artis.

This provisional genus includes the piths of *Dadoxylon, Sigillaria,* and other plants, usually preserved as casts in sandstone, retaining more or less perfectly the transverse partitions into which the pith-cylinders of many coal-formation trees became divided in the process of growth. These fossils are most abundant in the Upper coal formation, but occur also in the Middle coal formation. The following varieties may be distinguished:

(*a*) Var. *approximata,* with fine uniform transverse wrinkles. This is usually invested with a thin coating of structureless coal.

(*b*) Var. *angularis,* with coarser and more angular transverse wrinkles. This is the character of the pith of Dadoxylon.

(*c*) Var. *distans,* usually of small size, and with distant and irregular wrinkles. This is sometimes invested with wood having the structure of *Calamodendron,* and perhaps is not generically distinct from *C. approximatum.*

(*d*) Var. *obscura,* with distinct and distant transverse wrinkles, but not strongly marked on the surface. This is the character of the pith cylinders of *Sigillaria* and *Lepidophloios.*

ENDOGENITES, L. & H.

Many sandstone casts, answering to the character of the plants described under this name by Lindley, occur in the Upper coal formation. They are sometimes three inches in diameter and several feet in length, irregularly striate longitudinally, and invested with coaly matter. Sometimes they show transverse striation in parts of their length. I believe they are casts of pith cylinders of the nature of *Sternbergia,* and probably of sigillaroid trees.

SOLENITES, L. & H.

Plants of this kind are found in the sandstones of the Upper coal formation of the Joggins.

For all the specimens noted in the above list, as collected by Sir W. E. Logan, Richard Brown, Esq., of Sydney, Cape Breton, Henry Poole, Esq., of Glace Bay, C. B., and G. F. and C. B. Matthew and C. F. Hartt, Esqs., St. John, New Brunswick, I am indebted to the kindness of those gentlemen. To Mr. Brown especially I am under great obligations for his liberality in placing at my disposal his large and valuable collection of the plants of the Cape Breton coal field.

The general conclusions deducible from the above catalogue, as well as detailed descriptions of the new species, I hope to give more fully hereafter, when I shall have completed my examination of the microscopic structure of the several coal seams. In the mean time the following summary may be useful:

1. Of 192 nominal species in the list, probably 44 may be rejected as founded merely on parts of plants, leaving about 148 true species.

2 Of these, on comparison with the lists of Unger, Morris, and Lesquereux, 92 seem to be common to Nova Scotia and to Europe, and 59 to Nova Scotia and the United States. Most of these last are common to Europe and the United States. There are 50 species peculiar, in so far as known, to Nova Scotia, though there can be little doubt that several of these will be found elsewhere. It would thus appear that the coal flora of Nova Scotia is more closely related to that of Europe than to that of the United States, a curious circumstance in connection with the similar relationship of the marine fauna of the period; but additional information may modify this view.

2. The greater part of the species have their head-quarters in the Middle coal formation, and scarcely any species appear in the Upper coal formation that are not also found in the former. The Lower coal formation on the other hand seems to have a few peculiar species not found at higher levels.

3. The characteristic species of the Lower coal formation are *Lepidodendron corrugatum* and *Cyclopteris Acadica*, both of which seem to be widely distributed at or near this horizon in Eastern America, while neither has yet been recognized in the true or Middle coal measures. In the Upper coal formation *Calamites Sucksowii, Annularia galioides, Sphenophyllum emarginatum, Cordaite simplex, Alethopteris nervosa, muricata etc., Pecopteris arborescens, P. abbreviata, P. rigida, Neuropteris cordata, Dadoxylon materiarum, Lepidophloios parvus, Sigillaria scutellata*, are characteristic plants, though not confined to this group.

4. In the Middle coal formation and in the central part of it, near the greater coal seams, occur the large majority of the species

of *Sigillaria*, *Calamites*, *Lepidodendron* and *Ferns*; some of the species ranging from the Millstone grit into the Upper coal formation, while others seem to be more narrowly limited. It is to be observed, however, that as we leave the central part of the system, the total number of species diminishes both above and below, and that it is only in those beds which hold large numbers of plants *in situ* or nearly so, that we can expect to find a great variety of species, and especially the more delicate and perishable organisms.

It is also quite observable in the Joggins section that while some beds, in the same part of the system, supported *Sigillariæ*, others carried *Calamites*, others mixtures of these with other plants; so that differences of soil, moisture, etc., frequently cause neighbouring beds to be more dissimilar in their fossil contents than others much more widely separated. These local and temporary differences must always have occurred in the deposition of the coal measures, and should not be confounded with those general changes which are connected with lapse of time.

ART. XXXI—*On the Origin of Eruptive and Primary Rocks*; by THOMAS MACFARLANE. *Part III.*

III. THE PRIMARY FORMATION.

Following out the plan indicated in the first part of this paper, we proceed to the consideration of the primary rocks, with the view of ascertaining whether they, in part at least, may reasonably be regarded as constituting the first solidified crust of the earth. The igneous condition of the original globe has already been adverted to, and it would seem unnecessary here to refer at length to what may be called the keystone of this theory, viz. the flattening of the earth at the poles. It is sufficient to remark on this point, that Newton and Huygens first maintained and proved this to be the case, from mathematical grounds alone. Subsequently numerous measurements of the length of a degree in various lands, but especially in those near the equator and under the polar circle, have thoroughly established the truth of Newton's theory. They have proved that the length of a degree of latitude increases with the distance from the equator. The following are some of the results obtained:

	Latitude.	Length of degree of Latitude.
Peru	1°31	56736.8 toises.
India	12°32	56762.3 "
France	46°8	57024.6 "
England	52°2	57066.1 "
Lapland	62°20	57196.2 " *

* Muller's Kosmische Physik, p. 51.

The meridian lines are therefore more considerably curved in the neighbourhood of the equator than at the poles, and the equatorial diameter of the earth is consequently greater by about 24 geographical miles than the polar diameter. This is of course, a consequence of the revolution of the earth on its axis, and of the influence of centrifugal force. This influence could not, however, have made itself felt, had not the earth been originally in a fluid, or at least plastic condition, so that the depression at the poles constitutes one of the most unequivocal proofs of the original fluid condition of the globe.

Assuming this fluid condition to have been owing to the prevalence of an extremely high temperature, we are necessitated to suppose that the atmosphere was then very differently constituted than it is at present. This has been remarked by many previous writers. Dr. Hunt describes it as 'an atmosphere holding in the state of acid gases all the carbon, the sulphur and the chlorine, besides the elements of air and water."* Quensted remarks: "According to the igneous theory the whole of the siliceous rocks were originally in lava-like fusion. It follows of course that not only the whole of the sea must have existed in the atmosphere. but also a multitude of substances, which could not exist otherwise than in the gaseous state, such as carbonic acid, chlorine, sulphur, etc."† These inferences are legitimately drawn. The sandstones, shales, and the fixed parts of the limestones of sedi mentary formations then existed in the fused matter, along with the materials of the igneous and primary rocks, the soda of sea-salt and the inorganic constituents of plants and animals. On the other hand, the carbonic acid of the limestones must have existed in the atmosphere. The chlorine of the sea salt also could scarcely have existed anywhere else than in the atmosphere in combination with hydrogen, or with those metals which form with it volatile chlorides, such as lead, zinc, copper, iron, cobalt, nickel, etc. Those volatile chlorides, which are decomposable while in the gaseous state by oxygen, (such as those of the three metals last named) could not however have existed in an atmosphere containing free oxygen, but it would seem, that the primitive atmosphere did not contain any such free oxygen. Bischof first adopted this view. He maintains that the carbon disseminated through the dark clay slates of the pre-carboniferous

* Canadian Naturalist, p. 202.

† Epochen der Natur. p. 20.

periods, is in itself more than sufficient to take up all the oxygen which the atmosphere of the present day contains.* He calculates also that a stratum of carbon, spread over the whole surface of the globe, 2.6 feet thick, would be sufficient to convert all the oxygen of the atmosphere into carbonic acid; and after considering how richly furnished the sea is with animal and vegetable life, how rich its sedimentary deposits must be in organic substances; that the earlier sedimentary rocks are highly changed with carbonaceous and bituminous substances, that beds of coal and lignite are spread over an area of many hundreds of square miles with a very considerable average thickness, he comes to the conclusion, that a layer 2.6 feet thick is far from being an equivalent to all the carbon existing in the earth, leaving altogether out of the question the carbon of the organic world on its surface. This opinion certainly seems to be well grounded, and there would appear to be just reason for supposing that the oxygen of the atmosphere existed originally in the state of carbonic acid, and that a considerable quantity of carbon, besides that which was in combination with the oxygen, must have existed in the original atmosphere, either free, or in combination with other elements, and probably especially with hydrogen. Thus the gaseous envelope of the original globe must have been an enormous atmosphere of water, carbonic acid, carburetted hydrogen, and nitrogen, together with comparatively small quantities of sulphurous acid, and sulphuretted hydrogen, hydrochloric acid and metallic chlorides. The pressure of such an atmosphere must have been prodigious, at least 100 times greater than that of the present time; and in conjunction with its composition sufficient to produce effects totally different from those caused by atmospheric influences at the present day. Among its most remarkable properties must have been its power of absorbing heat. Dr. Hunt has shown that the atmosphere of paleozoic times must, from the amount of carbonic acid in it, have greatly aided to produce the elevated temperature then existing.† How much more must this have been the case when the atmosphere contained such hydro carbons as marsh and olefiant gases, whose power of absorbing radiant heat greatly exceeds that of carbonic acid.‡ Dr. Hunt has indeed indicated the part which such hydrocarbons may thus have played. After the fluid globe had suffi-

* Chem. and Phys. Geologie, ii. p. 35.

† Canadian Naturalist, vol. viii. p. 324.

‡ Tyndal: Heat considered as a mode of motion, p. 362.

ciently cooled, to allow the condensation of some of the constituents of this primitive atmosphere, the action of these on the earth's crust must have been very energetic, and must have caused the formation of products differing considerably from the sedimentary deposits of later periods. We shall return to this subject, when adverting to the rocks of the so-called Primitive Slate formation.

With regard to the fluid part of the original globe, we have seen that it must have been made up, with but little exception, of the inorganic constituents of the earth's crust. It is evident, that in this fluid globe the heavier particles must have found their way to the centre, and that then, as now, the interior of the globe must have had a greater density than its surface. Indeed, the fact that this is the case at the present day is another proof that the globe must have been originally in a state of igneous fluidity, otherwise we could not account for the accumulation of the denser particles at the centre. In the same way as the densest particles were influenced by gravitation, so must also the fused silicates of different densities, and the metallic sulphurets and arseniurets have found their places in successive concentric zones, one beneath the other, according to their increasing specific gravities. Thus the theory of Sartorius von Waltershausen would appear to be as fully applicable when the earth was in a fluid state, as at the present time.

There is nothing unreasonable or inconsistent with the observations which we are able to make at the present day, in supposing the inorganic constituents of the earth to have once been in a state of igneous fusion. The various layers of fused material, to judge from the rocks resulting from their solidification, must have closeresembled in chemical composition the scoriæ produced in different blast-furnaces. If we suppose the uppermost highly silicified and consequently most difficultly fusible layer to be represented by granite, we find many instances of slags from iron-furnaces having almost as acid a composition. Many granites contain only 63 per cent. of silica, but those of the Hartz as high as 73.* On the other hand there are instances of iron-slags containing 70 and 71 per cent.† silica. So far as the other more basic layers and the rocks resulting from them are concerned, we can find their equivalents among the slags of iron, copper, and lead furnaces, since the silica contents of the latter range from 70 through every per-

* Bischof: Chemical and Physical Geology, III. p. 414.
† Kerl: Handbuch der Hüttenkunde, I. p. 323.

centage down to 8 p.c. If we continue the analogy, and suppose the properties of these slags, to correspond somewhat to those of the eruptive rocks having a similar chemical composition, we may find a clue to the explanation of the various forms of deposition, and other characteristics of the latter. Thus it is well known that the slags in which silica preponderates flow sluggishly and solidify slowly, while basic slags flow quick and hot and harden suddenly. It may reasonably be concluded, that the rocks of igneous origin would act similarly, and that consequently granites, porphyries and trachytes would be more viscid, and have better time for cooling and crystallizing, than the more basic greenstones, melaphyres and basalts. The greater frequency of impalpable and finely granular varieties among the latter rocks would be in this way accounted for.

We now proceed to consider what must have been the consequence of the gradual radiation of heat from the igneous globe. "I know of no mode," says McCulloch,* "in which the surface of a fluid globe could be consolidated but by radiation, while of the necessity of such a process I need not again speak. The immediate result of this must have been the formation of rocks on that surface; and if the interior fluid does now produce the several unstratified rocks, the first that were formed must have resembled some of these, if not all. We may not unsafely infer that they were granitic, perceiving that substances of this character have been produced wherever the cooling appears to have been most gradual. The first apparently solid globe was therefore a globe of granite, or of those rocks which bear the nearest crystalline analogies to it." To these utterances we must in the main assent, inquiring however whether the relations existing at the time of this first solidification might not have given rise to the formation of schistose granite or gneiss. Nothing is more conclusively established, than that there exists, at the present day, in the atmosphere and ocean, a series of currents, caused by or attributable to the diurnal motion of the earth. May not similar currents have been in operation in the fluid igneous material, during the first solidification of the earth's crust? Is it not possible that after this solidification had commenced, the outer shell may have moved quicker than the fluid interior, from east to west, and that the gradual accumulation of crystallized rock on the interior of the crust may have taken place under circumstances

* System of Geology, vol. ii. p. 417.

similar to those so well described by Naumann in referring to the parallel structure of certain igneous rocks? * There are not wanting instances of the formation of a slaty structure in artificially formed slags, from a similar cause. Nothing is more common than to observe in slags from iron-furnaces a distinct streaked or banded appearance, evidently caused by the different rate of motion in the interior and outside parts of the flowing stream of slag. This phenomenon I have often observed at the Eglinton iron-works, Scotland, and more recently at Bethlehem, Pennsylvania. It is simply another instance of the production of a stratified appearance, similar to those described by Tyndall in his work "On the Glaciers of the Alps." In this work he shows that the banded appearance of glacier-ice, the lamination of wax subjected to pressure, and the fibrous texture of rolled iron, are caused by the motion under pressure of the atoms constituting those substances. Not only has a banded structure been observed among certain furnace scoriæ, but the latter have even been observed to possess sometimes both fibrous and foliated structures. The raw slag from the "Frischfeuer" at Bieber in Hessia, possesses a marked fibrous texture, and slag with a distinct slaty texture is produced at the blast-furnace in Mägdesprung. The latter is formed swimming on melted iron, while its surface comes in contact with the cold air. Small pieces of this slag resemble the refuse of roofing slate, not only in their appearance, but also in their cleavage. In larger pieces perfectly vitreous layers are combined with the slaty ones, both graduating into each other.† From these instances, and considering that the existence of internal currents at that period is highly probable, it would appear not unreasonable to expect that some of the rocks solidified on the surface of the fluid globe, would have a schistose structure. It is impossible to suppose that the particles of the fluid material beneath the solidifying crust, would always preserve the same relative position to the latter, in spite of the daily revolution of the globe. The liquid rock beneath the crust must have moved in one direction or other almost as freely as the water of a frozen river under the ice which covers it. The schistose structure resulting from this solidification under motion must however have resembled more the foliation of certain igneous rocks than the

* Canadian Naturalist, vol. viii. p. 375.

† Von Leonhard, Hüttenerzeugnisse und andere auf künstlichem Wege gebildete Mineralien als Stützpunkte geologischer Hypothesen, p. 156.

stratification of sedimentary strata. The stratification of gneiss and gneissoid rocks has not unfrequently been denied. Thus Featherstonhaugh declared, that "what has been called the stratification of these igneous rocks, may be owing to the principle which occasions their fissility." Coquand regards gneiss as a "granite stratoïde, mais non stratifié."* Rivière opines also that gneiss does not form true layers, but is only a fissile or pseudo-stratified rock.† Even McCulloch makes the following admission: "Gneiss has not yet indeed presented any decided marks of that mechanical arrangement which so often occurs in the other stratified rocks; since I must explain the parallelism of the mica, which has been supposed a proof of such arrangements, in a very different way. In hypersthene rock, an unstratified member of the trap family, the crystals of that mineral often occur in a similar laminar manner, so as to communicate a fissile tendency to it; and in Kerrara mica itself is thus found not only in a mass of trap, but in a vein of the same substance, with the same parallelism to the sides of the vein as it has to the plane of the stratum in micaceous schist."‡ The idea that gneiss may have been formed in the manner above indicated is not entirely new. In 1845 it was stated that the gneiss of the Saxon Erzgebirge "perhaps differs only from granite because it solidified under the influence of certain pressures or tensions.||

Whether the explanation here attempted of the parallel structure of gneiss may be regarded as adequate or not, it does not at any rate seem to be any more far-fetched than the theory which attributes this phenomenon to the influence of electrio magnetic currents (Scheerer's theory) or even than that which regards gneiss as a sedimentary rock, altered in some obscure manner by heat or other agencies. Besides the arguments given above in support of the first mentioned view, there are also some general considerations in favor of the existence of a primitive formation, which are stated as follows by Naumann.§ "The oldest sedimentary formations must have had some material from which they could be formed, and a foundation on which to be deposited. The whole series of sedimentary formations must have been borne by something, and the material of at least the first member of this series

* Bull. de la Soc. Geol. tome ix. 1838, p. 222.

† Compte rendus, tome xxv. 1847, p. 898.

‡ System of Geology, Vol. II. p. 152.

|| Geognostische Beschreibung des Königreiches Sachsen, 2tes Heft, p. 122.

§ Lehrbuch der Geognosie, ii., p. 8.

must have been derived from something, which something cannot be assumed to be the result of a sedimentary operation."

"In the same way there must have existed a covering through which the oldest eruptive formations were protruded, and a foundation upon which they could spread themselves out; and the whole series of eruptive rocks must, like those of sedimentary origin, have at the commencement been borne by something which cannot be regarded as the result of an eruptive operation."

"We find ourselves thus obliged, from two sides, to assume the existence of an originally existing solid crust of the planet, which formed the theatre and the foundation for all the later formations, above and beneath which those two energies in nature could develop themselves; through which on the one side the sedimentary, and on the other side the eruptive formations were brought into existence; and that formation of which this original foundation consisted it is consequently proper to entitle the primitive or themelian, the original or fundamental formation."

"To this formation those enigmatical, deepest-lying rocks belong which resemble sedimentary strata, in possessing more or less perfect stratification, and which resemble eruptive rocks, when their mineral composition and their crystalline structure are taken into consideration; but they are devoid of the fragmentary rocks and the organic remains by which the sedimentary formations are characterized, and on the other hand do not possess the veins, masses and streams common to eruptive rocks, nor the abnormal relations of these at their junction with other rocks. In a word, we meet in the primitive formation many of those rocks which we have above designated cryptogenous, such as gneiss, mica schist, hornblende-schist, etc.; rocks whose unaltered character we are not justified in denying in every case, merely because in some cases similar rocks have been formed by the metamorphosis of sedimentary strata, or in an eruptive manner. Those who, because a few beds of mica-schist or gneiss have been admitted to be metamorphosed clay-slate or greywacke slate, declare that all mica-schists and gneiss are only altered sedimentary rocks, only meta-metamorphosed beds of mud, virtually remove the ground from beneath our feet, and limit us to a transcendental succession of sedimentary deposits, which, downward, has no end, or rather no demonstrable commencement; because finally the actual sedimentary origin can neither be recognized nor proved, but can only be maintained as a hypothetical assumption."

"The primitive formation appears to possess quite an extraordinary thickness; and to reach very far down into the depths of the earth. At the same time it shows in a remarkable manner, in those different regions where it comes to the surface, such a general resemblance as regards its rocks, their structure and form of stratification, that one is led from this alone to think that some stupendous process must have taken place over the whole surface of the earth at the same time and in the same manner, and that it is to this process that the primitive formation owes its existence; and even, although it may be so completely covered over in regions of immeasurable extent that in these it is not observed to come to the surface, still we are entitled with complete justice to suppose the existence of an uninterrupted extension of the same, under all the sedimentary and eruptive formations with which we are acquainted.

"The necessity of a primitive formation is besides so apparent that one can scarcely comprehend how its existence could ever be doubted. It appears, in fact, to be a first and indispensable condition, without which the possibility of sedimentary, as well as of eruptive formations cannot be comprehended. The primitive formation has also been, by different authors, entitled the prozoic, azoic or hypozoic formation, because it existed long before the commencement of the first races of animals or plants, and therefore contains not a trace of organic remains, and lies beneath all fossiliferous formations. But all eruptive formations are likewise azoic; the oldest sedimentary formation is likewise prozoic, and the term hypozoic is perhaps a word which does not correspond sufficiently well with the idea intended to be expressed by it."

"It is possible for us to regard the primitive formation perhaps, as the uppermost part of the original solidified crust of our planet; and this supposition has here and there been adopted. We leave, however, the process of their formation undecided, and rest satisfied, in the meantime, with the negative result, that according to the present condition of our knowledge, the primitive formation can neither be a sedimentary formation, in the usual signification of the term, nor yet an eruptive formation, properly speaking. It is however a most remarkable fact, that a few comparatively far younger formations show a surprising similarity to the primitive formation in the structure and architecture of their rocks, (viz., the Münchberg gneiss-formation in Oberfranken, and the protogine formation of the Alps). This fact, as well as the circumstance, that they are almost all cryptogenous or stratified crystalline rocks, which occur, on the one hand, as undoubted primitive, and on the other as newer products, make it advisable to class both together under the common name of the cryptogenous formations, or also of the stratified silicate formations."

"Many, perhaps even the most of the geologists of the present day, are of the opinion that the strata of the primitive formation are very ancient metamorphic sedimentary strata. Until convincing proofs are adduced in support of this view, it may however, only be excused as an attempt to bring incomprehensible phenomena into unison, at least hypothetically, with comprehensible appearances. 'Whereupon,' asks Humboldt, 'do the oldest sedimentary rocks rest, if gneiss and mica-schist are only to be regarded as altered sedimentaay strata?' Cosmos, i., p. 299."

It is very evident from the foregoing, that Naumann leans to the opinion that the primitive formation is the result of the first process of solidification which the fluid globe underwent. He refrains from declaring himself in favor of this idea, principally on the grounds mentioned in another chapter of his "Lehrbuch," a translation of which has already been given in this Journal.* These grounds are the foliated texture of gneiss and its associated rocks, and the highly inclined position of their strata. The first of these phenomena I have already attempted to account for. We shall, in the course of the following remarks, endeavour to ascertain whether the almost vertical position of the primitive strata is also capable of being explained.

In regarding gneiss as an igneous rock, there are, of course, the same difficulties arising from its mineralogical composition, to be explained away, as in the case of granite, but these we intend to postpone considering, until we come to speak of the protrusion of the latter rock. The same mode of explanation adopted in the case of gneiss, would of course require to be resorted to in the case of the schistose rocks associated with it, especially such as mica-schist and hornblende slate. We must not suppose that the latter rock was formed from the same zone of igneous material as the gneiss, but on the contrary, that it is the product of some of the lower zones, brought up to the newly formed crust by cosmical influences, and consolidated on the inner part of the same, subject, of course, to the same influences during its solidification as we have supposed in the case of gneiss, We thus suppose that the first stage of the consolidation of the globe consisted in the

* Vol. vi., p. 254.

formation of a thin crust of stratified rocks; those rocks being now to be found constituting the so-called primitive gneiss formation.

In accordance with the views given in the second part of this paper, of the nature of the process of solidification at present progressing beneath the earth's crust, we must suppose that during the solidification of the first crust, a contraction of the volume of the originally fluid material took place. This view must be adopted on experimental grounds also. Bischof found, in casting a globe of basalt, twenty-seven inches in diameter, that in the centre of the mass, on cooling, a cavity had formed capable of containing half a pint of water. Further, at the Muldner smelting works, near Freiberg, stones are cast of the slag run out of the reverberatory furnaces. They are two feet long, one foot deep and one broad, and when broken after cooling, they are found to contain in the middle irregularly shaped cavities from three to five inches wide, the sides of which are covered with brilliant microscopic crystals.* From these instances it might be expected, that during the first solidification, a vacuum might, to some extent, have been formed beneath the crust of the earth. With the progress of the consolidation the dimensions of the vacuum must have increased, and the power of the crust to support the enormous pressure of the then existing atmosphere must have decreased. We may suppose that ultimately a point was reached, when the crust was unable longer to support the enormous load, and that it then gave way in various places, its fragments sinking down to the fluid interior and floating upon its surface. In this way the first great subsidence of the earth's crust may be reasonably supposed to have taken place. The area of the original globe having however decreased during the solidification, it would be impossible for the fragments of the crust to maintain their original horizontal position. Very likely also the still fluid material beneath the crust would protrude itself through between the fragments, thrusting them aside, and limiting still further the space occupied by the latter. The consequence of this would be, that the fragments would arrange themselves in positions more or less vertical, and, although some of them might still remain horizontal, still highly inclined positions would be the rule. We can even imagine how corrugations of the strata, such as described by Sir William Logan in Canada, and by McCulloch in

* Leonhard, Hüttenerzeugnisse, p, 186.

Scotland, could be formed under the influence of the various forces here at work. While great areas of the earth's crust must have been dislocated in this manner, it is quite possible that other great areas may have been able to preserve, throughout these convulsions, their originally horizontal position. That part of the fluid material which may have protruded itself through the fractured crust, we may reasonably imagine to have solidified somewhat out of the range of the internal currents, and to have produced the first erupted granites. We may further reasonably suppose that the same fluid material must have penetrated into the interstices between the various fragments of the original crust, and have solidified there. This fractured and re-consolidated part of the crust would then present exactly the same appearance, so far as the relations of the various rocks are concerned, as the primitive strata of Canada, Scandinavia, and the north of Scotland do at the present day. That is to say the strata of gneiss, granite, mica and hornblende schist would be arranged in highly inclined positions, and if in contact with rocks of later periods, the latter would overlie the primitive strata unconformably. This peculiar build of the primitive rocks is characteristic of those districts where they have been admitted to be the oldest rocks on the earth's surface. Thus, in some of the Western Islands of Scotland, the primitive strata are not overlaid by any newer rock; and in Canada the vertical strata of the Laurentian series are in many places covered by the horizontal beds of the Potsdam sandstone. In Norway the outcrops of the highly inclined primary strata frequently occupy areas of several hundred square miles, and, at the outskirts of these areas they are overlaid by fossiliferous strata of the Silurian system. The primitive rocks of Brazil, consisting of gneiss, gneiss-granites, granite, syenite, mica-schist, and hornblende rocks, extend north and south through fourteen degrees of latitude, and have a breadth of 250 geographical miles, in which enormous area, strata inclined from 45 to 70 degrees are alone observable. We cannot suppose that these rocks were originally formed in this position; nor can we reasonably regard them as a system of strata, having, in their original horizontal position, a thickness of upwards of 100 geographical miles. There remains only the explanation given above, that the originally not very thick strata assumed their highly inclined position owing to the lateral pressure to which they were exposed; the latter having been caused partly by the contraction experienced by the globe in cooling, and partly by the protrusion of igneous matter from beneath the broken crust. An analogous phenomenon may every winter be observed on the St. Lawrence. When the ice shoves, pressure being exerted upon it from higher up the stream, the floes of ice are raised upon their ends, and a confused aggregate of inclined beds is the result; and it is worthy of remark that each of these beds is in itself distinctly stratified, just as are the individual layers of the primary rocks, the cause of this stratification being in each case not entirely dissimilar.

We have thus endeavoured to remove Naumann's principal objections to the igneous origin of the primary stratified rocks. We have next to refer to the objection founded on the mineralogical composition of gneiss, which is the same as in the case of granite. This objection is the presence in it of quartz, which occurs in such a manner, as to indicate that it must have been the mineral which solidified last of all, although it is the most infusible of the constituents of granite. Perfectly well formed crystals of it often, it is alleged, leave their impression on the adjoining feldspar and mica. We have already seen that this is denied by Sartorius von Waltershausen, who also insists that the quartz formed subsequently to the consolidation of the granite, by the action of water, must not be confounded with the original granular quartz, which is never or seldom found crystallized. In spite, however, of this denial, many supporters of the igneous origin of granite consider it necessary to attempt to account for the occurrence of quartz in the manner above stated. The following are the remarks of Naumann on the subject: "Gaudin's experiments have shown that melted silica becomes viscid before it solidifies, and while in this state it may be drawn out into threads like sealing wax. This proves that the temperature, at which it solidifies, lies very far below the temperature, at which it fuses, wherefore this phenomenon has been used by Fournet in support of his theory of the surfusion of silica, the fundamental idea of which theory has also been strongly supported by Petzholdt (Fournet, Compte Rendu, tome xviii. 1844., p. 1050; and Petzholdt, Geologie, p. 313). Moreover Durocher has pointed out that the fusing temperature of silica (perhaps amounting to 2800 degrees C.) is not necessary in order to explain the crystallization of granite, because the silica of the quartz formed, combined with the elements of the feldspar and the mica, a completely homogenous, igneous magma, in order to the fusion of which a temperature approaching the fusing point of orthoclase may have been sufficient. While the feldspar and mica crystallized from this magma, the excess of silica was merely *separated* as quartz.* These two explanations must not be confounded with each other. The surfusion of Fournet differs essentially from the viscosity of Durocher. "En vertu du premier," says the latter philosopher, "une substance peut conserver sa parfaite liquidité, à une température inférieure à son point de fusion. En vertu du second, des substances diverses, chauffées jusqu'à liquéfaction, puis abannonnées au refroidissement spontanné, dans les mêmes circonstances, mettent des temps fort inégaux à se solidifier, celles qui tendent à crystalliser, deviennent solides les premières; celles qui constituent des masses amorphes restent longtemps dans un état plastique analogue à celui de la poix et intermédiaire entre l'état liquide et l'état solide."† When we take into consideration the common blowpipe reaction, in which silica is often separated from a fused bead as a gelatinous skeleton, it would appear to lend considerable support to Durocher's theory.

I here conclude the explanation which I have attempted of the origin of the Primitive formation. I conceive that only one series of rocks is entitled to this appellation. The term primary has often been applied to quartzites and slates of later age; which rocks have been classified by German geologists under the name of the Primitive Slate formation. It is very evident, however, that there can have been but one primitive formation, and since the slates and quartzites above referred to bear evidence of their having been derived from pre-existing rocks, it would appear incorrect to entitle them primary or primitive. Were it not that geological nomenclature is already sufficiently confused, it would appear much more reasonable to apply the old term of Transition Formation to these rocks; since it is highly probable that during the period in which they were formed, the temperature of the first crust gradually decreased to a temperature at which it was possible for water to exist in large quantity on the earth's surface. We have seen that during the first granitic eruptions, water did not exist on the surface, otherwise rocks of a more or less tufaceous character would have been produced. This conclusion would also seem to be corroborated by the ideas which we must entertain of the high temperature of the newly solidified crust. When the temperature of the latter so far decreased as to admit of the condensation of the water existing in the atmosphere, the rain, which fell upon it, must

* Naumann, Lehrbuch, i., p. 740.

† Bul. de la Soc. Geol. 1849-50, p. 276.

have been instantaneously evaporated. This rapid condensation and evaporation must have continued through long ages before any considerable accumulation of water could have taken place. Even then such accumulations must have possessed for a long time a boiling temperature, and long ages must again have been necessary before it cooled down to such an extent as to enable animated creatures to exist within it. If to these considerations we add the following, namely that the water condensing upon the heated rocks must have been charged with muriatic and carbonic acids, (the latter at a later stage than the former), it is very plain that the products of the action of the atmospheric influences then, must have been of a character widely different from those produced by the same agencies at the present day. The action of such acidulated water aided by heat must have been much more energetic then than now. This has been already fully recognized by Dr. Hunt. "The solid crust," he remarks, "would afterwards be attacked by the acids, precipitated, with water, under the pressure of a high atmospheric column, and at an elevated temperature; from which would result the separation of a great amount of silica, and the formation of an ocean, whose waters would contain in the state of chlorides and sulphates not only alkalies, but also large portions of lime and magnesia. At a later period, the decomposition of exposed portions under the influence of water and carbonic acid would give rise, on the one hand to clays, and on the other to carbonate of soda. This latter reaction upon the calcareous salts of the seawater must produce chloride of sodium and carbonate of lime. We have here a theory of the source of the quartz, the carbonate of lime and the argillaceous matters of the earth's crust explaining at the same time, the origin of the chloride of sodium of the sea, and the fixation of the carbonic acid of the atmosphere in the form of carbonate of lime."* I may be permitted to remark, that no theory accounts more completely and satisfactorily for the origin of the so-called Primitive Slate formation, than does this. It is surely not too much to assume, that the crystalline character of its rocks has been caused by the nature of the agents then at work, and the influence of the higher temperature and greater atmospheric pressure then prevailing. It is evident that the action of the muriatic acid of the atmosphere *must* have long preceded the action of carbonic acid, since we are almost unable to conceive that the latter gas could exist in

*Canadian Naturalist, vol. vii., p. 202.

water of higher than ordinary temperature. The quartz, the carbonate of lime, and the argillaceous matter above mentioned are peculiarly at home in the Primitive Slate formation, and are comparatively rare in the fundamental gneiss or primitive formation proper. We have only to refer to the highly quartzose rocks of the Huronian formation, of the Thelemarken quartz formation, and of the so-called primary sandstones of the western islands of Scotland, to show that the separation of quartz on an extraordinary scale must have been one of the first products of the condensation of aqueous vapour on the earth's surface. Moreover, although primary limestones are not of unfrequent occurrence in gneiss, they are of trifling extent compared with the limestones of the so called Primitive Slates. At first of less frequent occurrence, of light grey colour, and crystalline character, and evidently more the result of a chemical precipitation than made up of animal organisms, they pass through various gradations of color, becoming more frequent and of darker color (more charged with carbon) as they grow younger. In the micaceous and the clay slates, which exceed in extent of developement both quartzites and limestones, we find a similar gradual change in their colours and lithological characters; the younger they become the more they are charged with carbon, and the more they resemble slates of more modern formations. The source of this carbon was undoubtedly the atmosphere, where it probably existed free, or was derived from the decomposition of its compounds with other elements. During the period, when the primitive slate rocks were formed, the metallic chlorides were also most probably removed from the atmosphere. This may have given rise to the extensive metallic deposits existing among these crystalline slates.

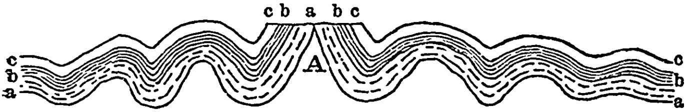
After the abrasion of the material from which the quartzose, micaceous and argillaceous slates resulted, we must suppose that it became deposited in the hollows of the then existing crust, which hollows were most probably occupied by primitive strata lying horizontal or nearly so. Those parts of the first crust, which rose above this primitive ocean, are most likely to have been the highly inclined primitive strata or eruptive masses of granite. If this view be correct then the rocks of our Transition formation must generally have been deposited conformably upon horizontal gneiss, or rocks allied to it.

While the atmospheric agencies, and more especially water, were thus at work upon the surface of the original crust of the earth, the same process of solidification which we formerly referred to, must have been progressing beneath it. The interior of the globe must have experienced a further contraction; and after having resisted for some time, the earth's crust must have subsided, and become fractured and folded in the same manner as the primitive gneiss, though perhaps to a less violent degree. This idea of a gradual contraction of the globe, and the consequent folding of the strata composing the crust, has especially been advocated by French geologists such as Rivière and Constant-Prévost. The latter geologist has the following remarks upon it: "Après des dissidences plus apparentes que réelles, presque tous les géologues tendent à admettre aujourd'hui, que l'enveloppe consolidée de la terre a éprouvé, et éprouve encore, un mouvement centripète contenu, dû à la diminution de chaleur et de volume de la masse intérieure du globe. De ce mouvement il résulte nécessairement, dans l'enveloppe solide, et après une résistence plns ou moins longue, des ondulations, des plissements, des redressements et des ruptures, dont les unes sont produites dans les parties enfoncées, et les autres dans les parties relevées des plis. C'est par ces pentes que sont sorties les matières encore molles sous-jacentes; elles ont traversé les issues qui leur étaient offertes, mais elles n'ont pas brisé les barrières qui les retenaient. Sans doute qu'avec ces mouvements généraux des approchements du sol vers le centre de la planète, le refroidissement a produit des retraits locaux particls dans les matières refroidies; que la diminution inégale des matières de nature diverse a également donné lieu à des changements relatifs de niveau et à des ruptures quelquefois très-importantes; que souvent aussi le plissement de tables horizontales a pu occasionner des pressions latérales qui ont poussé, de dedans ou en dehors, des matières malléables en sens inverse de celui déterminé par la grande cause première du mouvement, lesquelles matières ont pu redresser, renverser, soulever les lambeaux des strates brisées. Mais ce sont là des faits de détail, des exceptions qui, loin d'infirmer la loi générale, viennent la confirmer, lorsqu'ils sont analysés avec attention et réduits à leur juste valeur."* In describing and accounting for the architecture of the "Terrain gnéissique de la Vendée" Rivière adopts the same theory.†

* "Constant-Prévost, sur le mode de formation des chaînes de montagnes." Bul. de la Soc. Géol. de France, 1849-50, tome vii, p. 53.

† Bul. de la Soc. Geol., 2 series, tome vii., p. 327.

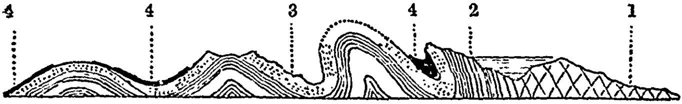
We may now proceed to consider what effects, according to this theory, would be produced on the earth's crust as the same was constituted after the slate rocks above mentioned, and even the so-called greywacke series had been deposited. The slates and sandstones of the latter formation are the oldest rocks which thoroughly resemble, in their lithological characters, the sedimentary deposits of later periods; wherefore we may suppose that at the same time they were formed, the temperature of the earth's surface and the agencies at work upon it somewhat approximated to those of the present day. The portion of the earth's crust least likely to be affected by the subsidences consequent upon the contraction of the globe, may reasonably be supposed to have been the thickest part, that part where vertical strata of gneiss and rocks allied to it, extended deep down into the earth's crust. The part most liable to be fractured and raised into folds, would most probably be the thinnest, or that part where horizontal or but slightly inclined gneiss strata, had been conformably overlaid by micaceous, argillaceous, chloritic and quartzose slates. If we attempt to speculate as to what might be the first consequences of the contraction upon these latter rocks, we would naturally suppose that after a fissure had once been formed, the strata bordering on it would rise in a manner sketched in the subjoined figure.



a. gneiss, b. mica schist, c. clay slate.

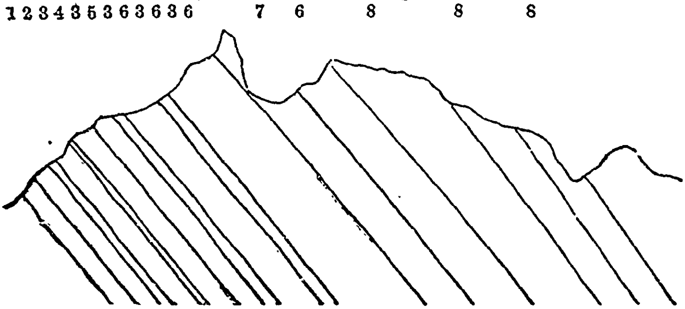
And in reality not a few of the so-called Primitive Slate districts possess an architecture closely analogous to the above ideal section. This is especially the case in the Alps of Salzburg and Upper Carinthia. In this part of the central Alps, according to Credner, a mass of granitic gneiss, drawn out from east to west, forms the centre. On the north as well as on the south side of this mass crystalline slates overlie it. On the north side the dip is at a high angle to the north, and on the south side the highly inclined strata dip to the south. These crystalline slates are divisible into three groups, the lowest consisting of common and calcareous mica-slate, the middle group of chlorite and talc slates, and the upper group of common and calcareous clay-slate. Moreover the structure of the metamorphic rocks of eastern North America, and also of the slate districts north of the Mjo'sẹn in

Norway, would seem greatly to resemble the above ideal section, if we suppose one half of the same to be obliterated. The following is a section of the Alleghany chain according to Rogers:*



1. Gneiss, mica slate, &c.
2. Silurian system (so-called metamorphic strata).
3. Devonian "
4. Carboniferous "

The above delineated structure of the slate rocks would have experienced a modification, in the event of igneous rocks having been protruded through the fissures formed by these movements of the earth's crust. These igneous rocks would most easily be protruded at the point marked A in the sketch first above given. If we imagine a granitic mass to be erupted at the point so marked, we have then a section resembling in its general features the build of the so called primitive rocks in many parts of the Alps of Switzerland, in the Saxon Erzgebirge, in Hungary, and in the gneissoid region of La Vendée, above mentioned. The following is a section given by Beudant, of the structure of the schistose rocks in the county of Gömör in Hungary.†



1. Granite.
2. Gneiss.
3. Mica-schist.
4. Greenstone.
5. Limestone.
6. Clay-slate.
7. Iron ore.
8. Schistose greywacke and limestone.

Here the primitive and slate strata rest upon the granite in the following order: 1st gneiss, 2d mica-schist, 3d clay-slate. The

* Naumann, Lehrbuch, i, 994.

† Voyage en Hongrie, Atlas, Fig. 5.

mica-schists and clay-slates in the districts above mentioned never occur overlying the gneiss strata unconformably. On the contrary, they are so intimately connected that a gradual transition is generally observed to take place between them; the gneiss gradually changes into mica-schist, the latter gradually becomes less crystalline, and finally argillaceous and chloritic rocks result.

A further modification of the above type of the structure of the slate rocks occurs when the granite is so extensively protruded as to overlie the gneiss strata, or when the latter have not been forced up to the surface. In this case the micaceous or argillaceous slate is found immediately reposing upon or at least in contact with the granite. In this manner the mica-schist with interstratified limestones, north of Drontheim in Norway, overlie the granite of Vestfjord, and in this way also the killas or clay-slates of Cornwall lean upon the granite of Dartmoor. In the latter cases no lithological transitions are observable between the slates and the granite, while in former cases, where gneiss is interposed between them, the transition from the latter rock to granite is distinctly observable. This phenomenon, it will be observed, however, is not inconsistent with the explanation here given of the origin of these rocks.

I have thus attempted to explain some of the most remarkable phenomena connected with the primary rocks. It will be observed that in so doing, I have tried to elaborate and combine together many of the ideas expressed by different geological authorities. I am far however from maintaining that the theory here given is adequate to account for all the facts observable in connection with these rocks. Nor is it at present necessary that this explanation should be perfect. There must be in geology as in other sciences, obscure problems always awaiting solution. The best apology which I can offer for presuming to attempt an explanation of the enigmatical phenomena connected with the primary rocks, is in the following words of McCulloch:* "The human mind is so constituted that it cannot rest content with facts. If it posesses innate propensities, the investigation of causes is assuredly one of them. The very geologist who disclaims all theory has his own; the lowest of the vulgar desire reasons. The laws which govern the phenomena of nature force themselves irresistibly on our attention. They are strictly involved with the analogies which regulate all our reason-

* System of Geology, vol. i, p. 485.

ings and direct our observations; and without them we cannot proceed a step on firm ground. They distinguish the philosopher from the empiric, and combine scattered observations into a body of useful and rational science. Even in the science of nature, as in that of numbers, the assumption of imaginary or erroneous laws, leads to the discovery of the truth. The history of astronomy is in itself a lesson to those who ignorantly undervalue the pursuit of general laws. Bewildered in spheres and vortices, it arose, as in a moment, complete, from the theory of gravitation.

"Hence the consideration of secondary causes, forms, not only a legitimate, but an essential part of geological science. That science, like all others, comprises the history of all the facts which it involves; and from these, it establishes certain general analogies. Ascending a step higher it declares the laws which have regulated, and will continue to regulate, all the phenomena of the globe; and thus finally establishes a legitimate theory of the earth."

No trace of organic remains has been discovered in these micaceous, chloritic or argillaceous slates, nor even in the limestones associated with them. The adherents of the metamorphic hypothesis attempt to account for this by supposing that the fossils have been obliterated by the agencies which have effected the alteration. But even in the greywacke slates and sandstones, traces of life are rare; and it is only in the very newest strata of that series, that they become at all frequent, and then they belong to the inferior grades of animal organisms. That the air-breathers, recently described by Dr. Dawson, first make their appearance in the coal-measures, may be regarded as a proof of the absence of free oxygen from the atmosphere which existed during the deposition of the Lower Silurian rocks. Not until the carbonic acid was to a great extent removed from the atmosphere by the luxuriant vegetation of the coal period, and its place taken up by oxygen, was it possible for air-breathers to exist. The extraordinarily rich vegetation of that epoch was no doubt stimulated by the immense quantities of carbonic acid in the atmosphere, and the exceedingly warm climate which then prevailed over the whole surface of the earth. This warm climate, we are justified in supposing, was caused more by the radiation of heat from the interior of the earth, than by solar influence. So that it is possible to trace a connection between the phenomena of internal heat and the characteristic strata of the carboniferous system, and between that series of rocks and the constitution of the primitive atmosphere. In this, as in much of what has been stated in this paper we recognise how intimately linked together all natural phenomena and all departments of science are. The various natural sciences are like the crystalline rocks; they graduate into each other, forming, when properly interpreted, a compact, well ordered and harmonious whole.

And while we study and recognise all this, surely it behoves us to acknowledge reverently the great Author of all. The mere external features of primitive districts inspire us with feelings of wonder and awe. Standing on the summit of Gaustafjeld, we can look northward over hundreds of square miles of primitive rocks, forming there the broad, barren plateau of Hardangerfjeld. As far as the eye can reach there is spread out a desert of rocks broken only by the lakes, which form the sources of the turbulent streams that leap down into the fiords of the west and south, or by valleys with precipitous sides, which seem as if hewn out of the solid rock of the plateau beneath the level of its general surface. The scanty and stunted vegetation heightens the desolation of the scene, but nevertheless its rugged grandeur causes the observer to be deeply impressed with his own insignificance, and with the awful power of the Originator of the universe. But how greatly is this feeling deepened when the architecture of these rocks and the mode of their formation is considered. Here we feel our utter littleness even more forcibly; but we at the same time gain some idea of that series of processes and revolutions by which the earth was fitted for man, and of the power and wisdom of the great Designer who caused our present beautiful earth to emerge from the chaos of the primitive period. We also learn enough to exclaim with the Psalmist, "Of old hast Thou laid the foundations of the earth."

Acton Vale, C. E.

12th January, 1864.

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