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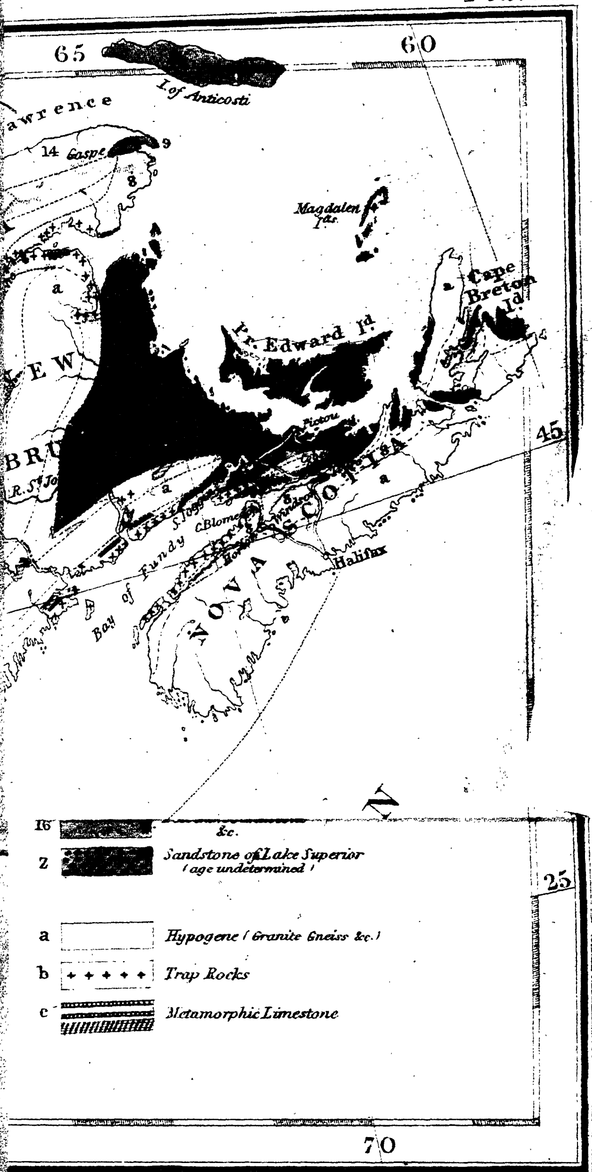
Plate II



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Lyell's First Visit to North America.

TRAVELS

IN

NORTH AMERICA,

CANADA, AND NOVA SCOTIA.

WITH

Geological Observations.

BY SIR CHARLES LYELL, F.R.S.

AUTHOR OF "PRINCIPLES OF GEOLOGY," "MANUAL OF ELEMENTARY GEOLOGY," ETC.

IN TWO VOLUMES.—VOL. II.

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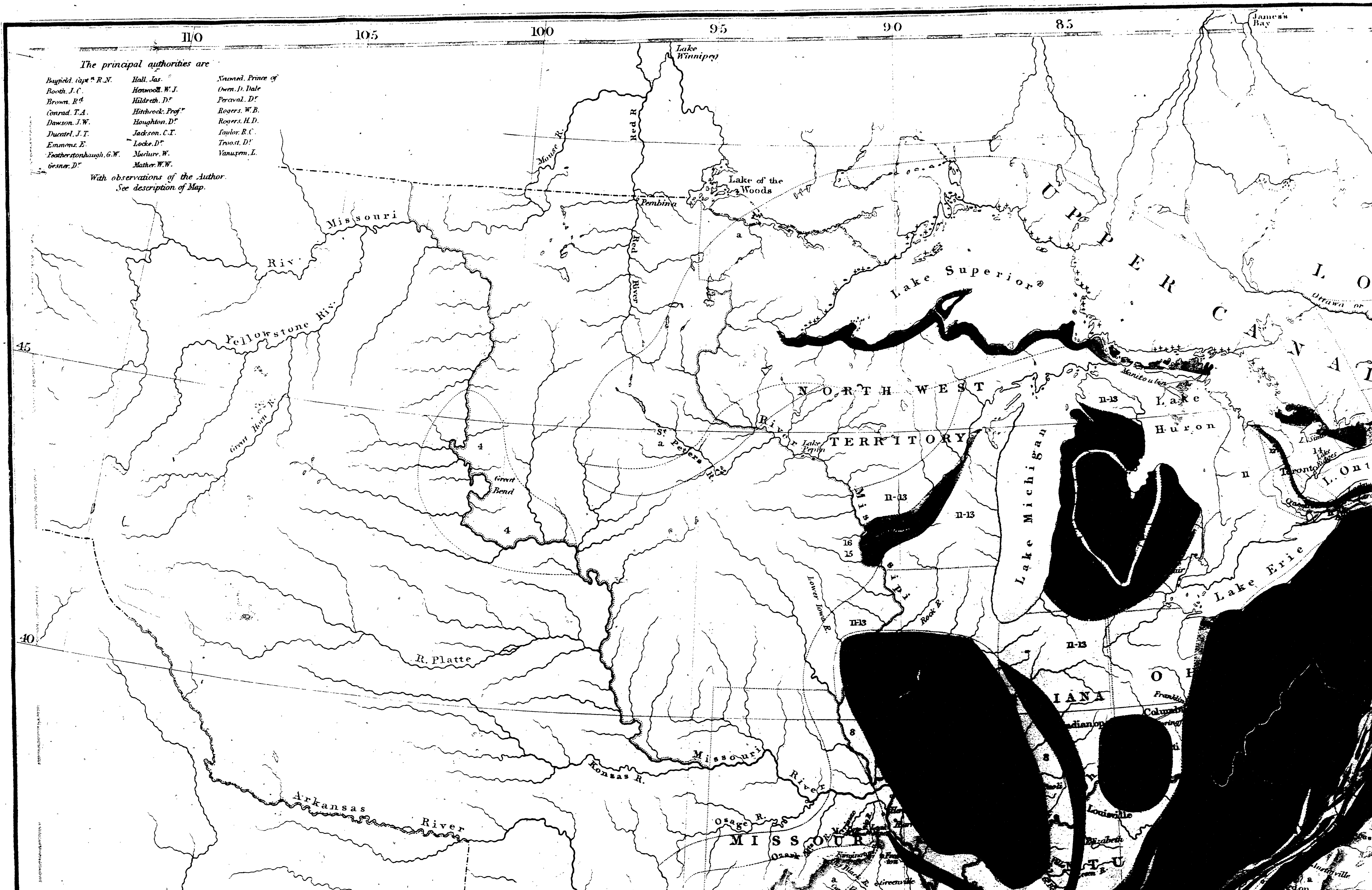

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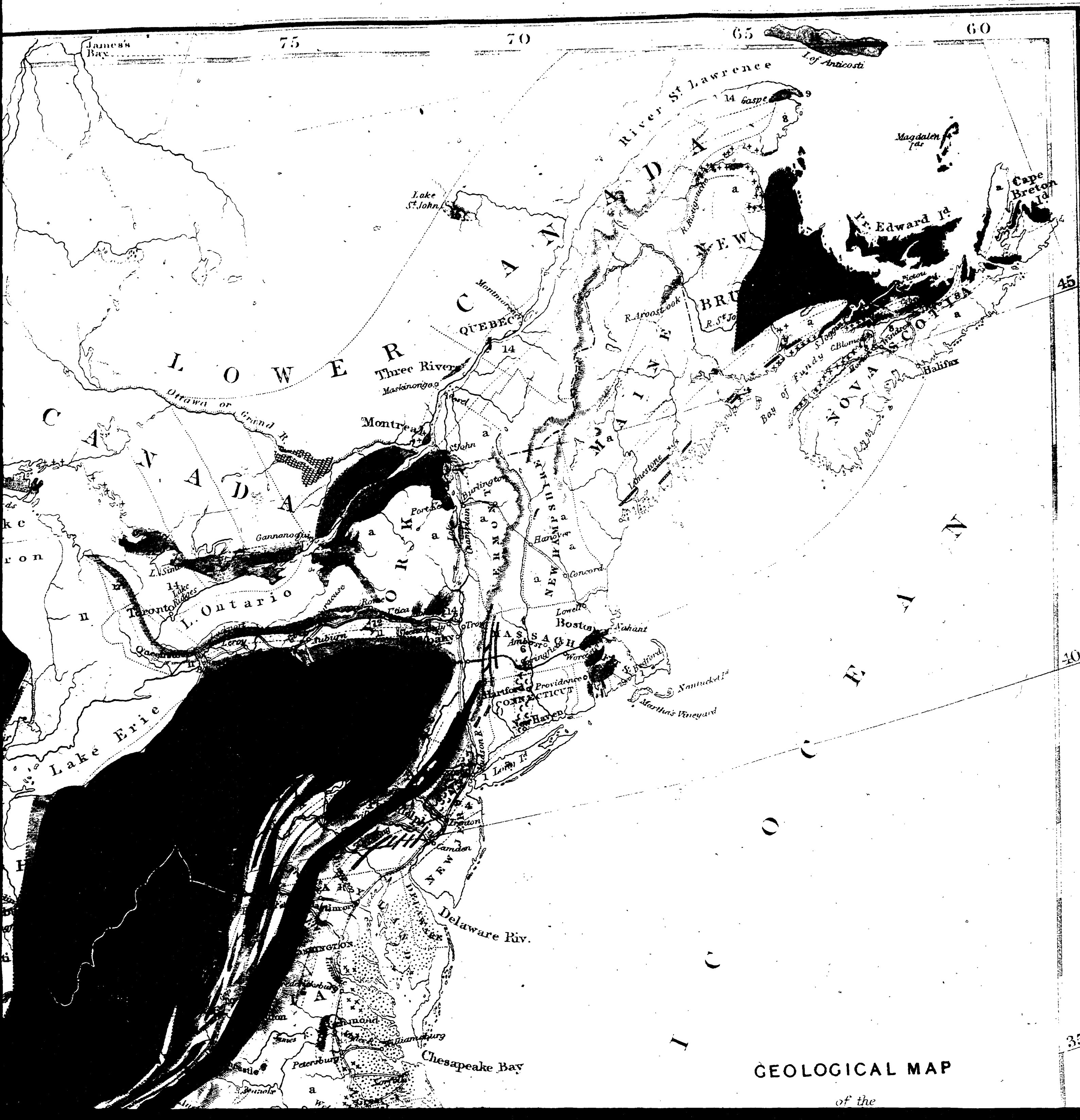
105
100
95
90
85
James's Bay
Lake Winnipeg
The principal authorities are
Bayfield. Captⁿ R.N.
Booth. J.C.
Brown. Rd
Conrad. T.A.
Dawson. J.W.
Ducatel. J.T.
Emmons. E.
Featherstonhaugh. G.W.
Gesner. Dr
Hall. Jas.
Henwood. W.J.
Hildreth. Dr
Hitchcock. Profr
Houghton. Dr
Jackson. C.T.
Locke. Dr
Maclure. W.
Mather. W.W.
Neuwied. Prince of
Owen. D. Dale
Percival. Dr
Rogers. W.B.
Rogers. H.D.
Taylor. R.C.
Troost. Dr
Vanuxem. L.
With observations of the Author.
See description of Map.
Mouse R.
Red R.
Lake of the Woods
Pembina
Missouri
Riv.
Red River
UPPER CANADA
Lake Superior
Yellowstone Riv.
45
Manitoulin
NORTH WEST TERRITORY
Great Horn R.
St. Peters R.
River
Lake Pepin
Lake Huron
Lake Michigan
Great Bend
Toronto
L. Ont
Lake Erie
Mississippi
Lower Iowa R.
Rock R.
40
R. Platte
INDIANA
Missouri River
Konzas R.
Arkansas River
Osage R.
MISSOURI
Louisville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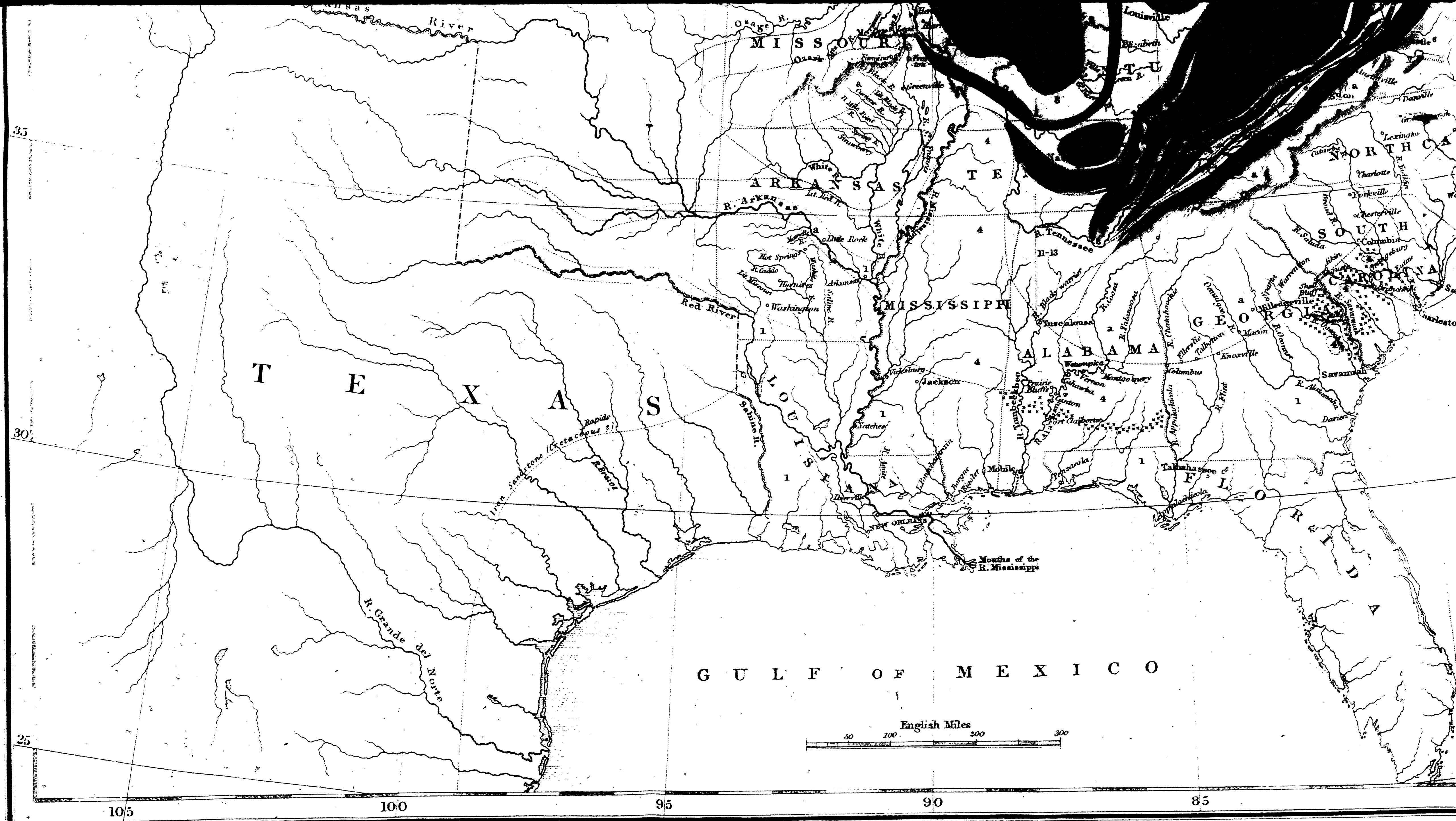
James's Bay
I. of Anticosti
River St. Lawrence
Gaspe
Magdalen Is.
Cape Breton Id.
Pr. Edward Id.
Lake St. John
LOWER CANADA
CANADA
QUEBEC
Three Rivers
Maskinongo
Montreal
Ottawa or Grand R.
NEW BRUNSWICK
R. Aroostook
R. St. John
Pictou
Bay of Fundy
C. Blomedon
NOVA SCOTIA
Halifax
MAINE
Limestone
NEW HAMPSHIRE
Hanover
Concord
VERMONT
Burlington
Champlain
Gannanoqui
L. Simcoe
Lake Ridges
Toronto
L. Ontario
Rome
Utica
Albany
Troy
Leroy
Auburn
Lake Erie
MASSACHUSETTS
Lowell
Boston
Nahant
Amherst
Springfield
Worcester
N. Bedford
Providence
Nantucket Id.
Martha's Vineyard
Hartford
CONNECTICUT
New Haven
Hudson R.
Long Id.
Trenton
Camden
NEW JERSEY
Delaware Riv.
Baltimore
WASHINGTON
Fredericksburg
Richmond
Williamsburg
Petersburg
Chesapeake Bay
OCEAN
ATLANTIC
GEOLOGICAL MAP
of the



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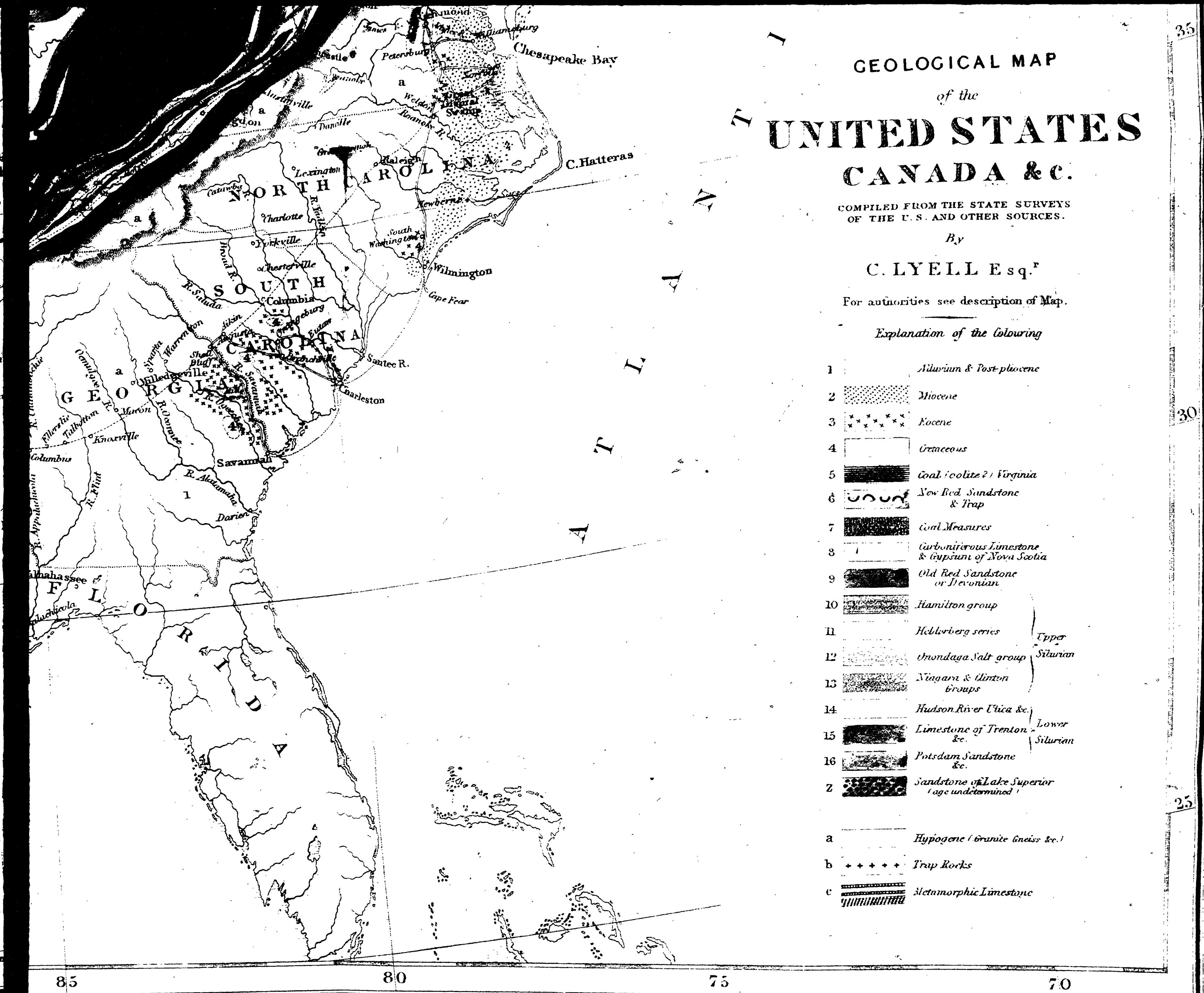

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Plate II.—Geological Map of the United States, Canada, &c., compiled from the State Surveys of the U. S., and other sources.

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Section 2.— *Geological Formations expressed by different Colours and Numbers on the Map.*—No. 1. *Alluvium and Post-Pliocene.*— No. 2. *Miocene.*—No. 3. *Eocene.*—

JOURNAL

OF A

ERRATA IN VOL. II.

Page 241. line 5. from bottom, for "Miscon," read "Missouri."
249. line 15. for "beyond the river," read "beyond the rivers Nashwack and Miramichi."
250. line 8. for "Miscon," read "Miscou."

regular duty of late years; but there seemed no reason to anticipate that he would so soon be taken

JOURNAL

OF A

TOUR IN NORTH AMERICA,

IN 1841–2.

CHAPTER XIV.

Dr. Channing.—Agitation in Rhode Island.—Armed Convention.—Sail through Amboy Straits.—Journey to Philadelphia and Baltimore.—Harper's Ferry.—Passage over the Alleghanies by National Road.—Parallel Ridges.—Absence of Drift.—Structure and Origin of Appalachians.—Theory of Subsidence and Contraction of Subterranean Fluid.—Kentucky Farmers.—Emigrants.—Cumberland Coal Field.—Clay with Stigmaria.—Marine Shells in Coal Measures near Frostburg.—Wide Geographical Distribution of Fossil Coal Plants.

April 17. 1842.—DURING my stay at Boston, I was fortunate enough to hear Dr. Channing preach one of the last sermons he delivered from the pulpit. His declining health had prevented him from doing regular duty of late years; but there seemed no reason to anticipate that he would so soon be taken away from a community over which he exerted a great and salutary influence. His sermon was less impressive than I had expected, and fell short of the high conception I had formed of him from his writings; but this I imputed entirely to his want of physical strength, and the weak state of his voice. I had afterwards the pleasure of conversing freely with him at a small dinner party on various subjects in which he was interested; among others, the bearing of geological discoveries, respecting the earth's antiquity and the extinct races of animals, on the Mosaic account of the history of man and the creation. I was struck with the lively interest he took in the political affairs of Rhode Island, — a neighbouring state, containing about 110,000 inhabitants, and now convulsed by a revolutionary movement in favour of an extension of the suffrage. The sympathies of Dr. Channing appeared to lean strongly to the popular party, which, in his opinion, had grievances to complain of, however much, by their violent proceedings, they had put themselves in the wrong.

As some alarmists assured me that the railway to Providence, by which I intended to pass southwards in a few days, "was commanded by the cannon of the insurgents," my curiosity was awakened to enquire into this affair, the details of which were not uninstructive, as giving a curious insight into the character of the New England people, and showing their respect for law and order, even when their passions are highly excited. I found that Rhode Island was still, in the year 1842, governed according to a charter granted by Charles II. in the year 1663, no alteration having been made in the qualifications of voters at the period when the sovereignty was transferred from the crown of Great Britain to the freeholders of Rhode Island. Although the State has been flourishing, and is entirely free from debt, a large majority of the people have, for the last forty years, called loudly on the privileged landholders to give up their exclusive right of voting, and to extend the suffrage to all the adult males, in accordance with the system established in all the neighbouring states. The dispute turned mainly on a question of a very abstract nature for the comprehension of the multitude, though in reality one of great constitutional importance; namely, whether the change should be made according to the forms prescribed in the charter of 1663, or might be effected by the people in its capacity of sovereign, without regard to any established forms. The latter method was advocated by the democratic leaders as most flattering to the people, and with such success that they organized a formidable association in opposition to the government. Their demands did not differ very materially from those which the legislature was willing to concede, except that the democrats claimed the suffrage, not only for every American-born citizen, but also for the new-comers, or the settlers of a few years' standing. Both parties agreed to exclude the free blacks. At length, as their wishes were not complied with, the "Suffrage Convention" resolved to intimidate their opponents by a military enrolment and drilling, and were soon joined by several companies of militia.

The governor of Rhode Island was so much alarmed as to call on the President of the United States to afford him aid, which was declined on the ground that no overt act of violence had been committed. The insurgents then elected a separate senate and house of representatives, and one Dorr as governor of the State, who proceeded to Washington, and had an interview with the President of the United States and with several members of congress. Meanwhile military preparations were making on both sides. A second appeal was made in vain by the State of Rhode Island for aid from the federal government at Washington. Meetings of sympathizers were held at New York to co-operate with the popular party, who had now obtained some pieces of cannon, and attempted to get possession of the arsenal at Providence. On this occasion, however, the State government called out the militia, who mustered in great force, and, after a bloodless affray, the popular party, which had already dwindled down to a few hundreds, deserted their leader, Dorr. This champion made his escape, but was soon after taken, tried for high treason, and condemned to imprisonment. Before the conclusion of this affair the government at Washington signified their readiness to furnish the required troops, but their offer of aid came late, and the assistance was no longer needed.

The firmness of the Rhode Island legislature under the threats of the armed populace at home, and, what was more formidable, of the sympathizers from without, and the respect shown to constitutional forms by the mass of the people in the midst of this excitement, are circumstances highly creditable to the majority of the citizens. It remains to be seen whether an extension of the suffrage, which was afterwards granted, will promote or impede the cause of freedom and good government in this small State.

May 2. 1842.—We now set out on a tour to the valley of the Ohio and the country west of the Alleghany mountains, taking the railway to Providence, and a steam-boat from thence to New York. Afterwards we went to Philadelphia by Amboy, passing through the beautiful strait which separates the mainland of New Jersey from Staten Island. This winding channel is, in parts, only half a mile, and even less, in width, with many elegant villas and country houses on Staten Island. Its banks are often well-wooded, and it resembles a river, or Homer's description of the broad Hellespont, which, as Gibbon observes, the poet had evidently likened to a river, and not to an arm of the sea.

The trees in New England are now only beginning (in the first week of May) to unfold their leaves, after an unusually mild winter. They remain leafless for nearly seven months in the year, although in latitude 42° and 43° N., corresponding geographically to Southern Italy. In New Jersey the scarlet maple is putting forth its young leaves; the horse-chesnuts and lime-trees are in bloom; the lilacs flowering in the gardens, and the Judas tree conspicuous with its purplish pink blossom. The dogwood also abounds in the forests, with such a display of white flowers as to take the place of our hawthorn.

We reached Philadelphia without fatigue in less than twenty-two hours, a distance of 300 miles from Boston, having slept on board the steam-boat between Stonington (Rhode Island) and New York. We proceeded from Philadelphia to Baltimore, and from thence ascended the beautiful valley of the Patapsco, for 60 miles, to Frederick. Between

Baltimore and Frederick, I passed over highly inclined strata of gneiss, mica schist, and other metamorphic rocks, which began to be covered at Frederick, and between that and the first ridge of the Alleghany hills, with unconformable beds of the New Red Sandstone, dipping gently to the southwest, or towards the mountains. We continued chiefly on this red sandstone between Frederick and Harper's Ferry, and then entered again upon mica schist and chlorite slate.

At Harper's Ferry, in Virginia, the Potomac, about fifty miles above Washington, is joined by the Shenandoah, a river as large as itself, and after uniting, they issue through a transverse gorge in the mountains. This gorge interested me from its exact resemblance to the Lehigh Gap before described in Pennsylvania, by which the Delaware flows out from the hilly country. The scenery of Harper's Ferry has been overpraised, but is very picturesque.

I had hired a carriage at Frederick to carry me to Harper's Ferry, and thence to Hagarstown, on the main road across the mountains. When I paid the driver, he told me that one of my dollar notes was bad, "a mere personal note." I asked him to explain, when he told me that he had issued such notes himself. "A friend of mine at Baltimore," he said, "who kept an oyster store, once proposed to me to sign twenty-five such notes, promising that if I would eat out their value in oysters, he would circulate them. They all passed, and we never heard of them again." I asked how he reconciled this transaction to his conscience? He replied, that their currency was in a very unsound state, all the banks having suspended cash payment, and their only hope was that matters would soon become so bad that they must begin to mend. In short, it appeared that he and his friend had done their best to hasten on so desirable a crisis.

The next day two Marylanders, one of them the driver of the stage coach, declared that if the State should impose a property tax, they would resist payment. As funds are now wanted to pay the dividends on the public debt, the open avowal of such opinions in a country where all have votes, sounded in my ears as of ominous import.

In our passage over the Alleghanies, we now followed what is called the National Road to Cumberland and Frostburg, crossing a great succession of parallel ridges, long and unbroken, with narrow intervening valleys, the whole clothed with wood, chiefly oak. The dogwood, with its white flowers, was very conspicuous. The north-western slopes of the hills were covered with the azalea in full flower, of every shade, from a pale pink to a deep crimson. They are called here the wild honeysuckle. Had not my attention been engrossed with the examination of the geological structure of the numerous parallel chains, the scenery would have been very monotonous, the outline of each long ridge being so even and unbroken, and there being so great a want in this chain of a dominant ridge. There is a remarkable absence of ponds or lakes among these mountains, nor do we see any of those broad dead flats so common in other chains, especially the Pyrenees, which seem to indicate the place of ancient lakes filled up with sediment. Another peculiarity, also, of a negative kind, is the entire absence of the boulder formation, or drift with transported blocks, which forms so marked a feature in the hills and valleys of New England.

I have before spoken briefly of the structure of the Alleghanies (p. 92.) and their geological conformation, as explained by the Professors W. B. and H. D. Rogers. The accompanying map (pl. 2.) will serve to give the reader some idea of the manner in which the parallel belts, or long narrow zones of disturbed strata of different ages, break out at the surface along the line of this mountain chain, so as to be represented by numerous stripes of colour, running in a general direction from N. E. to S. W. It will be seen that the inferior or older groups of the Silurian series range chiefly along the eastern or south-eastern flank of the Appalachians, while the newer groups of the same series, together with the Devonian or carboniferous formations, make their appearance as we proceed farther westward. After having found fossils in such abundance in the corresponding Silurian rocks of New York, I was struck with their absence, or much greater rarity, in the inclined strata of these mountains, especially in the oldest limestones, or those corresponding in age to "the Trenton group." I have before endeavoured to give, at p. 92., an ideal section of the structure of the Appalachian chain, in accordance with the views of the Professors Rogers, and have described the numerous arches and troughs, or parallel, anticlinal, and synclinal bends into which the strata are folded. Between these and the external geographical features of the country there is a manifest connection; nevertheless, it is necessary to bear in mind that the present outline of the hills has been due to changes long subsequent to the era when the rocks acquired their principal flexures and fractures. These changes have consisted of the denuding operations of the sea, which probably took place, in great part at least, during those movements of elevation which, after the period of the New Red Sandstone, uplifted the Appalachian strata to their present level above the ocean.

To those who are not accustomed to reflect on the long succession of natural events, often differing from each other greatly in kind, which have concurred to produce a single geological phenomenon, such as a mountain chain, it will always appear very paradoxical that the structure of such a chain is attributed in great part to the sinking, rather than to the forcing upwards, of a portion of the earth's crust. I shall add, therefore, a few words to the brief remarks before advanced (p. 98.), in favour of the theory which attributes the folding of strata such as those of the Alleghanies to subsidence. This hypothesis is simply a modification of one very popular with the earlier geologists, who ascribed the fractured condition of the most ancient rocks to the shrinking of the supposed original fluid nucleus of the planet, it being assumed that the earth passed gradually from a state of fusion by heat to a solid condition. It was truly remarked, that during the process of congelation and contraction, the incumbent strata, or those first solidified, would sink and accommodate themselves to a narrower area, namely, the circumference of a spheroid of smaller diameter, and, according to their different degrees of pliability or hardness, the beds would be bent or broken.

When this theory was first propounded, all the disturbances of the rocks were referred to a remote geological era, and supposed to have been nearly simultaneous. We have now ascertained that, on the contrary, they have been produced at a great variety of successive epochs, and that some mountain chains are very modern in the earth's history in comparison with others. Nevertheless, the hypothesis may in a limited sense be quite sound, for we may imagine one part after another of the subjacent nucleus, underlying the thin coating or crust which we explore geologically, to be melted by volcanic heat, and, after expansion, to cool and become again consolidated and collapse. The rocks would undergo some disturbance when they were first uplifted, but when the heat was withdrawn, and contraction took place, there would be a still greater amount of dislocation, crumpling, and folding of the beds. All the elaborate mechanical explanations resorted to in illustration of the doctrine of a general contraction, and a diminution in the size of the entire planet, may be applicable to the phenomena of strata, whether in plains or mountains, which have at successive periods become contorted within limited areas. We have only to substitute the partial liquefaction of the interior of the earth at moderate depths for the primitive fusion of the entire incandescent nucleus, and to suppose that each local development of subterranean heat was followed by refrigeration, and we then discover a cause fully adequate to produce the fracture, plication, and lateral pressure of rocks, at as many successive periods of the past, as the facts now established in geology require.

Nearly all mountain chains can now be shown to have been, like the Appalachians, of later date than the creation of organic beings. We also know that, at each geological period characterized by the appearance of distinct races of living beings, the earth's surface, although for the most part tranquil, has been in some regions the theatre of volcanic eruptions. It is very probable that the Silurian, Devonian, and carboniferous strata, which enter into the composition of the Appalachians, underwent the principal movements of upheaval and subsidence to which their prevailing structure is due, at a time when they were still submerged beneath that ocean in which they were originally formed, — for that they were at first marine deposits is testified by their imbedded corals and shells. It is therefore certain that they have undergone some elevation before they arrived at their present position. But we cannot infer from this fact that movements of elevation rather than of subsidence have been most effective in impressing upon them their present structure. The reader will observe, in the section at p. 92. vol. i., that nearly horizontal beds of Newer Red Sandstone (No. 4., fig. 5.), rest unconformably on the inclined strata of the Alleghanies. Hence he will perceive that the last series of movements which upraised this continent, was quite distinct from those prior movements, which threw the ancient strata (Nos. 5, 6, 7., fig. 5.) into their inclined and curved position.

Having one day entered a stage coach in our passage over these mountains, I conversed with two Kentucky farmers returning in high spirits from Baltimore, where they had sold all their mules and cattle for good prices. They were carrying back their money in heavy bags of specie, paper dollars being no longer worthy of trust. They said their crops of grain had been so heavy for several seasons, that it would have cost too much to drag it over the hills to a market 400 miles distant, so they had "given it legs by turning it into mules." I asked why not horses. They said mules were nearly as serviceable, and longer lived, coming in for a share of the longevity of the ass. During several days of travelling in public conveyances on this line of route, we met with persons in all ranks of life, but with no instance of rude or coarse manners.

Entering a cottage at Frostburg, we talked with the mother of the family, surrounded by her children and grandchildren. She appeared prosperous, had left Ireland forty years before, at the age of seventeen, yet could not speak of the old country without emotion, saying, "she should die happy could she but once more see the Cove of Cork." Her children will be more fortunate, as their early associations are all American.

We passed many waggons of emigrants from Pennsylvania, of German origin, each encumbered with a huge heavy mahogany press, or "schrank," which had once, perhaps, come from Westphalia. These antique pieces of furniture might well contain the penates of these poor people, or be themselves their household gods, as they seem to be as religiously preserved. Our companions, the two farmers from Kentucky before mentioned, shook their heads, remarking, "that most of them would go back again to Pennsylvania, after spending all their money in the West; for the old people will pine for their former homes, and persuade the younger ones to return with them."

I found some of the iron mines near Frostburg in a bankrupt state, and met a long train of luggage waggons conveying the families of the work-people to new settlements in the West. The disappointed speculators are clamouring for a tariff to protect their trade against English competition. When I urged the usual arguments in favour of free trade, I was amused to perceive how the class interests of my new companions had overcome the usual love of equality, which displays itself in the citizens of the

United States. One of the superintendents of the mines expressed surprise that I should have gone through so many states, and not grown tired of the dull mediocrity of income which mere land under the custom of equal division among children produced! "Why limit our civilization and refinement to small farmers, who expend their surplus gains in tobacco and lawsuits, and can never make ample fortunes, such as spring from manufacturing and commercial industry?"

The iron and coal mines near Frostburg are well worthy of examination. The principal coal seam is ten feet thick, besides six feet of incumbent and less pure carbonaceous matter, the coal bituminous, though containing less volatile matter (oxygen, hydrogen, and nitrogen,) than farther west on the Ohio. According to the analysis of my friend Dr. Percy, the quantity of gaseous matter, as compared to the carbon and ash, is only in the proportion of 9½ per cent. in the specimens of coal which I obtained here from the best seam, whereas the proportion was exactly twice as great in the coal afterwards examined by me farther west at Pomeroy on the Ohio, confirming the theory first advanced by Mr. H. D. Rogers, of the progressive debituminization of coal as we advance from east to west, or from the anthracite of Pennsylvania to the horizontal coal fields in the plains of the Ohio. See above, pp. 89. and 249. vol. i.

The coal measures of this part of Maryland are usually called the Cumberland coal field, from Fort Cumberland, famous for the wars of the English with the French and Indians, in which General Washington took part, before the American Revolution. The carboniferous strata consisting, as usual, of shale, grit, sandstone, limestone, argillaceous iron ore, and coal, are arranged geologically in a trough, about twenty-five miles long, from north to south, and from three to four miles broad. Professor Silliman and his son, who surveyed them, have aptly compared the shape of the successive beds to a great number of canoes placed one within another. The entire thickness of the coal measures is about 1500 feet, including the fundamental quartzose sandstone, called by the miners here, as in England, the millstone grit, which is about forty feet thick, and contains small pebbles, sometimes as big as nuts. These pebbles, therefore, are very diminutive in comparison with those before mentioned as occurring in the same rock in the anthracite basins of north-eastern Pennsylvania, where some of them were stated to be as large as a hen's egg. The conglomerate of that region, it will be remembered, was 1500 feet in thickness, instead of forty feet as at Frostburg, showing the reduction of size in the formations of mechanical origin as we proceed westward. (See above, pp. 84. and 86. vol. i.)

The seams of coal at Frostburg are numerous, there being three workable, besides nine or ten smaller beds. Under several of these, I found clays with Stigmaria, usually, as elsewhere, unaccompanied by any other fossil plants. At one spot, however, on the north-eastern confines of the coal basin, about fifty feet above the millstone grit, I saw a bed of coal four feet thick, resting on a blue clay containing Stigmaria. This clay was twenty feet thick, and as usual without slaty texture, and the rootlets, commonly called leaves, radiated in all directions from the stems of the Stigmaria. Dispersed plentifully through the same clay, I found the leaves of two species of Pecopteris, and an Asterophyllite, the only instance, in several hundreds which I examined in the United States, where ferns and other coal plants were associated with the Stigmaria, imbedded in its natural position, and not having been drifted.

Higher in the series, but still 300 feet below the principal coal seam, an interesting example occurs of a black shale full of marine shells, resting on a seam of coal about three feet thick. When we have once embraced the doctrine of the origin of pure coal from terrestrial plants, which grew like peat in the spots where we now find them, the contact of an incumbent regular bed of black bituminous slate, ten or twelve feet thick, abounding in sea shells perfectly preserved, is highly interesting. Captain George Green, superintendent of the mines here, kindly presented me with a collection of these shells, which are referable to no less than seventeen species. Some are identical with, and almost all the rest have a near affinity to, species found in the Glasgow and other British coal measures. Among the rest is *Bellerophon Urii*, and two others of the same genus; *Euomphalus carbonarius*, several species of *Nucula*, one of *Loxonema*, and a *Producta*, allied to *P. scabricula*.

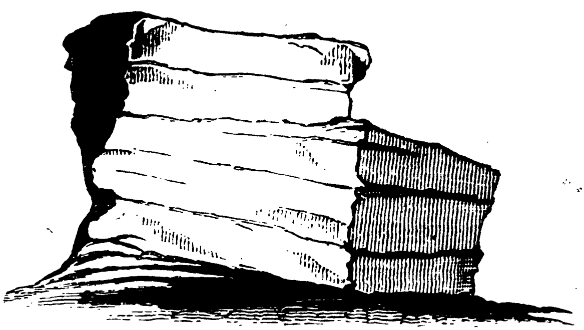
Among the plants occurring usually in the shaly roof or ceiling of the coal, are many identical with European species, such as *Calamites dubius* and *C. nodosus*, *Pecopteris arborescens*, and two other species in ironstone shale, both in fructification; also *Lepidodendron tetragonum*, *L. aculeatum*, *Neuropteris cordata*, *N. gigantea*, *Sigillaria reniformis*, *Caulopteris*, *Stigmaria*, *Asterophyllites tuberculata*, *A. foliosa*, and many others.

I have alluded to two species of ferns (*Pecopteris*) in fructification. One of these, abundant in the Jack Porter mine, appears to agree with the European *Hemitelites Trevirani* of Göppert. It agrees in its venation and the position of its sori with the recent subgenus *Goniopteris*. When we consider how rapidly the fructification decays on the back of the leaves of ferns, it is wonderful to see them thus petrified. The resemblance, moreover, of some of the common American and European coal plants, such as *Pecopteris lonchitica*, and *P. Serlii*, to ferns now living, such as *Pteris caudata*, and *P. aquilina*, is well worthy of notice. The leaves would be undistinguishable if the veins in the fossil species were not finer, closer together, and more perpendicular to the mid-rib, than in the recent ferns.

The specific agreement of so many of the American coal plants with European fossils implies a greater uniformity in the carboniferous flora, throughout a large part of the globe, than appears to have prevailed in the co-existing conchological fauna, so far as it is known at present. Those English naturalists who assisted me in naming my American plants came to the opinion that two thirds of them are the same as species well known in the coal measures on the other side of the Atlantic. M. Adolphe Brongniart informs me that he has arrived at the same result, the general accuracy of which cannot, I think, be impugned by questioning the botanical determinations arrived at from such characters, as the venations of fern leaves, or the markings left by the attachment of fronds on the bark of such trees as Sigillaria and Lepidodendron. If the prevailing vegetation of two distant parts of the globe were now to become fossil, the more common species would no where present so uniform a character, if we confined our comparison simply to corresponding organs, namely, the leaves, bark, fruits, the internal woody fibre, whether cellular or vascular, and the roots, if, indeed, the Stigmariæ be of that nature. As to the ferns, it should not be forgotten, that, although in the existing state of the globe, they are less cosmopolite than lichens and mosses, there are some of them, nevertheless, which have an extremely wide range, such as *Didymochlæna sinuosa*, common to Brazil, Java, and Manilla; and *Polypodium incanum*, to Brazil and the Cape of Good Hope. The recent ferns of North America, according to Pursh's Flora, are sixty-nine in number, of which fifteen, according to the same authority, are natives of Europe. It is also worth remarking, that very few of the *genera* of living ferns are confined to one particular country, or even to one continent. The larger genera appear to have species in nearly all the regions of the world, except the colder latitudes. The mere generic resemblance, therefore, of the fossil ferns of North America and Europe, would not have been remarkable, as indicating a different geographical distribution from that now prevailing.

While at Frostburg, I rode one day on horseback, with Captain Green, superintendent of some of the mines there, and followed the course of Jenning's Run, returning by Cumberland. In this route, we saw a fine section of the coal measures, the underlying grit or conglomerate, and a great thickness (5000 or 6000 feet) of still older Devonian and upper Silurian strata. In those ridges, along the crest of which the yellow and white quartzose carboniferous grit crops out, the monotonous outline was occasionally broken by outliers of the rock twenty feet and upwards in height, remaining *in situ* with their perpendicular sides and sharp angles (see fig. 7.), and showing clearly that large portions of the strata had been removed from the tops of the hills as well as from the valleys.

Fig. 7.



Outlier of quartzose grit 20 feet high.

I was surprised, in the course of our ride along the bottom of a wooded valley, to find the air infected far and wide with a fetid odour, which, my companion informed me, proceeded from a skunk. The animal, he supposed, might be half a mile or more to windward of our path.

CHAPTER XV.

Alleghany Mountains.—Union.—Horizontal Coal Formation.—Brownsville on the Monongahela.—Facilities of working Coal.—Navigable Rivers.—Great future Resources of the Country.—Pittsburg.—Illinois Coal Field.—Fossil Indian Corn.—Indian Mounds near Wheeling.—General Harrison on their high Antiquity.—Dr. Morton on the aboriginal Indians.—Remarks on the Civilization of the Mexicans and other Tribes.—Marietta.—Silicified Trees or Psarolites of Ohio.—Coal of Pomeroy.—New Settlements.—Cincinnati.

AFTER leaving the small mining village of Frostburg, which is about 1500 feet above the level of the sea, we continued to ascend and descend a succession of steep ridges till we came to the summit level, where the climate was sensibly colder, and the oaks and other trees still leafless. At Smithfield we crossed a river flowing westward, or towards the Monongahela and Gulf of Mexico, and soon afterwards passed the grave of General Braddock, and followed the line of his disastrous march towards Fort Duquesne, now Pittsburg.

At length we reached Laurel Hill, so called from its rhododendrons, the last of the great parallel ridges of the Alleghanies. From this height we looked down upon a splendid prospect, the low undulating country to the west, appearing spread out far and wide before us, and glowing with the rays of the setting sun. At our feet lay the small town of Union, its site being marked by a thin cloud of smoke, which pleased us by recalling to our minds a familiar feature in the English landscape, not seen in our tour through the regions where they burn anthracite, to the east of the Alleghanies.

After enjoying the view for some time we began to descend rapidly, and at every step saw the forest, so leafless and wintry a few hours before, recover its foliage, till the trees and the climate spoke again of spring. I had passed several times over the Pyrenees and the Alps, and witnessed the changes of vegetation between the opposite flanks, or between the summits and base of those mountains; but this was the first time I had crossed a great natural barrier, and found on the other side people speaking the same language, and having precisely the same laws and political institutions.

The parallel ridges before alluded to, between Frostburg and Union, were formed partly of red sandstones (Old Red), but chiefly of white grit, the lowest member of the carboniferous group, each flexure or arch opening out and flattening as we went westward, in the manner explained in my description of the section at p. 92. Vol. I., the strata at the same time becoming more and more horizontal.

At the town of Union, which may be said to lie at the western foot of the mountains, I had an opportunity of seeing coal exposed to view in an open quarry of building stone. The coal seam was three and a half feet thick, with an intervening layer, as usual, between it and the freestone of dark slate or shale, four feet thick. When traced farther, the shale thinned out gradually, and in a neighbouring quarry, about thirty yards distant, it gave place to the yellow micaceous sandstone, which then formed the roof of the coal. These sandstone roofs are comparatively rare in America, as in Europe.

From Union, we went to Brownsville on the Monongahela, a large tributary of the Ohio, where the country consists of coal measures, like those at Union, both evidently belonging to the same series as those more bent and curved beds at Frostburg before described. I was truly astonished, now that I had entered the hydrographical basin of the Ohio, at beholding the richness of the seams of coal, which appear everywhere on the flanks of the hills and at the bottom of the valleys, and which are accessible in a degree I never witnessed elsewhere. The time has not yet arrived, the soil being still densely covered with the primeval forest, and manufacturing industry

To face Vol. II. p. 27.

Pl. VI.

View of the great Coal Seam on the Monongahela at Brownsville, Pennsylvania.

in its infancy, when the full value of this inexhaustible supply of cheap fuel can be appreciated; but the resources which it will one day afford to a region capable, by its agricultural produce alone, of supporting a large population, are truly magnificent. In order to estimate the natural advantages of such a region, we must reflect how three great navigable rivers, such as the Monongahela, Alleghany, and Ohio, intersect it, and lay open on their banks the level seams of coal. I found at Brownsville a bed ten feet thick of good bituminous coal, commonly called the Pittsburg seam, breaking out in the river cliffs near the water's edge. I made a hasty sketch of its appearance from the bridge, looking down the river, in which the reader will see (*a*, Pl. VI.) the coal, ten feet thick, covered by carbonaceous shale (*b*), and this again by micaceous sandstone (*c*). Horizontal galleries may be driven everywhere at very slight expense, and so worked as to drain themselves, while the cars, laden with coal and attached to each other, glide down, as shown in the plate, on a railway, so as to deliver their burden into barges moored to the river's bank. The same seam is seen at a distance, on the right bank (at *a*), and may be followed the whole way to Pittsburg, fifty miles distant. As it is nearly horizontal, while the river descends it crops out at a continually increasing, but never at an inconvenient, height above the Monongahela. Below the great bed of coal at Brownsville is a fire-clay eighteen inches thick, and, below this, several beds of limestone, below which again are other coal seams. I have also shown in my sketch another layer of workable coal (at *d*, *d*), which breaks out on the slope of the hills at a greater height. Almost every proprietor can open a coal-pit on his own land, and, the stratification being very regular, they may calculate with precision the depth at which the coal may be won.

So great are the facilities of procuring this excellent fuel, that already it is found profitable to convey it in flat-bottomed boats for the use of steam-ships at New Orleans, 1100 miles distant, in spite of the dense forests bordering the intermediate river-plains, where timber may be obtained at the cost of felling it. But no idea can be formed of the importance of these American coal-seams, until we reflect on the prodigious area over which they are continuous. The boundaries of the Pittsburg seam have been determined with considerable accuracy by the Professors Rogers in Pennsylvania, Virginia, and Ohio, and they have found the elliptical area which it occupies to be 225 miles in its longest diameter, while its maximum breadth is about one hundred miles, its superficial extent being about fourteen thousand square miles.*

In the acompanying map (Pl. II.), the reader will see a sketch of the outline of what has been called the Appalachian coal-field, the vast area of which was before alluded to at p. 88. Vol. I., as extending for a distance of 720 miles from N. E. to S. W., its greatest width being about 180 miles. This outline must be regarded as giving a mere approximation to its true limits, but when the State Surveys of Pennsylvania and Virginia are published, the extent of this great coal-field will be most accurately delineated. While alluding to the vast area of these carboniferous formations in the United States, so rich in productive coal, I may call attention to the Illinois coal-field, the area of which has been also laid down on the map (Pl. II.), reduced from a large map of the Western States executed by Mr. Dale Owen of Indiana, and of which he has liberally given me the free use for the present publication. That coal-field, comprehending parts of Illinois, Indiana, and Kentucky, is not much inferior in dimensions to the whole of England, and consists of horizontal strata, with numerous rich seams of bituminous coal. Its position relatively to

* Trans. of Amer. Geol. 1840, p. 446.

the Appalachian coal-field may be seen in the western part of the section at p. 92. Vol. I.*

At the edge of the left bank of the Monongahela, we collected shells of many species of freshwater muscles (*Unio*), and were much interested in finding them all different from those which we had previously met with in the Connecticut, Delaware, and other eastern rivers. We had now in fact entered an entirely new zoological province, so far as conchology was concerned.

May 15. 1842.—We embarked at Brownsville for Pittsburg in a long narrow steamer, which drew only eighteen inches water, and had a single paddle behind like the overshot wheel of a mill. It threw up a shower of spray like a fountain, which had a picturesque effect. The iron-works of the machinery and the furnace were all exposed to view, and the engineers were on deck in a place cooled by the free circulation of air.

The wooded hills rise to the height of from 300 to 450 feet above the river between Brownsville and Pittsburg. (See Pl. VI.) The latter place is situated at the junction of the Alleghany and Monongahela rivers, which after their union form the Ohio. It is a most flourishing town, and we counted twenty-two large steam-boats anchored off the wharfs.

* See also Description of Map.

From the summit of the hill, 460 feet high, on the left bank of the Monongahela, we had a fine view of Pittsburg, partially concealed by the smoke of its numerous factories. A great many fine bridges span the two broad rivers above their junction. In the same hill, I saw a fine section of the horizontal coal-measures. Far below the principal seam, and near the level of the river, there is a bed of coal a few inches thick, resting on clay. Upon this coal are layers of shale and limestone, in which I found the same *Bellerophon* allied to, or identical with, *B. Urii*, and the same *Leptæna sarcinulata*, *Spirifer*, allied to *S. Urii*, and other shells, which occur at Frostburg, together with *Encrinus*, and a small coral.

The steam-boats on the Ohio cannot be depended upon for punctual departure at the appointed hour, like those of the Hudson or Delaware. I therefore took places in a coach for Wheeling, and crossed a low and nearly level country, where I was struck with the absence of drift and boulders, so common in the north. The carboniferous strata were exposed on the banks of every small streamlet, and not concealed by any superficial covering. On reaching one of those innumerable towns to which, as if for the sake of confusion, the name of Washington has been given, I received the agreeable intelligence that, instead of travelling to Wheeling before sunset, I must wait till another mail came up in the middle of the night. I was very indignant at this breach of promise, but was soon appeased by the good-natured landlord and postmaster, who addressed me by the conciliatory appellation of "Major," and assured me that the new post-office regulation was as inconvenient to him as it could possibly be to us.

The next day we embarked at Wheeling on the Ohio for Marietta. I had been requested by my geological friends, when at Philadelphia, to make inquiries respecting some Indian corn said to have been found fossil at some depth in a stratified deposit near Fish Creek, a tributary of the Ohio, and presumed to be of high antiquity. A proprietor who had resided twenty-six years near the spot assured me that the corn occurred in an island in the river at the depth of no more than two feet below the surface of the alluvial soil. It consisted of parched corn, such as the Indians often buried when alarmed, and in the present year the Ohio had risen so high as to inundate the very spot, and throw down several fresh layers of mud upon the site of the corn.

Five miles below Wheeling, on the left bank of the Ohio, is a terrace of stratified sand and gravel, having its surface about seventy-five feet above the Ohio. On this terrace is seen a large Indian mound.

On our arriving at Marietta, I learnt from Dr. Hildreth that skeletons had been found in it at various depths, together with pipe-heads and other ornaments. Their workmanship implies a more advanced state of the arts than that attained by the rude Indians who inhabited this fertile valley when it was first discovered by the white man. There are many other similar mounds in the valleys of the Ohio and its tributaries, but no tradition concerning their origin. One of these, near Marietta, in which human bones were dug up, must be more than eight centuries old, for Dr. Hildreth counted eight hundred rings of annual growth in a tree which grew upon it. But, however high may be the historical antiquity of the mounds, they stand on alluvial terraces which are evidently of a very modern geological date. In America, as in Europe, the oldest monuments of human labour are as things of yesterday in comparison with the effects of physical causes which were in operation after the existing continents had acquired the leading features of hill and valley, river and lake, which now belong to them. Dr. Locke of Cincinnati has shown that one of the earthworks, enclosing about one hundred acres on the great Miami, although nearly entire, has been overflowed in a few places, and partially obliterated. He infers from this and other facts, that these mounds extending to high-water mark, and liable to be occasionally submerged, were constructed when the streams had already reached their present levels, or, in other words, their channels have not been deepened in the last 1000 or 2000 years.*

The arguments for assigning a very remote period to the Indian antiquities above alluded to, have been stated with great force and clearness by General Harrison, late President of the United States, who was practically versed in woodcraft, and all that relates to the clearing of new lands. In his essay on the aborigines of the Ohio valley †, he states, that some of these earthworks are not mere mounds, but extensive lines of embankment, varying from a few feet to ninety feet in altitude, and enclosing areas of from one to several hundred acres.

"Their sites," he says, "present precisely the same appearance as the circumjacent forest. You find on them all that beautiful variety of trees which give such unrivalled richness to our forests. This is particularly the case on the fifteen acres included within the walls of the work at the mouth of the great Miami, and the relative proportions of the different kinds of timber are about the same."

He then goes on to observe that if you cut down

* Trans. of Amer. Geologists and Naturalists, p. 232.

† Trans. of Hist. and Phil. Soc. of Ohio, vol. i. 1839.

the wood on any piece of wild land, and abandon it to nature, the trees do not grow up as before, but one or two, or at most three species get possession of the whole ground, such for example as the yellow locust, or the black and white walnut. The process by which the forest recovers its original state is extremely slow. "On a farm of my own," says he, "at the end of fifty years, so little progress had been made, as to show that ten times that period would be necessary to effect its complete assimilation. When those kinds of timber which first establish themselves have for a long time remained undisputed masters of the soil, they at length die by disease, or are thinned by the lightning and tempest. The soil has no longer a preference for them, and by a natural rotation of crops other species succeed, till at length the more homogeneous growth ceases, and the denuded tract is again clothed with a variety of wood." As the sites of the earthworks command extensive views, it is reasonable to infer that no trees were suffered by the Indians to spring up upon them or in the immediate neighbourhood, and as no difference could be detected in the mixture of trees upon and near the mounds from the state of the surrounding forest, General Harrison concludes that several generations of trees had succeeded each other, before the present trees began to grow, and that the mounds were probably as ancient at least as the Christian æra. The rich valley of the Ohio, when first discovered by Europeans, was thinly peopled by rude tribes of Indian hunters. In what manner then could they have conquered and driven out that more civilized race which evidently preceded them? Harrison suggests that a great flood, like those which occurred in 1793 and 1832 after heavy rain, when the Ohio was unusually blocked up with ice, may have swept off Indian towns and villages, and caused the terrified occupants to remove. The flood would be construed by their superstition into a warning from heaven to seek a residence upon some smaller streams; and before the remembrance of this fearful calamity had been effaced from their imaginations, the deserted region would, from its great fertility, become an unusual resort of game. It would then be a common hunting ground for the hostile tribes of the north and south, and consequently a great arena for battle. In this state it continued when first visited by the whites.

Dr. Morton, in his luminous and philosophical essay on the aboriginal race of America, seems to have proved that all the different tribes, except the Esquimaux, are of one race, and that this race is peculiar and distinct from all others.* The physical

* Philadelphia, 1844.

characteristics of the Fuegians, the Indians of the tropical plains, those of the Rocky Mountains, and of the great valley of the Mississippi, are the same, not only in regard to feature and external lineaments, but also in osteological structure. After comparing nearly 400 crania derived from tribes inhabiting almost every region of both Americas, Dr. Morton has found the same peculiar shape pervading all, "the squared or rounded head, the flattened or vertical occiput, the high cheek bones, the ponderous maxillæ, the large quadrangular orbits, and the low receding forehead." The oldest skulls from the cemeteries of Peru, the tombs of Mexico, or the mounds of the Mississippi and Ohio, agree with each other, and are of the same type as the heads of the most savage existing tribes. If we next turn to their arts and inventions, we find that a canoe excavated from a single log was the principal vessel in use throughout the New World at the period of its discovery, the same primitive model existing among the Fuegians, the predatory Caribs, and the more advanced Mexicans and Peruvians.

But although the various tribes remained in general as stationary in all matters requiring intellectual effort, as in their nautical contrivances, we behold with surprise certain points, of which Mexico was the most remarkable, where an indigenous and peculiar civilization had been developed, and had reached a high degree of perfection. However much we may admire their architecture, their picture-writing, and historical records, it is their astronomical science in particular, as Mr. Prescott observes, which was disproportioned to their advancement in other walks of civilization.* They had fixed the true length of the tropical year with a precision unknown to the great philosophers of antiquity, which could only be the result of a long series of nice and patient observations. By intercalating a certain number of days into the year at the expiration of every fifty-two years, they had even anticipated the Gregorian reform, so that their calendar at the time of the conquest was more correct than that of the Europeans. To ascribe the civilization of the Toltecs to an Asiatic origin, while it is admitted that there was no correspondence or relationship between their language and that of any known Asiatic nation, appears to me a baseless hypothesis, however true it may be that the aboriginal Americans had in the course of ages derived some hints from foreign sources. They could only have taken advantage of such aid, conjectural as it is, and without proof, if they were already in a highly progressive state; and if such assistance be deemed sufficient to invalidate their title to an independent civilization, no race of

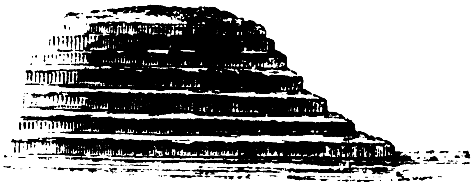
* Conquest of Mexico, vol. i. p. 111.

mankind can ever make good their claim to such an honour.

If, then, a large continent can be inhabited by hundreds of tribes, all belonging to the same race, and nearly all remaining for centuries in a state of apparently hopeless barbarism, while two or three of them make a start in their social condition, and in the arts and sciences; if these same nations, when brought into contact with Europeans, relapse and retrograde until they are scarcely distinguishable in intellectual rank from the rude hunter tribes descended from a common stock; what caution ought we not to observe when speculating on the inherent capacities of any other great member of the human family. The negro, for example, may have remained stationary in all hitherto explored parts of the African continent, and may even have become more barbarous when brought within the influence of the white man, and yet may possess within his bosom the germ of a civilisation as active and refined as that of the golden age of Tezcuco.

In proportion as the Ohio falls gradually in level after its inundations, it leaves a great succession of steps cut in its mud banks, each from four to ten inches above the other. I was informed that the action of the waves raised by the steam-boats causes this undermining of the bank. It appeared to me an exact miniature representation of the form in which the waves of the sea have denuded the land on the sides

Fig. 8.



Form of mud-banks of the Ohio River.

of some valleys in the limestone districts of Sicily and other countries bordering the Mediterranean.

When at Marietta, I examined, with Dr. Hildreth, some of the uppermost beds of the coal-measures, consisting of red shale, in which impressions of ferns, especially *Pecopteris cyathæa* Brongn., or a species closely allied to it, abound. From a locality in this part of Ohio, which I did not visit, but which must belong to the newest division of the carboniferous strata, the trunks of silicified trees have been procured in abundance, with one of which Dr. Hildreth presented me, and which Mr. R. Brown has since ascertained to belong to the genus *Psaronius* of Cotta. These stems, usually called Psarolites, have also been described by M. Ad. Brongniart as composed of two distinct parts, an outer zone, consisting of a great number of nearly cylindrical bundles of vessels, supposed to have been roots which proceeded from the stem near its base, and an inner part or axis. In the exterior portion, the fossil *air-roots* have a vascular tissue, but there is often a delicate cellular tissue interposed between them. In the axis, on the other hand, or central part of the stem, the vessels form zigzag or wavy bands, resembling those of ferns. These flexuous and vermiform bands are entirely composed of barred or scalariform vessels quite similar to those of ferns and Lycopodia. M. Adolphe Brongniart, therefore, considers the psarolites to have been the bases of the trunks of lycopodiaceous trees; but other eminent botanists incline rather to the opinion that they were true arborescent ferns.

I have examined at Autun, in France, the spot where more than one species of this genus occurs. The geological position of the fossils, as well as the associated plants and ichthyolites, imply that the beds containing them belong to the uppermost coal measures. The same appears to hold true of the strata at Chemnitz in Saxony, from which Cotta procured several species, as also in regard to the only other places in Europe where psarolites have been met with, namely, Neu Paka in Bohemia, and Ilmenau in Saxe Weimar. Some species are common to each of the spots above enumerated; but the American fossil appears to have been distinct from all, and is remarkable for the small size of the outer zone of roots when compared to the central axis. The latter is often no more than two inches in diameter, while the whole trunk is fourteen inches. My friend Mr. Robert Brown possesses a psarolite which he received from the northern part of Brazil.

May 20.—From Marietta we descended the river, about a hundred miles, to Pomeroy, where I entered a coal mine which had been worked horizontally in the face of a cliff on the right bank of the Ohio. The coal was bituminous, and I have already mentioned (p. 248. Vol. I.) that Dr. Percy has found the proportion of volatile ingredients (hydrogen, oxygen, and nitrogen) to constitute nineteen per cent. of the whole mass, which, except a slight quantity of ash, is all carbon.* In appearance, the coal greatly resembles charcoal, and, although very pure, its structure displays, in a remarkable manner, the vegetable origin of the mass. In the roof or ceiling of the gallery were seen flattened stems of *Calamites Suckowii* and *C. dubius*, matted together, in the same manner as I have seen these species occurring in the shales of our English coal mines, especially in Northumberland and Durham. The leaves, also, of ferns, *Pecopteris arborescens*, *P. plumosa*, *Neuropteris*

* See Journ. of Geol. Soc. London, vol. i. p. 207.

cordata, Cyclopteris dilatata, besides *Asterophyllites foliosa, Flabellaria,* and other plants, were spread out on the flat surfaces of the shale. The Sigillariæ are particularly abundant in the Ohio coal-field, and about half of those which I obtained are decidedly identical with European species.

We were fortunate, when at Pomeroy, to fall in with some New England settlers, who were nearly related to several of our most valued friends at Boston. Their description of what they had gone through since they first founded this flourishing colony in the wilderness, reminded us of that entertaining volume recently published in the United States, called "A New Home: Who'll Follow?" It is not the trees and their rank growth on the uncleared land, nor the wild animals, which are the most uncongenial *neighbours* to persons of superior education and refinement in a new settlement. To enjoy facilities, therefore, of communicating rapidly with the civilized Eastern States by founding their new town on the banks of a great navigable river, or close to some main road in the interior, is a privilege truly enviable. I remember wondering, when I first read Homer's graphic sketch of the advantages of wealth, that he should have placed his rich man's mansion on the road side—

ὁδῷ ἐπι οἰκια ναιων.

To an Englishman, the poet's notion seemed very un-aristocratic, for we are almost irresistibly reminded of the large sums which an English country gentleman would expend in order to remove the high road to a respectful distance. Probably the present condition of Ohio, rather than that of a county of parks and mansions like Surrey, was the model most frequently present to the minds of the migratory Greeks of the Homeric age.

From Pomeroy, a large steam-boat carried us more than 200 miles in about fifteen hours, down the broad, winding stream, past many a well-wooded island, to Cincinnati, where we were struck with the appearance of commercial activity, the numerous wharfs and steam-boats, the wide streets and handsome buildings.

CHAPTER XVI.

Succession of Strata on the Ohio between Pomeroy and Cincinnati. —Return up the Ohio to Rockville.— Waverley Sandstone.— Cliff Limestone. —Denudation. —Blue Limestone of Cincinnati. —Lower Silurian Fossils.—Limited Proportion of Silurian Species common to Europe and America.— Great Development of Brachiopoda.—Deep Sea Formations.—Rarity of Silurian Land Plants.— Silurian Fossil Fish.

BETWEEN the western extremity of the Appalachian coal-field and Cincinnati, as will be seen by referring to the section given at p. 92. Vol. I., the different formations, from the Devonian to the Lower Silurian inclusive, come up to the surface in succession, being well exposed in the cliffs or steep slopes of the hills which bound the Ohio valley. I have already mentioned a fine seam of coal at Pomeroy, beneath which, farther to the westward, the lower coal-measures are seen, and at length at Portsmouth, the inferior conglomerate or millstone grit, next to which, the formation, called by the Ohio geologists the Waverley sandstone, the equivalent of the Devonian formation (No. 9. in the large map, Pl. II.), makes its appearance. To this sandstone, the Upper Silurian slates and limestones (Nos. 10, 11. and 13. of the map) succeed in the descending order, and lastly, at Cincinnati, the Lower Silurian groups (Nos. 14. and 15. of the map) are exhibited in the hills, and in the bed of the Ohio at low water.

Having, when I came down the Ohio, made the last part of my journey in the dark, I re-ascended the river for a hundred miles, in company with Dr. Locke, a geologist lately engaged in the State survey of Ohio, and who liberally devoted his time to aid me in my inquiries. I was desirous of seeing the rocks corresponding to the Old Red sandstone before mentioned, and with this view we landed at Rockville, about eighteen miles below Portsmouth, and examined the Waverley sandstone at that place. Retaining in my mind a perfect recollection of the aspect of the deposits intervening in the state of New York, between the Coal and the Upper Silurian groups, at the distances of 400 and 500 miles, I was struck with their extraordinary decrease in volume, the absence of some formations, and the complete identity of those sets of strata which remained. I have before alluded to the gradual thinning out of the coarse sedimentary rocks, both in the Silurian and Carboniferous series of the U. S., as we proceed westward, and the increased thickness of many of the calcareous formations. The Waverley sandstone of Rockville has been recognised by Mr. Hall as the representative of the Chemung and Portage groups of the New York Reports. It contains here many ripple-marked flags with partings of shale. The surfaces of the slabs of sandstone display the festoon-shaped fucoid, called here *Fucoides cauda galli*, from its resemblance to a cock's tail. I saw some single individuals of this plant extending through layers eight inches thick. There were no associated shells; but in some of the uppermost strata of the series we found spirifers and other brachiopods, with many encrinites.

Between Rockville and Cincinnati the bituminous shales corresponding to the Hamilton group (or No. 10. of the large map) are seen, and below them what is called the "Cliff limestone," which is considered, and I believe correctly, by Mr. Hall, as the representative both of the Helderberg and Niagara limestones of New York. Among the characteristic shells, I observed the *Pentamerus oblongus*, so abundant in the Clinton group of New York, a shell considered by Messrs. Murchison and De Verneuil to mark the line of separation between the Upper and Lower Silurian rocks of Europe.

In discussing with Dr. Locke the probability of the former continuity of the Illinois and Appalachian coal-fields (see the section, Vol. I. p. 92.), and the possible extension of the strata (Nos. 5, 6. and part of 7. of that section, or 9, 10, 11. and 13. of the large map) over that flat dome on the middle part of which Cincinnati is built, we endeavoured to calculate the height which the central area would have attained, if the formations supposed to have been removed by denudation were again restored. In that case the thickness of the strata of coal, subjacent conglomerate, Devonian and Upper Silurian beds, which must have been carried away, could not, if we estimate their development from the mean of their aggregate dimensions on the east and west of Cincinnati, have been less than 2000 feet. The tops of the hills near Cincinnati, composed of the blue limestone, are about 1400 feet above the level of the sea. If, then, the formations presumed to have been destroyed by denudation were replaced, the height of the dome would be about 3500 feet, or exceeding the average elevation of the Alleghany Mountains.

The thinning out and disappearance of the mudstones and sandstones of the more eastern States, causing limestones, such as the Helderberg and Niagara, so widely separated in New York, to unite and form single and indivisible masses in Ohio, affords no argument against the classification of the New York geologists. Their grouping of the subordinate members of the Devonian and Silurian systems has been based on sound principles; on mixed geographical, lithological, and paleontological considerations; and the analogy of European geology teaches us that minor subdivisions, however useful and important within certain limits, are never applicable to countries extremely remote from each other, or to areas of indefinite extent.

The rock forming the hills and table lands around Cincinnati, called the blue limestone, has been commonly referred to the age of the Trenton limestone of New York (No. 15., map, Pl. II.), but is considered by Messrs. Conrad and Hall, and I believe with good reason, as comprehending also the Hudson River group (No. 14. of map). It seems impossible, however, to separate these divisions in Ohio, so that the district coloured blue (No. 15.) may be regarded as agreeing with Nos. 14. and 15. in other parts of my map. Several of the fossils which I collected at Cincinnati, the encrinites and Aviculæ (of the subgenus *Pterinea*) in particular, agree with those which I afterwards procured near Toronto, on the northern shores of Lake Ontario.

After seeing at Cincinnati several fine collections of recent and fossil shells in the cabinets of Messrs. Buchanan, Anthony, and Clark, I examined with care the quarries of blue limestone and marl in the suburbs. The organic remains here are remarkably well preserved for so ancient a rock, especially those occurring in a compact argillaceous blue limestone, not unlike the lias of Europe. Its deposition appears to have gone on very tranquilly, as the Lingula has been met with in its natural and erect position, as if enclosed in mud when alive, or still standing on its peduncle. Crustaceans of the genus *Trinucleus* are found spread out in great numbers on layers of the solid marl, as also another kind of trilobite, called *Paradoxides*, equally characteristic of the Lower Silurian system of Europe. The large *Isotelus gigas*, three or four inches long, a form represented, in the Lower Silurian of Northern Europe, by the Asaphi with eight abdominal articulations, deserves also to be mentioned, and a species of graptolite. I obtained also *Spirifer lynx* in great abundance, a shell which Messrs. Murchison and De Verneuil regard as very characteristic of the lowest Silurian beds of Russia and Sweden. Among the mollusca, I may also mention *Leptæna sericea*, *Orthis striatula*, *Bellerophon bilobatus*, *Aviculæ* of the subgenus *Pterinea*, *Cypricardia*, *Orthoceras*, and others. There were also some beautiful forms of Crinoidea, or stone-lilies, and many corals, which Mr. Lonsdale informs me differ considerably from those hitherto known in Britain, a circumstance probably arising from the small development of coralline limestones in the Lower Silurian strata of our island. Several species of the new genus Stenopora of Lonsdale are remarkably abundant.

In regard to the proportion of species common to the Silurian beds of Europe and America, whether of the lower or upper division, I may confidently affirm, that it is not greater than a naturalist would have anticipated, from the analogy of the laws governing the distribution of living invertebrate animals. A contrary opinion has prevailed very widely, it being rashly assumed, that at remote epochs the majority of species were far more cosmopolite than in modern times.

The recent researches of Messrs. Murchison and De Verneuil point to the conclusion that the fossil shells, corals, and trilobites of the Silurian system of Scandinavia and Russia, resemble greatly those of the British Isles; yet nearly half the species which they collected there were different from ours, and the departure from a common type was far more conspicuous in the Lower Silurian fossils of Britain and Russia, than in those of the upper division. When the same fossils of Northern Europe were compared by M. de Verneuil with those brought by me from America, the distinctness was obviously much greater, although the representation of generic forms, whether in the organic remains of the upper or lower Silurian strata, was most clear and satisfactory.

On both sides of the Atlantic, these ancient marine formations are characterized by a prodigious development of one peculiar family of mollusca, called brachiopoda (palliobranchiata) — shells, which, as they inhabit deep water, are little known, and have received no common name in our language. They are represented by the living genera Terebratula, Orthis, Lingula, Orbicula, and Crania. The existence of Orthis, a form till lately supposed to be extinct, has been made known to us by the researches of Philippi in the Mediterranean. Some other genera may hereafter be detected by deep dredging, for we learn from Professor E. Forbes, that at the depth of 100 fathoms in the Mediterranean the profusion of individuals of certain species of Terebratula is extremely great. Nevertheless it may be safely assumed, that the present seas, as well as the tertiary strata of the epochs immediately preceding our own, exhibit a smaller variety in the forms of this tribe of mollusca than the Silurian rocks in which they seem to have attained their maximum of development. The oldest known fossiliferous period was in fact the age of brachiopods; as the carboniferous period was that of ferns, and the oolitic that of reptiles.

The great number of crustaceans of the extinct family called *Trilobites*, is also another feature of the formations older than the carboniferous, and especially of the Silurian rocks. No country is richer in fossils of this class than the United States; and Mr. Conrad has given a table of distinct genera of trilobites, which characterise his Upper, Middle, and Lower Silurian formations of New York, each of which larger divisions he considers to be quite as distinct as the Devonian, and as capable of being classed as an independent group by reference to organic remains.*

There are some negative characters showing a resemblance between the most ancient of the fossiliferous rocks yet known in Europe and America, which deserve notice, although they belong to a perfectly different order from those before mentioned, as deduced from the analogy of organic forms. Of these points of agreement, the most remarkable are the absence or extreme rarity of land plants and vertebrate animals. That the vegetable world had already been called into existence is proved by the presence of various forms of fucoids, which are plentifully distributed through every part of the series. Some of the slabs of the lowest Silurian slates of Wales are covered with sea-weeds of such genera as are plainly indicative,

* Journ. of Acad. Nat. Sci. Philadelphia, 1842, vol. viii. part 2. p. 233.

like the brachiopoda, of deep water. There is, indeed, every reason to conclude that the Silurian deposits generally were formed far from land, which would alone explain the extreme scarcity of terrestrial plants; for how seldom do we meet with wood or fruits floating in mid ocean; and, if they are sometimes carried there by currents, how rarely can we expect them to sink to the bottom precisely in those places where, before decay, they may become enveloped and permanently preserved in sediment.

A few examples, however, of Devonian and Silurian land plants have been brought to light in the course of the New York survey. One of these was shown me by Mr. Vanuxem, and has been figured in his final Report, p. 157. It appeared to me more allied to the Lepidodendron than any fossil genus hitherto described. Its position is in the Hamilton or Upper Silurian group, in which we find a great variety of trilobites, Spiriferæ, and other brachiopoda and corals, all agreeing perfectly with European Upper Silurian types. Other plants allied to these, and ferns, have been met with in the lowest Devonian or Chemung strata of the State of New York (the olive slate of Pennsylvania and Virginia), associated with fossil shells, very closely allied to the Silurian.*

* Hall's Report, p. 276.

These exceptions to the general rule have been found in those eastern parts of the United States where the Devonian and Silurian sandstones and mudstones are of the greatest thickness, and which we may therefore presume to have originated nearest to the lands then exposed to denudation. The neighbouring continent of that remote epoch may probably have occupied the space now covered by the Atlantic, and there may have been another in the Pacific, while the lands now existing were then the site of deep oceans.

The greater the lapse of ages which separates the origin of a given set of strata from our own times, the greater is the probability that our acquaintance with those strata will relate chiefly to pelagic deposits, or those formed in deep seas, and far from land. It must require a long continuance of subterranean movements, and a frequent shifting of the principal areas of upheaval, before extensive tracts of the bed of deep oceans, such as the Atlantic and Pacific, can be converted into continents. On the other hand, we may presume that the estuary, littoral, and lacustrine strata of such remote ages, being at first of small horizontal extent, as compared to the contemporaneous coral reefs and fine sedimentary deposits of the ocean, would have become in great part submerged, or covered by newer formations, or destroyed by denudation, during that immense interval of time which separates their origin from our own period.

In regard to the rarity of marine vertebrate animals in the oldest rocks, it may perhaps be no greater than is observed in strata of more modern date, formed in seas of equal depth, or at points as remote from the land. Many years have not elapsed since the Old Red sandstone was thought to be barren of ichthyolites; but now, in addition to the numerous genera found in Scotland by Mr. Hugh Miller, and those described by M. Agassiz, the last-mentioned zoologist has announced that nine genera of sharks of the division Cestracion occur in the Devonian beds of Russia, examined by Messrs. Murchison and De Verneuil. The appearance of fish so highly organised in some of the oldest formations, is strongly opposed to the theory of progressive development advocated by some writers, and imagined by them to derive support from recent geological discoveries.

In England, the remains of fish have long been known in the highest beds of the Upper Silurian, and they have lately been found as far down as the Wenlock limestone. The New York surveyors have met with them in more than one member of the Helderberg series (No. 11. Map. pl. II.). Long ichthyodorulites, or spines of the dorsal fins of fishes, have been obtained, for example, from the Corniferous limestone.

But the lowest rock in which they have been traced in America is, I believe, the Clinton group, which may be considered the bottom of the Upper, or top of the Lower, Silurian series. Mr. H. D. Rogers informs me, that he and his brother have traced the scales of fish through strata of this series from the south-western part of Virginia to the north branch of the Susquehanna, in Pennsylvania.

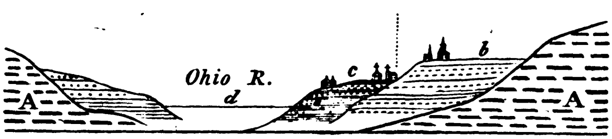
Professor E. Forbes, after acquiring much experience, by dredging in the Mediterranean, of the fauna which characterizes the sea at different depths, has inferred that the Silurian seas in those areas hitherto examined were at first very deep and tranquil, although in parts they afterwards grew shallower. The following are the principal grounds of this conclusion:— first, the small size of the greater number of conchifera; secondly, the paucity of pectinibranchiata (or spiral univalves); thirdly, the great number of floaters, such as Bellerophon, Orthoceras, &c.; fourthly, the abundance of brachiopoda; fifthly, the absence or great rarity of fossil fish; sixthly, the deep-water forms of most of the sea-weeds; and seventhly, the absence of land plants.

CHAPTER XVII.

Alluvial Terraces at Cincinnati, and their Origin.—Bones of the Elephant and Mastodon.—Excursion to the Swamps of Big Bone Lick in Kentucky.—Noble Forest.—Salt Springs.—Buffalo Trails.—Numerous Bones of extinct Animals.—Associated Freshwater and Land Shells.—Relative Age of Northern Drift, and Deposits with Bones of Mastodon on the Ohio.

THE Ohio river at Cincinnati, and immediately above and below it, is bounded on its right bank by two terraces, on which the city is built; the streets in the upper and lower part of it standing on different levels. These terraces are composed of sand, gravel, and loam, such as the river, if blocked up by some barrier, might now be supposed to sweep down in its current, and deposit in a lake. The upper terrace, *b*, (fig. 9.) is bounded by steep hills of ancient fossiliferous rocks, A, the blue, Lower Silurian limestone, mentioned in the last chapter, in horizontal stratification. The higher terrace, *b*, is about 60 feet above the lower, *c*, and this again about 60 feet above low water in the Ohio, *d*. The geologists here are convinced that the inferior terrace, *c*, is of newer origin than *b*, as shown in the section (fig. 9.), and proved by excavations, not exposed at the time of my visit.

Fig. 9.



A. Blue limestone (Lower Silurian).
b. Upper terrace. *c*. Lower terrace.
e. Fossil wood and nuts, &c. found here in silt.

In sinking a well through *c*, at the distance of 300 yards from the Ohio, and at the depth of 50 feet from the surface, they found, at *e*, pieces of wood and many walnuts in a bed of silt.

Near the edge of the higher terrace, in digging a gravel-pit, which I saw open at the end of Sixth street, they discovered lately the teeth of the *Elephas primigenius*, the same extinct species which is met with in very analogous situations on the banks of the Thames, and the same which was found preserved entire with its flesh in the ice of Siberia. Above the stratum from which the tooth was obtained, I observed about six feet of gravel covered by ten feet of fine yellow loam, and below it were alternations of gravel, loam, and sand, for 20 feet. But I searched in vain for any accompanying fossil shells. These, however, have been found in a similar situation at Mill Creek, near Cincinnati; a place where several teeth of mastodons have been met with. They belong to the genera *Melania, Lymnæa, Amnicola, Succinea, Physa, Planorbis, Paludina, Cyclas, Helix,* and *Pupa*, all of recent species, and nearly all known to inhabit the immediate neighbourhood. I was also informed that, near Wheeling, a bed of freshwater shells, one foot thick, of the genus *Unio*, is exposed at the height of 120 feet above the mean level of the Ohio. The remains of the common American mastodon (*M. giganteus*) have also been found at several points in the strata in the upper terrace, both above and below Cincinnati.

Upon the whole it appears, that the strata of loam, clay, and gravel forming the elevated terraces on both sides of the Ohio and its tributaries, and which we know to have remained unaltered from the era of the Indian mounds and earthworks, originated subsequently to the period of the existing mollusca, but when several quadrupeds now extinct inhabited this continent. The lower parts both of the larger and smaller valleys appear to have been filled up with a fluviatile deposit, through which the streams have subsequently cut broad and deep channels. These phenomena very closely resembly those presented by the *loess*, or ancient river-silt of the Rhine and its tributaries, and the theory which I formerly suggested to account for the position of the Rhenish loess (also charged with recent land and freshwater shells, and occasionally with the remains of the extinct elephant) may be applicable to the American deposits.

I imagine first a gradual movement of depression, like that now in progress on the west coast of Greenland, to lessen the fall of the waters, or the height of the land relatively to the ocean. In consequence of the land being thus lowered, the bottoms of the main and lateral valleys become filled up with fluviatile sediment, containing terrestrial and freshwater shells, in the same manner as deltas are formed where rivers meet the sea, the salt-water being excluded, in spite of continued subsidence, by the accumulation of alluvial matter, brought down incessantly from the land above. Afterwards, I suppose an upward movement gradually to restore the country to its former level, and, during this upheaval, the rivers remove a large part of the accumulated mud, sand, and gravel. I have already shown that on the coast of Georgia and South Carolina (see Vol. I. p. 164.), in the United States, we have positive proofs of modern oscillations of level, similar to those here assumed.

Two days after I reached Cincinnati, I set out, in company with two naturalists of that city, Mr. Buchanan and Mr. J. G. Anthony, who kindly offered to be my guides, in an excursion to a place of great geological celebrity in the neighbouring state of Kentucky, called Big Bone Lick, where the bones of mastodons and many other extinct quadrupeds had been dug up in extraordinary abundance. Having crossed the river from Cincinnati, we passed through a forest far more magnificent for the size and variety of its trees than any we had before seen. The tulip-tree (*Liliodendron tulipiferum*) the buckeye, a kind of horse-chestnut, the shagbark hickory, the beech, the oak, the elm, the chestnut, the locust-tree, the sugar-maple, and the willow, were in perfection, but no coniferous trees,— none of the long-leaved pines of the Southern Atlantic border, nor the cypress, cedar, and hemlock of other States. These forests, where there is no undergrowth, are called "wood pastures." Originally the cane covered the ground, but when it was eaten down by the cattle, no new crop could get up, and it was replaced by grass alone.

Big Bone Lick is distant from Cincinnati about twenty-three miles in a S.W. direction. The intervening country is composed of the blue argillaceous limestone and marl before mentioned, the beds of which are nearly horizontal, and form flat table-lands intersected by valleys of moderate depth. In one of these, watered by the Big Bone Creek, occur the boggy grounds and springs called Licks. The term Lick is applied throughout North America to those marshy swamps where saline springs break out, and which are frequented by deer, buffalo, and other wild animals for the sake of the salt, whether dissolved in the water, or thrown down by evaporation in the summer season, so as to encrust the surface of the marsh. Cattle and wild beasts devour this incrustation greedily, and burrow into the clay impregnated with salt, in order to lick the mud. Bartram, the botanist, tells us, that in his time (1790) he visited Buffalo Lick in Georgia, forming part of a cane swamp, in which the head branches of the Ogeechee river take their rise. The lick consisted of "white-coloured tenacious fattish clay, which all kinds of cattle lick into great hollows, pursuing the delicious vein." "I could discover nothing saline in its taste, but an insipid sweetness. Horned cattle, horses, and deer are immoderately fond of it, insomuch that their excrement, which almost totally covers the earth to some distance round this place, appears to be perfect clay, which, when dried by the sun and air, is almost as hard as brick." (Travels in N. and S. Carolina, &c. p. 39.)

The celebrated bog of Kentucky is situated in a nearly level plain, in a valley bounded by gentle slopes, which lead up to the table-lands before mentioned. The general course of the meandering stream which flows through the plain, is from east to west. There are two springs on the southern or left bank, rising from marshes, and two on the opposite bank, the most western of which, called the Gum Lick, is at the point where a small tributary joins the principal stream. The quaking bogs on this side are now more than fifteen acres in extent, but all the marshes were formerly larger before the surrounding forest was partially cleared away. The removal of tall trees has allowed the sun's rays to penetrate freely to the soil, and dry up part of the morass.

Within the memory of persons now living, the wild bisons or buffaloes crowded to these springs, but they have retreated for many years, and are now as unknown to the inhabitants as the mastodon itself. Mr. Phinnel, the proprietor of the land, called our attention to two buffalo paths or trails still extant in the woods here, both leading directly to the springs. One of these in particular, which first strikes off in a northerly direction from the Gum Lick, is afterwards traced eastward through the forest for several miles. It was three or four yards wide, only partially overgrown with grass, and, sixty years ago, was as bare, hard, and well trodden as a high road.

The bog in the spots where the salt springs rise is so soft, that a man may force a pole down into it many yards perpendicularly. It may readily be supposed, therefore, that horses, cows, and other quadrupeds, are now occasionally lost here; and that a much greater number of wild animals were mired formerly. It is well known that, during great droughts in the Pampas of South America, the horses, cattle, and deer throng to the rivers in such numbers, that the foremost of the crowd are pushed into the stream by the pressure of others behind, and are sometimes carried away by thousands and drowned.* In their eagerness to drink the saline waters and lick the salt, the heavy mastodons and elephants seem in like manner to have pressed upon each other, and sunk in these soft quagmires of Kentucky.

The greater proportion both of the entire skeletons of extinct animals, and the separate bones, have been taken up from black mud, about twelve feet below the level of the creek. It is supposed that the bones of mastodons found here could not have belonged to less than one hundred distinct individuals, those of the fossil elephant (*E. primigenius*), to twenty, besides which, a few bones of a stag, horse, megalonyx, and bison, are stated to have been obtained. Whether the common bison, the remains

* Darwin's Journal, p. 156.; Sir W. Parish's Buenos Ayres, pp. 151. and 371.

of which I saw in great numbers in a superficial stratum recently cut open in the river's bank, has ever been seen in such a situation as to prove it to have been contemporaneous with the extinct mastodon, I was unable to ascertain. In regard to the horse, it may probably have differed from our *Equus caballus* as much as the zebra or wild ass, in the same manner as that found at Newberne in North Carolina appears to have done. (See p. 165.) The greatest depth of the black mud has not been ascertained; it is composed chiefly of clay, with a mixture of calcareous matter and sand, and contains 5 parts in 100 of sulphate of lime, with some animal matter. (Cuvier, Oss. Foss. tom. i. p. 216.) Layers of gravel occur in the midst of it at various depths. In some places it rests upon the blue limestone. The only teeth which I myself procured from collectors on the spot, besides those of the buffalo, were recognised by Mr. Owen as belonging to extremely young mastodons. From the place where they were found, and the rolled state of some of the accompanying bones, I suspect that they had been washed out of the soil of the bogs above by the river, which often changes its course after floods.

Mr. Cooper of New York, who has given the fullest account of the fossils of this place, says, that the remains of reeds and freshwater mollusca accompany the bones; but he names no species of shells. Mr. Anthony and I were therefore diligent in our search for shells in pits which happened to have been recently laid open by collectors of fossil bones; and we soon obtained a small *Ancylus* and *Cyclas*. Afterwards, in the most eastern marsh, in the middle of which a powerful spring throws up beech nuts and shells from the mud below, we found two species of *Melania* known as recent, *Physa heterostropha*, *Cyclas similis*, *C. dubia?* (and another species, not known to naturalists here,) *Pisidium* (supposed to agree with one from Lake Erie), *Ancylus* (not known), and fragments of *Unio;* also the following land shells;—*Helix solitaria* (with bands of colour not effaced), *H. alternata*, *H. clausa*, *H. fraterna*, and *Pupa armifera*. As new terrestrial and freshwater shells are occasionally added to the recent American fauna, I think it very probable that all the fourteen species which we met with, and which, I believe, co-existed with the mastodon, are still living, though perhaps not all of them in the immediate neighbourhood.

It is impossible to view this plain, without at once concluding that it has remained unchanged in all its principal features from the period when the extinct quadrupeds inhabited the banks of the Ohio and its tributaries. But one phenomenon perplexed us much, and for a time seemed quite unintelligible. On parts of the boggy grounds, a superficial covering of yellow loam was incumbent on the dark-coloured mud, containing the fossil bones. This partial covering of yellow sandy clay, was at some points no less than fifteen or twenty feet thick. Mr. Bullock passed through it when he dug for fossil remains on the left bank of the creek, and he came down to the boggy ground with bones below. We first resorted to the hypothesis that the valley might have been dammed up by a temporary barrier, and converted into a lake; but we afterwards learnt, that although the Ohio is seven miles distant by the windings of the creek, there being a slight descent the whole way, yet that great river has been known to rise so high as to flow up the valley of Big Bone Creek, and, so late as 1824, to enter the second story of a house built near the springs. The level of the Licks above the Ohio, is about fifty feet, the distance in a straight line being only three miles. At Cincinnati the river has been known to rise sixty feet above its summer level, and in the course of ages it may occasionally have risen higher. It may be unnecessary, therefore, to refer to the general subsidence before alluded to (probably an event of a much older date), in order to account for the patches of superficial silt last described.

After spending the day in exploring the Licks, we were hospitably received at the house of a Kentucky proprietor a few miles distant, whose zeal for farming and introducing cattle of the "true Durham breed," had not prevented him from cultivating a beautiful flower-garden. We were regaled the next morning at breakfast with an excellent dish of broiled squirrels. There are seasons when the grey squirrel swarms here in such numbers, as to strip the trees of their foliage, and the sportsmen revenge themselves after the manner of the Hottentots, when they eat the locusts which have consumed every green thing in Southern Africa.

We then returned by another route through the splendid forest, and re-crossed the Ohio. The weather was cool, and we saw no fire-flies, although I had seen many a few days before, sparkling as they flitted over the marshy grounds bordering the Ohio, in my excursion up the river to Rockville.

Among the inquiries which can hardly fail to awaken the curiosity of a geologist who explores this region, one of the most natural relates to the relative age of the northern drift, and the deposits containing the remains of the mastodon and elephant, whether at Big Bone Lick, or in the higher terrace (*b*, fig. 9.) at Cincinnati. In my journey, some days afterwards, from the Ohio river to Cleveland on Lake Erie, I had not proceeded twenty-five miles to the northward before I again found myself in a country covered with northern drift, of which I had lost sight for many weeks previously. The first patches which I observed were about five miles N.E. of the town of Lebanon, after which I saw it in great abundance at Springfield, with large blocks and boulders of gneiss, reddish syenite, quartzite, and hornblende rock, all of which must have come from the north side of Lake Erie. The Ohio river, therefore, in the north latitude 40° and 41°, seems to mark the southern limit of the drift in this part of North America, although some scattered blocks have gone farther, and reached Kentucky.

I was also told that a boulder of gneiss, twelve feet in diameter, has been found resting on the upper terrace (*b*, *fig.* 9.), four miles north of Cincinnati, and that fragments of granite, in a similar situation, have been met with at that city itself. These may possibly have been brought into their present position since the period of the deposition of the principal mass of northern drift; for although I could not obtain sufficient data for forming an accurate opinion as to the relative age of the drift, and the beds containing the bones of mastodon and elephant, whether in the upper terrace above alluded to, or in the licks of Kentucky, I incline to believe the drift, as a whole, to be the older of the two formations. The swamps of the Big Bone Licks have the same intimate relation to the present superficial geography of the district, as have those marshes and alluvial deposits before described in New York, as containing the remains of mastodon and recent shells, which are decidedly more modern than the drift and its erratic blocks. (Vol. I. pp. 23. 25. and 67.)

CHAPTER XVIII.

Cincinnati.—Journey across Ohio to Cleveland.—New Clearings.—Rapid Progress of the State since the Year 1800.—*Increase of Population in the United States.—Political Discussions.—German and Irish Settlers.—Stump Oratory.—Presidential Elections.—Relative Value of Labour and Land.*

THE pork aristocracy of Cincinnati does not mean those innumerable pigs which walk at large about the streets, as if they owned the town, but a class of rich merchants, who have made their fortunes by killing annually, salting, and exporting, about 200,000 swine. There are, besides these, other wealthy proprietors, who have speculated successfully in land, which often rises rapidly in value as the population increases. The general civilisation and refinement of the citizens is far greater than might have been looked for in a state founded so recently, owing to the great number of families which have come directly from the highly educated part of New England, and have settled here.

As to the free hogs before mentioned, which roam about the handsome streets, they belong to no one in particular, and any citizen is at liberty to take them up, fatten, and kill them. When they increase so fast, the town council interferes, and sells off some of their number. It is a favourite amusement of the boys to ride upon the pigs, and we were shown one sagacious old hog, who was in the habit of lying down as soon as a boy came in sight.

May 29th. — We left Cincinnati for Cleveland on Lake Erie, a distance of 250 miles, and our line of route took us through the centre of the State of Ohio, by Springfield, Columbus, Mount Vernon, and Wooster, at all which places we slept, reaching Cleveland on the fifth day.

In our passage through Ohio, we took advantage of public coaches only when they offered themselves in the daytime, and always found good private carriages for the rest of the way. If some writers, who have recently travelled in this part of America, found the fatigue of the journey excessive, it must have arisen from their practice of pushing on day and night over roads, which are in some places really dangerous in the dark. On our reaching a steep hill north of Mount Vernon, a fellow-passenger pointed out to me a spot where the coach had been lately upset in the night. He said that in the course of the last three years he had been overturned thirteen times between Cincinnati and Cleveland, but being an inside passenger had escaped without serious injury.

In passing from the southern to the northern frontier of Ohio, we left a handsome and populous city and fine roads, and found the towns grow smaller and the high road rougher, as we advanced. When more than half way across the State, and after leaving Mount Vernon, we saw continually new clearings, where the felling, girdling, and burning of trees was going on, and where oats were growing amidst the blackened stumps on land which had never been ploughed, but only broken up with the harrow. The carriage was then jolted for a short space over a corduroy road, constructed of trunks of trees laid side by side, while the hot air of burning timber made us impatient of the slow pace of our carriage. We then lost sight for many leagues of all human habitations, except here and there some empty wooden building, on which "Mover's House" was inscribed in large letters. Here we were told a family of emigrants might pass the night on payment of a small sum. At last the road again improved, and we came to the termination of the table land of Ohio, at a distance of about sixteen miles from Lake Erie. From this point on the summit of Stony Hill we saw at our feet a broad and level plain covered with wood; and beyond, in the horizon, Lake Erie, extending far and wide like the ocean. We then began our descent, and in about three hours reached Cleveland.

The changes in the condition of the country which we had witnessed are illustrations of the course of events which has marked the progress of civilisation in this State, which first began in the south, and spread from the banks of the Ohio. At a later period, when the great Erie canal was finished, which opened a free commercial intercourse with the river Hudson, New York, and the Atlantic, the northern frontier began to acquire wealth and an increase of inhabitants. Ports were founded on the lake, and grew in a few years with almost unparalleled rapidity. The forest then yielded to the axe in a new direction, and settlers migrated from north to south, leaving still a central wilderness between the Ohio and Lake Erie. This forest might have proved for many generations a serious obstacle to the progress of the State, had not the law wisely provided that all non-resident holders of waste lands should be compelled to pay their full share of taxes laid on by the inhabitants of the surrounding districts for new schools and roads. If an absentee is in arrear, the sheriff seizes a portion of his ground contiguous to a town or village, puts it up for auction, and thus discharges the debt, so that it is impossible for a speculator, indifferent to the local interests of a district, to wait year after year, until he is induced by a great bribe to part with his lands, all ready communication between neighbouring and highly cultivated regions being in the mean time cut off.

Ohio was a wilderness exclusively occupied by the Indians, until near the close of the last century. In 1800 its population amounted to 45,365, in the next ten years it had increased five-fold, and in the ten which followed it again more than doubled. In 1840 it had reached 1,600,000 souls, all free, and almost without any admixture of the coloured race. In this short interval the forest had been transformed into a land of steamboats, canals, and flourishing towns; and would have been still more populous had not thousands of its new settlers migrated still farther west into Indiana and Illinois. A portion of the public works which accelerated this marvellous prosperity, were executed with foreign capital, but the interest of the whole has been punctually paid by direct taxes. There is no other example in history, either in the old or new world, of so sudden a rise of a large country to opulence and power. The State contains nearly as wide an extent of arable land as England, all of moderate elevation, so rich in its alluvial plains as to be cropped thirty or forty years without manure, having abundance of fine timber, a temperate climate, many large navigable rivers, a ready communication through Lake Erie with the north and east, and by the Ohio with the south and west, and, lastly, abundance of coal in its eastern counties.

I am informed that, in the beginning of the present year (1842), the foremost bands of emigrants have reached the Platte River, a tributary of the Missouri. This point is said to be only half-way between the Atlantic and the Rocky Mountains, and the country beyond the present frontier is as fertile as that already occupied. De Tocqueville calculated that along the borders of the United States, from Lake Superior to the Gulf of Mexico, extending a distance of more than 1200 miles as the bird flies, the whites advance every year at a mean rate of seventeen miles; and he truly observes that there is a grandeur and solemnity in this gradual and continuous march of the European race towards the Rocky Mountains. He compares it to "a deluge of men rising unabatedly, and daily driven onwards by the hand of God." *

When conversing with a New England friend on the progress of American population, I was surprised to learn, as a statistical fact, that there are more whites now living in North America than all that have died there since the days of Columbus.

* Democracy in America, vol. ii. ch. x. sect. 4.

It seems probable, moreover, that the same remark may hold true for fifty years to come. The census has been very carefully taken in the U. S. since the year 1800, and it appears that the ratio of increase was 35 per cent for the first decennial periods, and that it gradually diminished to about 32 per cent in the last. From these data, Professor Tucker estimates that, in the year 1850, the population will amount in round numbers to 22 millions, in 1860 to 29 millions, in 1870 to 38 millions, in 1880 to 50 millions, in 1890 to 63 millions, and in 1900 to 80 millions.

The territory of the United States is said to amount to one-tenth, or at the utmost to one-eighth of that colonised by Spain on the American continent. Yet in all the vast regions conquered by Cortes and Pizarro, there are considerably less than two millions of people of European blood, so that they scarcely exceed in number the population acquired in about half a century in Ohio, and fall far short of it in wealth and civilisation.

We were perfect strangers in our tour through Ohio, and, when at inns and in public conveyances, had many opportunities of hearing lawyers, merchants, farmers, and labourers, conversing freely and unreservedly together. I have generally abstained from retailing such gossip, reflecting how small would be the value of the opinions which an American could derive from a similar source, or from talk overheard in an English railway or steamboat. I shall, however, depart slightly from my rule on this occasion, as my readers may, perhaps, be amused as I was, and will abstain from drawing general conclusions from the conversation of persons whom chance has thrown in the traveller's way.

As soon as we were recognised to be foreigners, we were usually asked whether we had made up our minds where we should settle. On our declaring that, much as we saw to like and admire in America, we had no intention of exchanging our own country for it, they expressed surprise that we had seen so many States, and had not yet decided where to settle. Nothing makes an English traveller feel so much at home as this common question. You have arrived at the domain of a rich and hospitable host, who is ready to welcome you, and where there is ample room and accommodation for all. Some of the more highly educated class, especially the lawyers, expressed their alarm at the growing strength of the democratic party in Ohio, owing to the influx of Irish and German labourers, nearly all Roman Catholics, and very ignorant. These new comers, they said, had lately turned the elections against a majority of native Americans, their superiors in wealth and mental cultivation. They also complained that many settlers of German origin from Pennsylvania were opposed to all improvement, and unwilling to be taxed for new schools, canals, and roads. They were indifferent to the speedy arrival of letters and daily newspapers, and other advantages, for which the New Englanders and the Scotch and English Protestants would pay most cheerfully. Yet they allege that these same Germans, opposed as they are to all useful innovations, are in the habit of giving their votes to demagogues, who are prepared to plunge the country into the most headlong career of political changes.

A thriving farmer, who entered the coach at Wooster, spoke vehemently against the new tariff, which, he said, would sacrifice the agriculturists of the West to the New England manufacturers, who meant to compel them to buy their home-made goods at a high price, while the raw produce of Ohio and the West would be shut out from the British market. He also boasted to me of the advantages they enjoyed in the U. S., commiserating the lot of the mass of the people in the old country, deprived of their political rights, and exposed to the tyranny and oppression of the rich. By way of drawing him out, I told him how I had found the day before a minister preaching in Welsh to a congregation of three hundred persons in the town of Columbus — that these and other poor settlers, Irish and German, were ignorant of the American laws and institutions, and wholly uneducated. Ought they to be permitted to turn the elections, as I was told they had recently done in Ohio? On this he poured forth an oration on the equality of the rights of all men, on the invidious distinctions some desired to establish between the franchise of old and new settlers, on the policy of welcoming new comers when the population was sparse, on the advantages of common schools, and, lastly, on the evil of endowing universities, which he said were "hot-beds of aristocrats." While descanting on these and other topics, the tone of his voice grew louder and louder as his warmth increased, and when he left the public coach, a lawyer of Ohio congratulated me that I could now understand what is meant in the United States by "stump oratory," or that kind of declamation which is addressed by a candidate for popular favour from the stump of a tree in a new clearing.

On another occasion, the respective merits of Mr. Van Buren, Mr. Clay, and others, were canvassed, and an animated discussion took place on their relative claims to fill the presidential chair at the next general election. I expressed surprise that, as there were still three years to run of Mr. Tyler's official career, they should be mooting this question already. The whole country had been so reeently convulsed by the severe contest between Harrison and Van Buren, in which parties had been so nearly balanced, that it was surely inexpedient that the minds of the people should be again excited and unsettled. I enlarged on the superior advantages of an hereditary monarchy, as preventing the recurrence of such dangerous agitation, and was prepared for a retaliatory attack upon the kingly office, and a eulogy on the superiority of the American constitution. But Americans at home, however loyal and patriotic, and as little disposed to change their form of government for a monarchy as we are to turn republicans, are, nevertheless, by no means optimists. When they travel in England, they acquire a habit of standing on the defensive, from hearing John Bull object to everything in which their laws and institutions may happen to differ from his own. But in the United States, I frequently heard politicians deplore the progress of democracy, argue that the president ought to be elected for six years instead of four, that he should not be re-eligible, that there should be no veto, and contend for other organic changes. In reply to my sally, one of the party, who had previously expressed his fears that General Harrison's death would lead to the democratic party regaining their ascendancy, remarked, "The most disastrous periods, sir, in your history, were the wars of a disputed succession. We are always engaged in a civil war of this kind." By way of consolation, I reminded him that, at all events, there had been less bloodshed in their battles for the chief magistracy than in our contests for the rightful heirs to a throne. He replied, "Yes, there has been less destruction of the body, but not of the soul. A president who has 60,000 places in his gift holds in his hands far greater means of bribery and corruption than did your Harry the Eighth, even after he had seized upon the property of the monasteries."

One of my travelling companions in Ohio assured me that agricultural labourers from the Lowlands of Scotland were the best settlers of all who came direct from Europe. Some of these had arrived with a large family, and with no money even to buy the implements of husbandry, and had in twelve years become the owners of 300 acres of cleared land, in which the log-house was replaced by a neat farm building, called a frame-house, with a small garden attached to it. They laugh here at the common error into which new settlers fall, who possess some money, and have been accustomed to English farming, especially their diligence in uprooting stumps, which have so slovenly an appearance. This practice seems to be in their eyes the most unequivocal test of extreme ignorance of the relative value of labour and land in a new country. Foreigners who have a small capital should always settle in districts which have been already cleared, and broken up by the plough.

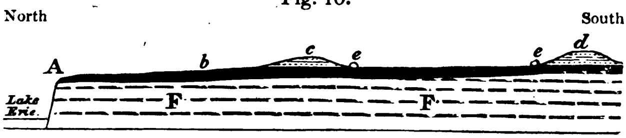
CHAPTER XIX.

Cleveland. — Ridges of Sand and Gravel along the Southern Coast of Lake Erie — Their Origin. — Fredonia; Streets lighted with natural Gas. — Falls of Niagara. — Burning Spring. — Passing behind the Falls. — Daguerreotype of the Falls. — Boulder Formation at Whirlpool, and Valley of St. David's. — Glacial polishing and Furrows. — Influence of Icebergs on Drift.

June 3. 1842.—THE morning after my arrival at Cleveland, Dr. Kirtland, the zoologist, took me to Rockport, about four miles to the west, and afterwards to the ravine of a torrent called the Rocky River, about six miles farther, in the same direction, that I might examine in both places what are here called the Lake Ridges. Like the "ridge road" of Lake Ontario before described (Vol. I. p. 24.), they resemble ancient beaches, running parallel to the shores of Lake Erie, and being composed of sand and gravel.

At the point which I first visited, in the town of Rockport, Lake Erie is bounded by a perpendicular cliff (A, *fig*. 10.), about seventy-five feet high, at the base of which the water is so deep, that, in some places, it can only be approached in a boat. Horizontal beds of shale, with some layers of sandstone, appear cut off abruptly in the face of this cliff, all referable to the Hamilton group, No. 10. of Map Pl. II., or the lowest part of the Devonian series (F). Proceeding from the summit of the cliff inland, we find the surface of the country covered with clay (*b*), sloping gently, so that, in half a mile, there is a rise of about forty feet, and we then come to the bottom of the first or northernmost ridge (*c*), which is about fifteen feet high, rising at an angle of about 12°, both on its northern and southern slope. Between this and the next ridge (*d*), which is about half a

Fig. 10.



"Lake Ridges" near Cleveland, Ohio.

mile distant, extends a line of swamps and marshes, some of them several hundred acres in extent. Two other parallel ridges of sand and gravel are observable still farther inland or southwards, the distance of each varying greatly according to the general slope of the land, for the same ridge occasionally approaches within a mile of the shore at one point, and recedes to the distance of eleven miles from it at another, apparently preserving everywhere the same level.

Boulders of granite, some of them three feet in diameter, which must have come from the north side of Lake Erie, are scattered sparingly here and there, as at *e, fig.* 10. I could not obtain any fossil shells from any of these ridges, although some are said to have been found, together with fragments of wood, similar to those now thrown up on the beach of the lake. The shells might at once decide the point whether the ridges are of marine or freshwater origin. If this were settled, another and distinct question would still remain; namely, whether they were for the most part formed at first under water, like sand-bars at the mouths of rivers; or were thrown up by the waves on the margins of ancient sheets of water, in the manner of beaches.

The section which I saw on the banks of the Rocky River appeared to me to favour the theory of the subaqueous origin of the ridges. This torrent, about a mile and a half above its mouth, flows in a narrow ravine, scarcely more than thirty yards wide, with perpendicular cliffs on each side, 110 feet high. When we arrive at the point where the ravine intersects the second of the Rockport ridges before alluded to (*d, fig.* 10.), we see the river-cliff suddenly heightened by the addition, for a short space, of a bank of sand and gravel, about 30 feet high, the pebbles in the ridge being rounded like those on the lake shore, and proving that the bank was never a mere dune of blown sand.

If we imagine bars or banks of sand and pebbles to have been formed in succession near the shore in shallow water, and then cut through by torrents when the land was elevated, we can explain the abrupt manner in which the ridge *d* terminates on each side of a ravine evidently excavated by the torrent in soft shale since the emergence of the strata. But it is difficult to imagine how an ancient beach, formed where a stream entered a lake or sea, could have been so straight and continuous, and so little modified and rounded off in its outline conforming to the shape of the small bay, which must have existed at the entrance of a stream. It will be unnecessary, however, to dwell longer on this question at present, as I shall resume the subject when discussing the nature and origin of the "lake ridges" near Toronto.

The town of Cleveland is built on a terrace of stratified clay and sand, the height of which is 103 feet above the lake. Its depth is unknown, the fundamental Devonian (or Hamilton) strata being concealed here, so that the newer deposit exclusively occupies the lake shore for forty miles. As several rivers besides the Cuyahoga of Cleveland cut winding courses through this terrace, we may presume that these rivers existed when the water stood 100 feet higher relatively to the land. If so, we seem to have here an upraised delta formed of the materials brought down by streams before the waters had sunk to their present relative level. The nature of the sand and clay is such as rivers might have washed down from the land above, but no shells have been discovered, although diligently searched for, during the excavation of a ship canal and other works in the town. The tooth of a mastodon, however, was shown me as having been found low down in the clay.

June 5. — Sailed in a steamboat to Fredonia, a town of 1200 inhabitants, with neat white houses, and six churches. The streets are lighted up with natural gas, which bubbles up out of the ground, and is received into a gasometer, which I visited. This gas consists of carburetted hydrogen, and issues from a black bituminous slate, one of the beds of the Hamilton group of the New York geologists, or part of the Devonian formation of Europe. The light-house-keeper at Fredonia told me that, near the shore, at a considerable distance from the gasometer, he bored a hole through this black slate, and the gas soon collected in sufficient quantity to explode, when ignited.

There is a ridge of sand at Fredonia, as at many other places, between Cleveland and the outlet of the Niagara from Lake Erie, but I tried in vain to identify the ridges with those seen by me at Rockport, and could not discover that their heights, as estimated by residents, agreed at different places. Some of them, indeed, according to Mr. Whittlesea, the engineer, decline in altitude as they are traced eastward.

We next reached Buffalo, and found so many new buildings erected since the preceding autumn, and new shops opened, that we were amazed at the progress of things, at a time when all are complaining of the unprecedented state of depression under which the commerce and industry of the country are suffering.

At the Falls of Niagara, where we next spent a week, residing in a hotel on the Canada side, I resumed my geological explorations of last summer. Every part of the scenery, from Grand Island above the Falls to the Ferry at Queenstown, seven miles below, deserves to be studied at leisure.

We visited the "burning spring" at the edge of the river above the rapids, where carburetted hydrogen, or, in the modern chemical phraseology, a light hydro-carbon, similar to that before mentioned at Fredonia, rises from beneath the water out of the limestone rock. The bituminous matter supplying this gas is probably of animal origin, as this limestone is full of marine mollusca, crustacea, and corals, without vegetable remains, unless some fucoids may have decomposed in the same strata. The invisible gas makes its way in countless bubbles through the clear transparent waters of the Niagara. On the application of a lighted candle, it takes fire, and plays about with a lambent flickering flame, which seldom touches the water, the gas being at first too pure to be inflammable, and only obtaining sufficient oxygen after mingling with the atmosphere at the height of several inches above the surface of the stream.

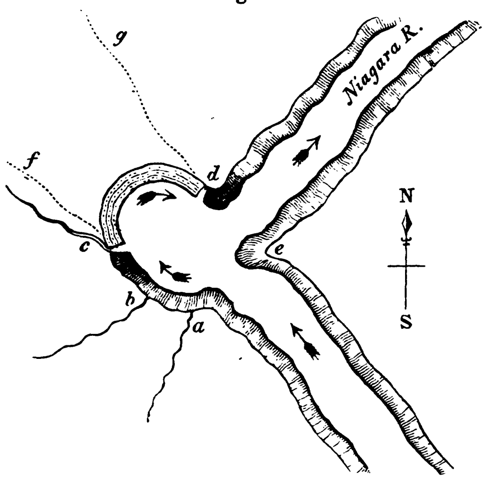
At noon, on a hot summer's day, we were tempted, contrary to my previous resolution, to perform the exploit of passing under the great sheet of water between the precipice and the Horse-shoe Fall. We were in some degree rewarded for this feat by the singularity of the scene, and the occasional openings in the curtain of white foam and arch of green water, which afford momentary glimpses of the woody ravine and river below, fortunately for us lighted up most brilliantly by a midday sun. We had only one guide, which is barely sufficient for safety when there are two persons, for a stranger requires support when he loses his breath by the violent gusts of wind dashing the spray and water in his face. If he turns round to recover, the blast often changes in an instant, and blows as impetuously against him in the opposite direction.

The Falls, though continually in motion, have all the effect of a fixed and unvarying feature in the landscape, like the two magnificent fountains in the great court before St. Peter's at Rome, which seem to form as essential a part of one architectural whole as the stately colonnade, or the massive dome itself. However strange, therefore, it may seem, some Daguerreotype representations of the Falls have been executed with no small success. They not only record the form of the rocks and islands, but even the leading features of the cataract, and the shape of the clouds of spray. I often wished that Father Hennepin could have taken one of these portraits, and bequeathed it to the geologists of our times. It would have afforded us no slight aid in our speculations respecting the comparative state of the ravine in the 19th and 17th centuries.

After one or two warm days, the weather became unusually cold for the month of June, with occasional frosts at night, and the humming-birds which we had seen before reaching Buffalo appeared no more during our stay here.

In my visits to Grand Island, Lewiston, and St. Catherine's, I made some of the observations already alluded to in the first volume (ch. ii. p. 27.); and I shall now confine myself to remarks on the connection of certain strata of drift which appear at the Whirlpool, and similar deposits observable in the valley of St. David's, about three miles west of Queenstown, where there is an opening in the escarpment, as shown in the bird's-eye view (Pl. I.), and in the map of the Niagara district (Pl. III.). In the former view, (Pl. I.), a small chasm is introduced on the left bank of the Niagara at the whirlpool, to mark the only spot where the continuity of the older formations (the limestone, shale, and subjacent rocks) is broken

Fig. 11.



Course of the Niagara at the Whirlpool.

a, b. Streamlets which are thrown in cascades over the limestone precipice, after cutting through superficial red drift, twenty-five feet thick.
c. Bowman's Run.
d. Small gulley, between which and *c* the cliffs consist of drift.
e. Summer house, where sand with fresh-water shells rests on the top of the precipice. See *fig.* 3. Vol. I. p. 40.
f, g. Probable course of the ancient valley, now filled with drift.

between the Falls and Queenstown. This interruption occurs precisely opposite the summer-house (*e, fig.* 11.).

The river-cliff, from *c* to *d*, or for a distance of about 170 yards, on the northern side of the whirlpool, consists exclusively of strata of sand, loam, and gravel; the latter in parts cemented together into a conglomerate, and all belonging to the drift or boulder formation. The visible thickness of this modern deposit is about 300 feet, but we know not to what depth it may extend below the level of the Niagara. It appears clearly that there was here an original valley, which was afterwards completely filled up with stratified drift. The same red clay which spreads far and wide over the limestone platform, forms the uppermost stratum of the mass, the occurrence of which, at this point, had been overlooked by geologists, until Mr. Hall and I observed it in 1841. He immediately suggested to me that it might be connected with the opening in the escarpment at St. David's, about three miles to the northwest, which I determined to examine the year after.

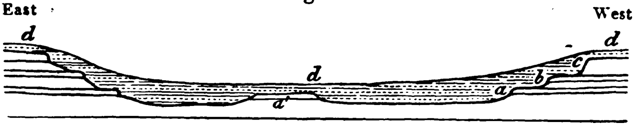
On a close inspection of the drift in the cliffs between *c* and *d*, we find it to be composed at the top of red clay, from twenty to thirty feet thick, below which is a conglomerate, including boulders of granitic and trappean rocks, of northern origin, mixed with fragments of the Niagara limestone. One angular block of the latter is no less than fifteen feet in diameter, having been evidently detached from the original wall of the chasm during its denudation. Below this come beds of white sand and loam, to which succeed gravel cemented into a conglomerate by carbonate of lime, the pebbles being of sandstone, limestone, and hornblende rock. Under this conglomerate are laminated clays, being the lowest visible strata.

Ascending the steep bank formed of these materials, we soon reach the general level of the table-land, and pass over it for two miles before we begin to enter the depression, which, deepening gradually, carries us down to St. David's. This valley is entirely excavated in the boulder formation, and we may infer that the latter maintains its full depth between St. David's and the whirlpool, from sections obtained in sinking wells in the intervening township of Stamford, where a great thickness of drift was passed through.

In the bird's-eye view (Pl. I. Vol. I.), the valley of St. David's is represented, for want of more space, as of small width; but it is, in fact, about two miles broad at its mouth, so that it bears no resemblance to the deep narrow chasm in which the Niagara flows. One end of it seems to have terminated originally in an angle at the point where the whirlpool is now situated; and the sections laid open in the gullies (*c* and *d*, *fig*. 11.) show that the walls of the ancient hollow were not perpendicular, but consisted of a succession of precipices and ledges. I was informed that, near St. David's, an outlier of quartzose sandstone (*a'*, *fig.* 12.) was found by boring through the drift, which may, therefore, have projected like an island in the middle of the original valley or channel.

The accompanying diagram will, probably, convey a correct notion of the manner in which the drift rests upon the older rocks near the northwestern end of the valley of St. David's. The outline of the older formation given in this transverse section is, in fact, the same as that presented by the same rocks in those parts of the escarpment east and west of Lewiston and Queenstown, where the face of the cliff is not masked by drift.

Fig. 12.



Supposed section of drift and subjacent rocks in valley of St. Davids.

a. Ledge of quartzose (Medina) sandstone.
b. Ledge of Clinton limestone.
c. Platform of Niagara limestone.
d. General covering of drift or boulder formation.

I shall afterwards describe cavities, or ancient valleys, intersecting the old Silurian rocks near Quebec, which have been filled up with transported materials, in which marine shells of recent species, and of a northern or arctic character, have been discovered. These shells have also been found in the drift of the valley of the St. Lawrence, at elevations of more than 500 feet above the level of the sea, or nearly as high as Lake Erie, so that I consider it to be a mere local accident that none of the same are preserved, or have yet been met with in the Niagara district.

Professor Emmons has shown that, on the removal of the clay and sand containing those marine shells in the valley of Lake Champlain, the rocks beneath are polished and furrowed, and similar phenomena are observed in the region now under consideration between Lakes Erie and Ontario. If the reader will glance at the frontispiece (Pl. I.), he will see in the distance a zone of country (No. 1.) bounding Lake Erie, part of which consists of an upper Silurian limestone, called in New York the Corniferous. It occurs at Black Rock among other places (see Map, Pl. III.). It is very hard, contains many corals, and has nodules of flint or chert dispersed through it in horizontal beds. The upper surface of this rock, when the boulder clay is removed, appears smoothed or polished, and usually scored with long parallel furrows. But the nodules of chert, although much rubbed down and worn, stand out slightly in relief, while narrow elongated ridges of limestone are seen extending from the southern end of each nodule, marking the space where the softer rock has been protected for a short distance from the triturating action which ground down the whole.

Mr. George E. Hayes of Buffalo showed me large specimens of the polished rock, on which these markings were conspicuous; and he and Mr. Haskin have ascertained that the general direction of the grooves in this region is N. E. and S. W., or N. 35° E. They are traced over the broad platform of the Niagara limestone No. 3. (see Frontispiece and Map, Pl. III.), retaining the same course wherever the drift is removed; and, what is still more remarkable, as Mr. Hall pointed out to me, near Lewiston and Lockport, they are imprinted at different levels on the projecting shelves formed by the more solid rocks of the great escarpment. Suppose, for example, the drift *d* (*fig.* 12. p. 96.) to be removed from the ledge of quartzose sandstone, *a*, and from the surface of the upper edge of Clinton limestone, *b*, and from *c*,—we should find everywhere grooves running nearly in the direction N. E. and S. W.

Some geologists have considered these facts as very difficult to reconcile with the glacial theory. To me they appear to indicate the following succession of events. First, the country represented in the frontispiece (Pl. I.) acquired its present geographical configuration, so far as relates to the outline of the older rocks, under the joint influence of elevatory and denuding operations. Secondly; a gradual submergence then took place, bringing down each part of the land successively to the level of the waters, and then to a moderate depth below them. Large islands and bergs of floating ice came from the north, which, as they grounded on the coast and on shoals, pushed along all loose materials of sand and pebbles, broke off all angular and projecting points of rock, and when fragments of hard stone were frozen into their lower surfaces, scooped out grooves in the subjacent solid strata. The sloping beach, as well as the level bottom of the sea, and even occasionally the face of a steep cliff, might all be polished and grooved by this machinery; but no flood of water, however violent, or however great the quantity of detritus, or size of the rocky fragments swept along by it, could produce straight, parallel furrows, such as are everywhere visible in the district under consideration.

Mr. John L. Hayes, in an able paper recently published, on the influence of icebergs upon drift, has shown, from a great variety of testimony, that they have a remarkable steadiness of motion, in consequence of the larger portion of their bulk being deep under water, so that they are not perceptibly moved by the winds and waves, even in the strongest gales. Many had supposed that the magnitude attributed to ice-islands by unscientific navigators had been exaggerated, but it appears that their estimate of their dimensions has rather fallen within than beyond the truth. Many of the icebergs, carefully measured by the officers of the French exploring expedition of the Astrolabe, were between 100 and 225 feet high, and from two to five miles in length. Captain D'Urville ascertained one of these bergs, floating in the Southern Ocean, to be thirteen miles long and a hundred feet high, with walls perfectly vertical. The submerged portions of such islands must, according to the weight of ice relatively to sea-water, be from six to eight times more considerable than the part which is visible, so that the mechanical power they may have exerted when fairly set in motion must be prodigious.*

To return to the succession of geological changes which immediately preceded the present period in the Niagara district:—Thirdly, after the surface of the rocks had been smoothed and grated upon by the passage of innumerable icebergs, the clay, gravel, and sand of the drift were deposited, and occasionally fragments of rock, both large and small, which had been frozen into glaciers, or taken up by coast ice, were

* J. L. Hayes, Boston Journ. Nat. Hist. 1844.

dropped here and there at random over the bottom of the ocean, wherever they happened to be detached from the melting ice. During this period of submergence, the valleys in the ancient rocks were filled up with drift, with which the whole surface of the country was over-spread. Finally; the period of re-elevation arrived, or of that intermittent upward movement, when the ridges to be described in the next chapter, were formed in succession, and, when valleys, like that of St. David's, which had been filled up, were partially re-excavated.

CHAPTER XX.

Mirage on Lake Ontario.—Toronto.—Excursion with Mr. Roy to examine the Parallel Ridges between Lakes Ontario and Simcoe.—Correspondence of Level in their Base-lines over wide Areas.—Origin of the Ridges.—Lacustrine Theory.—Hypothesis of Sand-banks formed under Water.—Rapid Progress of the Colony.—British Settlers unable to speak English.

June 14. 1842.—FROM Queenstown we embarked in a fine steamer for Toronto, and had scarcely left the mouth of the river, and entered Lake Ontario, when we were surprised at seeing Toronto in the horizon, and the low wooded plain on which the town is built. By the effect of refraction, or "mirage," so common on this lake, the houses and trees were drawn up and lengthened vertically, so that I should have guessed them to be from 200 to 400 feet high, while the gently rising ground behind the town had the appearance of distant mountains. In the ordinary state of the atmosphere none of this land, much less the city, would be visible at this distance, even in the clearest weather.

Toronto contains already a population of 18,000 souls. The plain on which it stands has a gentle, and to the eye imperceptible, slope upwards from the lake, and is still covered, for the most part, with a dense forest, which is beginning to give way before the axe of the new settler. I found Mr. Roy, the civil engineer, expecting me, and started with him the morning after my arrival to examine those ridges of sand and gravel, and those successive terraces, at various heights above the level of Lake Ontario, of which he had given an account in 1837 to the Geological Society of London. No small curiosity was excited, when his paper was read, by his endeavour to explain the phenomena, by supposing the former existence of a vast inland sea of fresh water, the barriers of which were broken down one after another until the present chain of lakes alone remained.

We started at an early hour from Toronto on horseback, taking a direction due northwards through the forest, and after riding for a mile over what seemed a perfectly level plain, came to the first ridge, the base of which my companion informed me was 108 feet above Lake Ontario. This ridge rose abruptly with a steep slope towards the lake, and was from 20 to 30 feet high. Its base consisted of clay, and its sandy summit, covered with pines, might easily be traced eastward and westward by the distinctness of the narrow belt of fir-wood, on each side of which other kinds of timber flourished luxuriantly on the clayey soils.

Continuing our ride over the plain we arrived at the second ridge, a mile and a half farther inland, having its base 208 feet above the lake; this level, and the others afterwards to be mentioned, having been accurately ascertained by Mr. Roy when employed professionally in making measurements for several projected canals and railroads. The second ridge is a far more striking object than the first, being from 50 to 70 feet high above the flat and even ground on both sides of it. At its foot were a great number of boulders of rocks which, by their composition, can be proved to have come from the north; and some few of which were perched on the summit of the ridge. Such transported fragments are rare on the soil between the ridges. Another ride of two miles and a half, in a northerly direction, brought us to the third ridge, five miles distant from the lake-shore, which was much less conspicuous than the preceding ones; it was indeed at the point where we crossed it, little more than a steep slope of ten feet, by which we mounted to a higher terrace. The surface of this terrace was only 80 feet above the base of the second ridge, so that the top of the latter, in those places where it is 70 feet or more in height, is nearly on a level with the bottom of the third ridge, or cliff.

In this manner we went on, passing one ridge or cliff after another, sometimes deviating from our course for several miles east and west, that my guide might point out to me the continuity of the ridges, and the uniformity of the level of their base-lines. This uniformity, however, though I have no doubt of its reality, I had no time to test by actual measurement. On tracing the same ridge for several miles east and west, I occasionally found it to vary greatly in height above the plain, and sometimes to divide into two. One of these sometimes formed a step immediately above the other, and sometimes diverged or branched off so as to form an upper and parallel ridge at some distance. They were all broken occasionally by deep narrow gaps, as I had observed in the Osars of Sweden.

I saw, on the whole, no less than eleven of these ridges, some of which might be called cliffs, or the abrupt terminations of terraces of clay, which cover every where the subjacent Silurian rocks to a great depth, and belong to the drift or boulder formation. The highest ridge is about 680 feet above Lake Ontario, the water-shed between that lake and Lake Simcoe being 762 feet high. There is then a descent of 282 feet from that summit level to the shores of Lake Simcoe, which is 42 miles from Lake Ontario. On this northern slope of 282 feet, Mr. Roy has traced several of the higher ridges, at levels precisely corresponding to those which I saw on the southern side. He also assures me that several of the ridges, which exceed in height the level of the table-land between Lakes Ontario and Erie, extend continuously to the northern shore of Lake Erie; and in another direction agree with ridges on the uplands bounding the valley of the Ottawa river.

The identification, however, of horizontal planes at points several hundred miles distant from each other, requires a nicety and exactness of trigonometrical measurement, which cannot as yet have been bestowed on this region; and when there are so many terraces at levels differing but slightly from each other, and some of them occasionally dividing into two, an upper and a lower shelf, they may easily be confounded at remote points.

I shall content myself with stating that, with the exception of the parallel roads or shelves in Glen Roy, and some neighbouring glens of the Western Highlands in Scotland, I never saw so remarkable an example of banks, terraces, and accumulation of stratified gravel, sand, and clay, maintaining, over wide areas, so perfect a horizontality, as in this district north of Toronto.

The hypothesis which attributes such appearances to the successive breaking down of the barriers of an ancient lake or ocean of fresh water, has now been very generally abandoned, from the impossibility of conceiving where, in North America, as in the west of Scotland, the lands capable of damming up the waters to such heights could have been situated, or how, if they ever existed, they could have disappeared, while the levels of the ancient beaches remained undisturbed. In order to dispense with the necessity of barriers, we may assume that the successive ridges and cliffs were formed on the margin of the sea, which changed its level relatively to the land again and again, while a large part of the continent emerged gradually from the waters. In that case, we must imagine the movement of upheaval to have been intermittent, so that there were pauses during which the coast-line remained stationary for centuries, and when the waves had time to cut cliffs, or throw up beaches, or throw down littoral deposits and sandbanks near the shore.

This theory has been objected to on the ground of the great improbability of so vast an amount of vertical movement having been developed so uniformly over areas several hundred miles in diameter. In some parts of Sweden and Finland, however, there has been a near approach to an uniform upward movement of two or three feet in a century throughout wide areas within the historical era, and we know far too little of the laws governing subterranean movements, to entitle us to raise objections, on the ground that the observed phenomena would imply a regularity in the process of upheaval, not in harmony with our pre-conceived notions.

Between the first and second ridges, north of Toronto, I saw a section 50 feet deep in the argillaceous deposit on which all the ridges rest, or in which cliffs, corresponding in level with some of the ridges, are cut. It consisted of blue clay in horizontal thin layers, with partings of yellow sand, and at the bottom yellow clay, with some interstratified layers of white clay. I observed no included boulders, but Mr. Roy has seen them at Toronto, where deep excavations were made for the foundations of buildings. They occurred near the junction of the clay and the subjacent rocks; and he remarked that the solid rocks, on the removal of the boulder formation, were polished and scored on the surface. I could find no shells either in the clay or in the ridges. I was informed, indeed, that marine shells had been met with in the clay, but, on inquiry, they turned out to be Silurian fossils, washed out of the ancient shales.

It will be seen from the above observations, that I consider the ridges and other marks of ancient water-levels, between Toronto and Lake Simcoe, as referable, some of them to ancient beaches and lines of cliff formed on the margins of channels of the sea;

others, including some of the loftiest ridges, as having originated in banks or bars of sand, formed, not at the extreme edge of a body of water, but at some distance from the shore, in proportion as the water obtained a certain shallowness by the upheaval of the land.

It is well known that on many shelving coasts the breakers and tides give rise to banks of sand at no great distance from the beach. I learn from Mr. Whittlesey that a bank of this kind has been formed for several miles along the southern shore of Lake Erie, near Cleveland, the origin of which he attributes in part to the reflux of the waves from the beach, by which pebbles and sand are swept out from the land.

Mr. Mather informs us that the great beach on the south coast of Long Island, in the State of New York, extends for a distance of 104 miles, with a breadth of from 100 to 1000 yards. For 70 miles it is separated from the mainland by a continuous line of bays, which are between half a mile and six miles broad. "This great beach or bank forms a line of spits and low islands. One of the islands is about 25 miles long, with a breadth of a few hundred yards. They are all narrow and long, and when above the reach of the surf they are covered by a labyrinth of hillocks of drifted sand, imitating almost all the variety of form which snow-drifts present after a storm."* They consist, he adds, of the materials derived from the neighbouring cliffs of Long Island, which are undermined and destroyed by the waves.†

Examples of similar banks parallel to the shore are cited by Mr. Darwin, in his work on Coral Reefs (p. 53.). Capt. Grey also states that the west coast of Australia, in lat. 24°, is fronted by a sand-bar about 200 yards in width, on which there is only two feet of water; but between it and the land the depth increases to two fathoms.†

At Bahia Blanca, in Brazil, Mr. Darwin observed a bar running parallel to the coast, on which they landed from the boats at low water, and then waded for a quarter of a mile to the shore. He has described a similar bar at Pernambuco, in Brazil, several leagues in length, in which the sand has been consolidated into a hard stone by calcareous matter. Within these bars currents are often seen to run strongly, caused by the water thrown over them by the waves when the tide is high. These waters run between the bar and the coast, until at length they find some breach in the bar by which they return to the sea.

In illustration of the ancient ridges or osars in Roxburghshire, Mr. David Milne, F.G.S., has de-

* New York State Report, 1838, p. 130.

† Journal of Two Expeditions, &c., vol. i. p. 369.

scribed many examples of narrow sandbanks now existing off the coast of Britain, some 5, others 30 miles in length, with ten or twelve fathoms water between them and the neighbouring shore.*

The existence of such bars near modern shores being ascertained, it follows that, if a coast be gradually upraised, many of them will be both formed and made to emerge *in succession*, all preserving the same general parallelism to each other which prevails in the ridges above the Canadian lakes. It is also clear that there will be swamps and ponds on the inland side of such upraised banks, representing the channels and lagoons which intervened originally between the bars and the mainland. There would also be occasional gaps in the ridges, some corresponding to original openings, through which the back water escaped, and others cut by torrents after the emergence of the land.

According to Mr. Whittlesey, the base lines of several ridges east and west of Cleveland are not strictly horizontal, but inclined five feet, and sometimes more, in a mile. To account for this differ-

* See Trans. Roy. Soc. Edinb. vol. xv. p. 484. Jan. 1843. My paper, citing analogous cases, in explanation of similar geological phenomena, was read at the same time to the Geological Society of London, without our having communicated together on the subject. See Abstract in Proceedings Geol. Soc., No. 92. p. 21. Jan. 4. 1843.

ence of level, it has been suggested that the upward movement of the land on the south side of Lake Erie may have been unequal, some parts being raised higher than others. But it deserves consideration whether the ridges, if some of them were bars or sandbanks, may not occasionally have varied in level from the first, according to the inequalities of the ground and the force of currents.

If we adopt the theory above set forth, we must still conceive the banks to have become *beaches* as they emerged, or cliffs partially undermined by the waves, while in some cases they may have been entirely destroyed, of which I thought I saw indications when tracing the continuity of some ridges near Toronto.

In my ride with Mr. Roy through the forest we went about twenty miles due north of Toronto, besides making many detours. A more active scene of the progress of a new colony could scarcely be witnessed. We often came upon a party of surveyors, or pioneers, tracing out a new line of road with the trunks of tall trees felled on every side, over which we had to leap our horses. Then we made a circuit to get to windward of some large stumps which were on fire, or, if we could find no pathway, hurried our steeds through the smoke, half suffocated and oppressed with the heat of the burning timber and a sultry sun. Sometimes we emerged suddenly into a wide clearing, where not a single clump of trees had been spared by the impatient and improvident farmer. All were burnt, not even a shrub remaining for the cattle and sheep, which, for want of a better retreat, were gasping under the imperfect shade of a wooden paling, called in America a Virginia, or snake fence.

The appearance of the country had been so entirely altered since Mr. Roy surveyed the ground two years before, and marked out the boundaries of the new settlements, that he lost his way while explaining to me the geology of "the ridges;" and after we had been on horseback for twelve hours we wandered about in a bright moonlight, unable to find the tavern where we hoped to pass the night. In the darker shade of the forest I saw many fire-flies; and my attention was kept alive, in spite of fatigue, by stories of men and horses swallowed up in some of the morasses which we crossed. I shall always, in future, regard a corduroy road with respect, as marking a great step in the march of civilization; for greatly were we rejoiced when we discovered in the moonlight the exact part of a bog, over which a safe bridge of this kind had been laid down. At length we reached a log-house, and thought our troubles at an end. But the inmates, though eager to serve us, could not comprehend a syllable of our language. I tried English, French, and German, all in vain.

Tired and disappointed, we walked to another log-house, a mile farther on, leading our weary horses, and then to others, but with no better success. Though not among Indians, we were as foreigners in a strange land. At last we stumbled, by good luck, upon our inn, and the next day were told that the poor settlers with whom we had fallen in the night before had all come from the British Isles in the course of the five preceding years. Some of them could speak Gaelic, others Welsh, and others Irish; and the farmers were most eloquent in descanting on their misfortune in having no alternative but that of employing labourers with whom they were unable to communicate, or remaining in want of hands while so many were out of work, and in great distress. For the first time I became fully aware how much the success and progress of a new colony depends on the state of schools in the mother country.

CHAPTER XXI.

Kingston. — Montreal. — French population and language. — Quebec. — Soldiers. — Deserters. — Three Rivers. — Scotch Emigrants. — Distinctness of French and British Canadians. Large military force. — American sympathisers. — Geological Survey. — Analogy in Structure of Canada and Scandinavia. — Section at Falls of Montmorency. — Unconformable position of lowest fossiliferous Sandstone to Gneiss. — Supposed monument of the commencement of the Organic World. — To what extent the Granitic Rocks are primary. — Difficulty of establishing the Date of Metamorphic Action. — Two sources of popular error respecting the more abundant production of Hypogene Rocks at remote periods.

June 18*th*. — AN excellent mail steam-packet carried us along the northern coast of Lake Ontario, from Toronto to Kingston, from whence I made a geological excursion to Gannanoqui. From Kingston we then descended the St. Lawrence to Montreal. The scenery of the Thousand Islands and of the rapids of the St. Lawrence owe much of their beauty to the clearness of the waters, which are almost as green, and their foam as white, as at the Falls of Niagara.

On approaching Montreal we seemed to be entering a French province. The language and costume of the peasants, and of the old beggars, the priests with their breviaries, the large crosses on the public roads, with the symbols of the Crucifixion, the architecture of the houses, with their steep roofs, large casement windows, and, lastly, the great Catholic cathedral rising in state, with its two lofty towers, carried back our thoughts to Normandy and Brittany, where we spent the corresponding season of last year. The French spoken in those provinces of the mother country is often far less correct, and less easy to follow, than that of the Canadians, whose manners are very prepossessing, much softer and more polite than those of their Anglo-Saxon fellow-countrymen, however superior the latter may be in energy and capability of advancement.

I was informed by a physician at Montreal that the English language has made great progress there within his recollection; and all agree that it would soon become still more general if the seat of government were transferred to that city,—a measure since realized, but which was then only beginning to be discussed (1842), and was exciting no small effervescence of party feeling. I was assured by many that it was the only step towards anglicizing Lower Canada that would be popular with the French party. The country round Kingston must always be comparatively barren, as much of the soil consists of granite and granitic detritus; and it could never become a large metropolis, such as Toronto might be made, or such as Montreal is even now.

Quebec, with its citadel and fortifications crowning the precipitous heights which overhang the St. Lawrence, and where the deep and broad river is enlivened with a variety of shipping, struck us as the most picturesque city we had seen since we landed in America. We were glad to meet with some old friends among the officers of the garrison, who accompanied us to the Falls of Montmorency, and other places in the neighbourhood. Their task in maintaining strict discipline in their corps, in preventing the desertion of soldiers, and keeping the peace along the frontier, has been more irksome than in quelling the rebellion. Those soldiers who have deserted to the States are said rarely to make good and thriving settlers; for they have been turned into such mere machines, into such creatures of routine, so exclusively trained for excellence in one art, that they want resources, and are singularly deficient in a virtue termed by the Americans "shiftiness," or the power of turning one's hand to any thing and every thing, for which the well-educated New England coloniser is celebrated.

On our way back from Quebec to Montreal I stopped at Three Rivers to make a geological excursion to the Falls of Maskinongé, about ten miles northward of the St. Lawrence. In the woods, near the beautiful waterfall, where the river forces its way through a narrow cleft in the gneissose rocks, I lost my way, and was attacked by myriads of musquitos — the only occasion, owing to the unusual coolness of the season, on which I was annoyed by these enemies, so much dreaded here by the lovers of angling.

When standing on the wharf at Three Rivers, I conversed with the proprietor of a large estate in the Eastern townships, who complained to me that while crowds were passing up the river every week to remote districts, and sometimes returning disappointed, and even occasionally re-crossing the Atlantic, he and other farmers were unable to get hands. While he was speaking, a large steamer, with several hundred Scotch emigrants from Ayrshire, came alongside the wharf. They were only to tarry there one hour to take in wood for the engines. My companion went on board, eagerly endeavouring to bribe some of the new comers to settle on his farm, but all in vain. They said they had cousins and friends in "Upper Canada," and were all resolved to go there. I could not help sympathising with him in his disappointment, and the more so, as I had seen at Toronto large bands of Irish and Welsh peasants in a state of destitution for want of work; and in spite of the liberality of the citizens, several gangs of them, while we were there, committed robberies in the neighbourhood. It appears that during the late troubles in Canada the tide of immigration was almost entirely stopped for several years; now it is setting in more strongly than ever: but as they come from all parts of the British Isles, it is scarcely possible unless the whole system of colonizing were under government regulation, and conducted on arbitrary principles, to adjust the supply of labour to the various and ever fluctuating local demands.

When passing in a carriage over the rich alluvial grounds on the left bank of the St. Lawrence I expostulated with some of the English proprietors on the intolerable condition of the muddy roads. I reminded them that all this part of Canada was a cleared and cultivated country, when half the United States was still a wilderness. They replied, that the French farmers, to whom most of the land belonged, refused to pay taxes for bettering the roads, contending that it was preferable to spend more time on the way, and to wear out their horses and vehicles somewhat faster, than to pay down money to a tax-gatherer.

The anecdotes told us by the British settlers, of the superstitious horror of the old Canadians at the new inventions and innovations of the Anglo-Americans, were very amusing. The river craft of the Canadian "voyageurs" was so unrivalled in its way that we may pardon them for beholding the first steamers with jealousy. One of them is said to have exclaimed, as he saw them ascending the St. Lawence, "Mais, croyez-vous que le bon Dieu permettra tout cela?" During this tour I often thought of the old story of the American, who said that "if the United States ever got possession of Canada they would soon *improve* the French off the face of the earth." The French party speak of the late Lord Sydenham as if they really believed him capable of conceiving and executing such a project. On the other hand, not a few of the English settlers, while they praised his zeal and habits of business, and devotedness to the interests of Canada, took pains to persuade me that if his measures were enlightened, his means of carrying them through the legislature were equally unscrupulous. One of his admirers, deeply imbued with the spirit of his policy, is said to have declared, "We shall never make any thing of Canada until we anglicize and protestantize it;" to which a French seigneur rejoined with bitterness, "Had you not better finish Ireland first?"

Some of the American travellers whom we met here were extremely entertained with the military display of the large army now quartered in this province, the reviews, the bands of music, the trains of baggage-waggons, which they occasionally met on the roads, the barracks of infantry and cavalry, the new fortifications of Kingston, and the old ones of Quebec. All this warlike parade, after a sojourn of nine months in the United States, appeared almost as great a novelty to us as to them; but the resemblance of the colony to a garrison afforded me no pleasure. It was a perpetual remembrance of the late troubles, and of that former mismanagement of which a civil war, however unjustifiable, affords ample proof. It reminded me also of the difficulties with which the wisest and best-intentioned government will have to contend, whose task it is to fuse into one harmonious whole two populations so dissimilar in origin and language as the French and British, and all whose ideas on social, political, and religious subjects, are so discordant. It recalled, moreover, to mind the unwarrantable conduct of those turbulent borderers, the American "sympathizers," who poured in by thousands to aid the insurgents, and whose intervention alone rendered the rebellion formidable for a time.

Great indignation was expressed to me by many Canadians, that these citizens should have been allowed with impunity, by the governor of New York, to take cannon out of a public arsenal, and invade a friendly territory in time of peace.

"Non cogente quidem sed nec prohibente tribuno."

Some New Yorkers, on the other hand, while they freely condemned the sympathizers, and said they had rejoiced in their defeat, defended their governor, saying it was impossible for him to have foreseen and provided against so sudden a movement along so extensive a frontier; that neither he nor the federal government had troops enough at their command to act as a sufficient police; and that it was too much to expect of them to maintain, permanently, a large standing army for the sake of being prepared for such rare emergencies.

That the whole of the British force now kept up in this colony is absolutely needed, I venture not to doubt; but they who refuse to hope for its speedy reduction, appear to me to libel by anticipation our future colonial policy. I listened with no small impatience to the wishes expressed by some residents, that this full war establishment should be permanent, and to their discussions on the desirableness of new fortifications, to be executed at great cost by England, and of fleets of war-steamers to be built on the lakes, in order that they might at all times be ready for an outbreak with the United States.

The population of the British possessions in America, in 1842, amounted in round numbers to one million and a half.

Lower Canada	- -	690,000
Upper Canada	- -	526,000
New Brunswick	- -	156,000
Nova Scotia	- -	180,000
		1,552,000

The annual growth of the population of the United States, with which their wealth and territory keep pace, exceeds at present 700,000 souls, so that every two years' increase is about equal to the number of all the present inhabitants of British America. The mere contemplation of these figures would seem to me enough to convince a reasonable man, that Canada must owe her security from external aggression, not to local armaments and provincial demonstrations, but to the resources of the whole British empire. A surplus revenue at home, or the remission of taxes which press heavily on industry and commerce, and economy in administering our colonial affairs in times of peace, are the true means of fortifying the Canadian frontier.

The legislature of Canada have lately voted a sum of money for a geological survey of the province, which has been placed under the direction of Mr. Logan, from whose labours we may soon expect an accurate map, with a description of the rocks and their organic remains, and a comparison of them with the equivalent formations in the United States. My own observations were confined to the valley of the St. Lawrence and its environs, where I was struck with the remarkable analogy between the structure of this part of North America and those portions of Scandinavia which I visited in 1834 and 1836. I seemed to have got back to Norway and Sweden, where, as in Canada, gneiss and mica schist, and occasionally granite, prevail over wide areas, while the fossiliferous rocks belong either to the most ancient or to the very newest strata, to the Silurian rocks, or to deposits so modern as to contain exclusively shells of recent species. In both countries, we pass over enormous spaces without beholding any formations of an intermediate age. In both, large erratics, or far-transported fragments of rock, have been carried from north to south, while the surfaces of solid rocks, covered at various heights by gravel, sand, and clay, have been smoothed and furrowed.

There are large parts of Scandinavia, where the Silurian strata have not been invaded by trappean rocks, whether felspathic or basaltic. There are others, where these igneous materials have intruded themselves, both in the form of dykes and overlying masses, as in Sweden, at Kinnekulle near

Lake Wener, and in Norway near Christiania. The same geological condition of things recurs in Canada, the mountain of Montreal affording a good example of slightly disturbed Silurian limestone full of shells and corals, with a capping of basalt or greenstone about eighty feet thick, which terminates abruptly towards the river, giving a picturesque outline to the hill. (See fig. 13. p. 140.) Numerous dykes or veins of trap, both felspathic and augitic, are seen penetrating the limestone, and some of them sending ramifications through it. One of the felspathic dykes (*d*, fig. 13.), consisting of claystone-porphyry, was well exposed to view by new excavations near M'Gill's College, at the time of my visit.

The limestone of this mountain, and of other districts in the valley of the St. Lawrence and the adjoining country, agrees in its fossils with the Trenton limestone of New York. (No. 15. of map Pl. II.) The same is seen at the Falls of Montmorenci, where it rests on the ancient sandstone (No. 15.), called the Potsdam sandstone, the lowest of more than twenty fossiliferous formations older than the coal, which are recognised in the classification of the New York surveyors. The upper part of this sandstone, at the falls above mentioned, is remarkable for containing boulders of enormous size, the largest I ever remember to have seen in any ancient stratified rock. I measured some of them which were eight feet long, but they may have been derived originally from the destruction of rocks in the immediate neighbourhood, as they consist of the same gneiss as that on which they rest, and therefore cannot be said, like certain modern erratics in Canada, to point to glacial action, or to imply that large blocks were transported by icebergs at a very remote period.

The strata of black slate, commonly called greywacke in Canada, which appear in a highly inclined position immediately below the Falls of Montmorenci, have, no doubt, been correctly referred, by Professor Emmons, to the slate of the Hudson river series. (No. 14. of map Pl. II.) In consequence of a derangement or fault in the strata, they appear, on a cursory view, to belong to an older formation than the less disturbed limestone and sandstone before mentioned. This fault is so extensive, that it has misled many of the earlier explorers of the valley of the St. Lawrence, who naturally concluded that the inclined greywacke was more ancient than the horizontal limestone of the same district, whereas it occupies in fact a higher place in the series.

The termination downwards of the most ancient fossiliferous rocks of Canada in a stratified quartzose sandstone with few fossils affords another point of analogy between the geology of Scandinavia and North America. An additional one is supplied by the unconformable superposition in both hemispheres of the inferior sandstone to gneiss. I saw a junction of this kind at Kinnekulle in Sweden, and in the U. S. at Little Falls on the Mohawk; and afterwards on the western borders of Lake Champlain in the U. S. At Little Falls, however, the ancient strata, which rest upon gneiss, do not belong precisely to the same part of this lower member of the Silurian series as those at Montmorenci, but to the beds next above the Potsdam; namely, those called the calciferous sandrock by the New York surveyors. This circumstance should serve as a warning against the hasty assumption that in any of these sections we have positively arrived at the lowest stratum containing organic remains in the crust of the earth, or have discovered the relics of the first living beings which were imbedded in sediment.

When reasoning on this subject, we must not forget that the oldest formations are those which must have suffered the greatest loss by aqueous denudation, and which have been most extensively altered by plutonic action. We must also remember how small a part of the earth's crust is accessible to human observation, three fourths of the surface of the globe being submerged beneath the ocean, and a fraction only of the remaining portion having been as yet carefully investigated by geologists. Nor must we overlook the large spaces occupied by formations newer than the Silurian, which may conceal from our view fossiliferous strata older than any yet brought to light.

As it is still a favourite theory of many geologists, that the granite and other formations, both stratified and unstratified, which I have called hypogene, were produced in far greater abundance before the origin of the oldest strata at present known to contain fossils than at any subsequent period; and as some are disposed to consider their conclusions on this head much strengthened by the fact that, in North America, as in Europe, there are certain points where granite, mica schist, and gneiss, can be shown to be of prior date to any of the fossiliferous rocks hitherto detected; I shall briefly refer to the leading arguments against this doctrine, which I have advanced both in my "Principles" and "Elements of Geology."

The crystalline formations, such as granite and gneiss, were termed primitive and primary by some of the earlier observers, because in each district they are the lowest in geological position. It is now understood, in regard to granite, syenite, and the unstratified class, that they are of various ages, often newer than fossiliferous strata, and that it by no means follows that they were first in the order of time, because they are inferior in position. Paradoxical as the first statement of this proposition appears, it is now acknowledged, that the superstructure is often older than the foundation on which it rests, the latter having been forced up subsequently from below either in a solid form, or, more frequently, like lava in a volcano. It is also now admitted, in direct contradiction to all preconceived opinions, that many stratified hypogene formations, the gneiss, mica schist, talcose schist, and saccharine marble of the Alps, Apennines, and other districts, have assumed their crystalline texture after the origin of many of the fossiliferous strata, even in some cases long after the deposition of those which repose directly upon them.

Nevertheless, if we confine the term primary to all rocks which we can prove to be of older date than strata in which organic remains have yet been discovered, we may affirm that the gneiss of Kinnekulle in Sweden before alluded to, or of the Falls of Montmorenci, and many of the unstratified or Plutonic rocks of the Adirondack Mountains, west of Lake Champlain, are truly primary. We may also extend the same appellation, without much liability of error, to all the crystalline rocks found for a considerable space on every side of the points where the lowest strata charged with fossils are incumbent upon the non-fossiliferous formations. But the farther we go from such points of departure, the more unsafe does our generalization become; and the American geologists have already found reason to retract their first conclusion, that the gneissose, micaceous, and talcose schists, of the Taconic range, (see above, p. 245. Vol. I.) are referable to a *primary* series.

The posteriority of age of many masses of granite and other Plutonic rocks is more easily proved than the modern origin of the stratified hypogene formations, because the former produce alterations of moderate extent, at the point of contact, or send veins into the newer fossiliferous strata. But where these strata have been altered on a great scale in texture, by heat and other subterranean causes, the evidence of transmutation is difficult to detect in proportion to the intensity of the metamorphic action. The study of the Alps and Apennines has shown that it is characteristic of such action to annihilate all signs of the date of its developement, by the obliteration throughout entire mountain masses of all traces of organic structure. We are therefore entitled, on every principle of sound reasoning, to suspect, that for one case where we can positively establish the secondary origin of any set of crystalline strata, there are many others where the proofs of their modern origin have been destroyed.

A geologist whose observations had been confined to Switzerland might imagine that the coal measures were the most ancient of the fossiliferous series. When he extended his investigations to Scotland, he might modify his views so far as to suppose that the Old Red sandstone marked the beginning of the rocks charged with organic remains. He might, indeed, after a search of many years, admit that here and there some few and faint traces of fossils had been found, in still older slates, in Scotland; but he might naturally conclude that all pre-existing fossiliferous formations must be very insignificant, since no pebbles containing organic remains have yet been detected in the conglomerates of the Old Red sandstone. Great would be the surprize of such a theorist, when he learnt that in other parts of Europe, and still more remarkably in North America, a great succession of antecedent sets of strata had been discovered, capable, according to some of the ablest paleontologists, of constituting no less than three independent groups, which are each of them as important as the "Old Red" or Devonian system, and as distinguishable from each other by their organic remains. Yet it would be consistent with methods of generalizing not uncommon on such subjects, if he still took for granted that in the lowest of these "Transition" or Silurian rocks, he had at length arrived at the much-wished-for termination of the fossiliferous series, and that nature had begun her work precisely at the point where his retrospect happened then to terminate.

It may be useful to enquire, whence arises this strong tendency to believe that the present limits of human knowledge in geological science exactly embrace that period of past time in which organic beings have flourished on the earth. If it be a very common delusion, there must be some cause for its popularity. Its source is, I believe, twofold; first, it is almost unavoidable that we should underrate the magnitude of the subterranean changes now in progress at great depths in the earth's crust; and, secondly, that we should equally exaggerate the amount of those which took place far below the surface at former eras, especially those most remote from our times.

In regard to the first of these sources of error, we have of late years grown familiar with the proofs of great subsidence and upheaval of land in modern times, without sufficiently reflecting on the enormous alterations in the condition, and probably the structure, of the subjacent parts of the earth's crust, which are implied by these movements. The connection of such rising and sinking of the solid parts of the globe with volcanic action can be demonstrated in many places, and fairly inferred in others, where the action of subterranean heat, owing to its great depth, is latent. I have endeavoured elsewhere to explain the grounds which we have for inferring that crystalline formations have been elaborated at many successive periods, both secondary, tertiary, and still more modern. We need go no farther, indeed, than the valley of the St. Lawrence, now under consideration, to find wide areas covered with marine shells of *recent* species, at the height of 500 feet above the sea, and where all the rocks can be shown, both to have sunk and to have been again uplifted bodily, for a height and depth of many hundred feet, since the deposition of these shells.

But however firmly we may be convinced that subterranean causes, connected with the developement of internal heat, have operated with great, and perhaps nearly uniform intensity, at each successive geological period of equal duration, we must still be prepared to find that by far the largest portions of the visible hypogene rocks are of high relative antiquity to the fossiliferous deposits. This must happen, if we are correct in assuming that the crystalline rocks, whether stratified or unstratified, have been formed originally at considerable depths in the crust of the earth. For in that case, a long period of time must have elapsed after their origin before they can have been brought up within the sphere of human observation. There must have been great upheaval and denudation to cause them to emerge, even in a single district; but it must require a series of geological epochs before those formed at a given era of the past can have become generally exposed at the surface. A repetition of one series of elevatory movements after another must have taken place in different areas, accompanied by denudation; and while such forces are acting, the deposition of new strata is going on, and the pre-existing crystalline rocks are becoming relatively more and more ancient.

What was before said of the succession of ages required to raise deep-sea formations extensively to the surface (see p. 55.) is equally applicable to rocks of deep subterranean origin. Hence it follows that the high relative antiquity of the visible crystalline rocks affords no better a presumption in favour of a period when nothing but granite and gneiss were formed, than the pelagic character of the visible Silurian strata and the absence of contemporaneous littoral deposits, imply the universality of the ancient ocean.

CHAPTER XXII.

Glacial Furrows in the Valley of the St. Lawrence. — Action of packed Ice in the Canadian Rivers. — Boulder Formation with and without Shells. — Gannanoqui. — Mountain of Montreal. — Recent Shells in Drift more than 500 Feet above the Sea. — Lake St. Peter. — Falls of Maskinongé. — Deposit of Shells at Beauport near Quebec. — Agreement with Swedish Fossils. — Shells in Boulder Formation of Lake Champlain. — Burlington, Vermont. — Fossils of Drift imply a colder Climate. — Scenery of Lake Champlain. — Organic Remains of lowest Silurian Sandstone. — Lingula. — Vermont Mountains. — Inns and Boarding Houses. — Return to Boston.

I HAD frequent opportunities in the valley of the St. Lawrence, especially at Kingston, and in the country between that city and Gannanoqui, of examining the recently bared surface of the fundamental rocks, consisting of, first, granite; 2dly, quartzose (or Potsdam) sandstone; 3dly, lower Silurian (or Trenton) limestone. Wherever the drift or superficial clay and gravel have been removed, the surfaces of these rocks are worn, smoothed, and furrowed, the furrows being least clearly defined on the sandstone.

The direction of all the straight and parallel grooves was nearly N. E. and S. W., differing uniformly in their general course from those traced by

Professor Hitchcock and Mr. Percival through New England, where they run usually from N. N. W. to S. S. E. It is worthy of notice, that in both regions the erratic blocks and boulders have been transported southwards, along the same lines as are marked out by the direction of the furrows. There is obviously, therefore, a connection between these two distinct classes of phenomena; and I know of no theory that can account for both of them, with any plausibility, except that already alluded to in the last chapter, viz. the agency of large islands of floating ice, which, by their buoyancy and enormous weight, supply the carrying power and pressure required to scratch, polish, and groove the solid floor of the ocean, and to convey stones of all sizes, firmly fixed and frozen into the ice, to great distances.

As large masses of ice are annually accumulated in the rivers of Lower Canada, and when they break up in spring are often the means of conveying from place to place huge fragments of rock, I hoped to discover indications, not only of the polishing, but also of the grooving of the surface, at those points where the packed ice is forced every year over the bottoms of the Canadian rivers. Accordingly, at Quebec, I went with Colonel Codrington, and searched carefully below the city in the channel of the St. Lawrence, at low water near the shore, for the signs of glacial action, at the precise point where the chief pressure and friction of packed ice are exerted every year. But the edges of the worn greywacke slates, in the channel there, are scarcely any of them hard enough to receive or retain such markings, and if they were so, the weight of the ice would probably be insufficient. At the bridge above the Falls, at Montmorenci, over which a large quantity of ice passes every year, the gneiss is polished, and kept perfectly free from lichens, but not more so than rocks similarly situated at waterfalls in Scotland. In none of these places were any long straight grooves observable, and I feel persuaded that any degree of freedom of motion in the rocky fragments forced along by small pieces of ice, or by a flood of water, would be quite incompatible with the mechanical effects exhibited in what are called glacial furrows.

I have stated that, between Kingston and Quebec, the quartzose sandstone retains the grooving much less distinctly than the limestone or granite. The largest area over which I observed the furrows to preserve a perfect parallelism, was a floor of limestone forty yards wide, from which clay had recently been removed. It was situated about six miles west of Gannanoqui. I saw the surfaces of smoothed granite on the Rideau Canal, six miles south of Kingston, swelling into those flattened dome-shaped forms called "roches moutonnées," so common in Sweden, and near the glaciers in Switzerland.

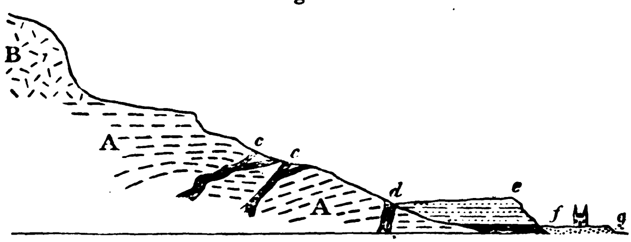
Although in this part of Canada the boulders are usually uppermost, yet at some points, near Gannanoqui, and elsewhere, they have been found, in sinking wells, to lie thirty feet deep in the clay and sand.

The St. Lawrence, in its course from Lake Ontario to Montreal, a distance of about 160 miles in a direct line, has a wide extent of low ground on both sides of it. The river falls in that distance 214 feet, descending by a succession of rapids, between which are lake-like expansions. At the rapids, the Transition limestone, or sandstone, or the intrusive trap, or subjacent gneiss, are exposed, but the valley is for the most part occupied by the boulder formation, the thickness of which, at the Belouse rapid, and at Cornwall, varies from twenty to forty feet. At Coteau du Lac, "the Cascades," and St. Ignatius, it constitutes a broad terrace, 80 to 100 feet above the St. Lawrence, and the small streams which drain the terrace have cut deep gullies or valleys through the clay.

This drift, or deposit of clay, sand, and gravel, is more usually stratified than that associated with large boulders in Scotland. It is generally destitute of organic remains, but in a few places contains them in abundance. In order to show the identity of the fossiliferous and non-fossiliferous portions of this formation, it will be necessary to enter into some details, which may not be without interest to the geologist who considers in how much obscurity all phenomena bearing on the glacial period are still involved.

Travelling from the south-west, I found no shells in the drift till I reached Montreal, which stands at the base of a mountain rising abruptly from a broad plain where the valleys of the St. Lawrence and the Ottawa meet. This mountain, which is 740 feet high above the St. Lawrence, terminates in two summits, one considerably higher than the other, and capped, as before stated, with a mass of greenstone about eighty feet thick. The subjacent beds of Silurian limestone are traversed by dykes and veins of trap. At the base of the hill, on its eastern side, in the suburbs of Montreal, we find clay and sand (*d*, *e*, fig. 13.) above 100 feet deep, in which marine shells occur. This deposit forms a terrace which ends abruptly in the steep bank (*e*) facing the river-plain, and running parallel to it for three or four miles. It varies in height from 50 to 150 feet, and at its base is a low flat of more modern gravel (*f*), rising from ten to twenty feet above the St. Lawrence. In certain places, as at the Côte St. Pierre, on the road from Montreal to Lachine, the surface of the terrace slopes from *e* to *d*, or towards the mountain. A good section of this modern deposit was to be seen at the Tanneries, a village in the parish of St. Henri in the

Fig. 13.



Section of Montreal mountain, with shelly drift at its base.

A. Silurian limestone.
B. Trap or greenstone.
c. Dykes of basaltic trap.
d. Dyke of felspathic trap, or claystone-porphyry.
d, e. Terrace of drift with shells.
f. Gravel, on which part of Montreal stands.
g. River St. Lawrence.

suburbs of Montreal, at the time of my visit (June, 1842). Excavations had recently been made for a new road, exposing horizontal beds of loam and marly clay, in one of which, at the height of about sixty feet above the St. Lawrence, I observed great numbers of the *Mytilus edulis*, or our common European mussel, the shells retaining both valves and their *purple colour*. In the same beds were specimens of *Tellina grœnlandica*, and a few of *Saxicava rugosa*. In the midst of the shells, I found a single isolated boulder of gneiss, six inches in diameter.

The Mytilus, although so abundant in this bed, is by no means of common occurrence in the drift of Lower Canada. The colour of the layers containing the Mytilus reminded me of those purple marls which I had seen in the boulder formation of Sweden, produced by the decomposition of countless numbers of these same shells.*

At the Côte St. Pierre, near the house of Mr. Brodie, forty feet above the section in the road last mentioned, and about ninety feet above the river, gravelly beds appeared, in which the *Tellina grœnlandica* and *Mya arenaria* were abundant, retaining both valves; they were also accompanied by *Saxicava rugosa.* The shelf (*d, e*) containing these remains is intersected here and there by deep narrow gullies, one of which terminates at the Tanneries. In the channels of the small streams draining these gullies I found fossil shells, washed out of the clay and sand, among which were a new species of *Astarte* (*A. Laurentiana*), *Saxicava rugosa,* and *Tellina grœnlandica,* yet nowhere could I see a single shell *in situ.* At some points, the upper beds of sand and gravel, at the same level as the shelly beds with Mytilus, before alluded to, become very coarse, and contain boulders of gneiss and syenite three feet in diameter,

* Phil. Trans. 1835, p. 7.

showing the inseparable connection between the fossils and the ordinary boulder formation of Canada.

As I could find no organic remains at any points higher than the terrace *d, e, fig.* 13., or none that were elevated 200 feet above the river, I might have gone away with the notion that the fossiliferous drift was confined to a comparatively low level, if Mr. Logan had not informed me the year before that Mr. M'Cord had been fortunate enough to meet with a small patch of gravel full of sea-shells at the height of more than 500 feet in the hollow between the two eminences which form the Montreal mountain. I was conducted by Dr. Holmes to this place, called the Côte de Neige, and found there a bed of gravel six feet thick, containing numerous valves of recent species, *Saxicava rugosa,* and *Tellina grœnlandica.* The deposit was covered by an unstratified mass of boulders and gravel twelve feet thick, which would have entirely concealed the shelly beds, had not the gravel been lately dug for road-making.

Mr. M'Cord estimated, from barometrical measurements, the height of these shells above the St. Lawrence, at Montreal, at 429 feet, which would give them an elevation above the sea of about 450 feet; but the same series of barometrical observations gave only 668 feet for the summit of Montreal mountain above the river, whereas Capt. Bayfield determined, by the mean of three trigonometrical measurements, the true height to be 760 feet, or 92 feet more. I am inclined, therefore, to believe that the shells are 520 feet above the river, or 540 feet above the sea, which gives an elevation of 306 feet above Lake Ontario, and places them nearly on a level with Lake Erie, which is 565 feet above the sea. Even if we adopt the lower estimate of Mr. M'Cord, and suppose the shells to be only 450 feet above the sea, they would be within 55 feet of the summit of the Falls of Niagara, and more than 200 feet above Ontario, between which lake and the mountain of Montreal there is an open and uninterrupted valley.

After this discovery of marine shells of living species, at so great an elevation in the drift of Canada, we must either conclude that the boulder formation of the Niagara district was deposited in the same sea, or abandon all idea of any approach to uniformity in the last series of upward movements, which raised the great lake district to its present height.

Between Montreal and Quebec, a distance of about 140 miles, in a straight line, I found the older rocks covered with a stratified drift similar to that already described, the lower beds usually consisting of laminated clay, and the upper of sand; but this arrangement is not constant. Boulders are for the most part sparingly interspersed, and often only seen on the surface. As I knew that Capt. Bayfield had met with marine shells in abundance, in the drift at several points between Quebec and Montreal, I inquired every where for fossils in the intervening country, but neither at Sorel, nor between Berthier and Maskinongé, nor on the shores of Lake St. Peter, could I see or hear of any.

At Lake St. Peter, the St. Lawrence expands into a lake, bounded by a low alluvial flat, which is sometimes several miles broad. This flat is in its turn bounded by a steep bank of sandy drift forty feet high, in which I could find no shells. Ascending it to a higher level, I went for nine miles over a sloping terrace of drift to the base of the mountains of gneiss, where the Falls of Maskinongé are situated. On the way, I examined the clay and yellow sand of St. Ursule, and other places, but was unable to detect a single shell. At the falls, at a height of more than 300 feet above the St. Lawrence, the gneiss makes its appearance in rounded domes (roches moutonnées). Higher up, or more than 400 feet above the St. Lawrence, the same gneiss is again covered deeply with stratified yellow sand, similar to that of the lower grounds.

Although, during my short stay, I was equally unsuccessful in detecting any marine shells at Three

Rivers, they have been met with in the neighbourhood, and at Port Neuf, and on the banks of the Jacques Cartier river, twelve miles above its junction with the St. Lawrence, about thirty miles above Quebec. My friend Col. Codrington observed there a fine section of drift, laid open by a landslip in May, 1842. At the top of the cliff was sand about thirty feet thick, and below blue clay, with shells of *Tellina calcarea*, *T. grœnlandica*, and *Astarte Laurentiana*.

I shall next describe the drift with shells in the immediate neighbourhood of Quebec, respecting which my curiosity had been excited as early as the winter of 1835, when Capt. Bayfield, then engaged in a trigonometrical survey of Canada, sent me a collection of marine fossil shells. In his letter, he described them as occurring in very modern strata, bordering the St. Lawrence, at a village called Beauport. When they arrived in London, Dr. Beck of Copenhagen, an eminent conchologist, happened to be with me; and great was our surprise, on opening the box, to find that nearly all the shells agreed specifically with fossils which, in the summer of the preceding year, I had obtained at Uddevalla in Sweden, and figured in my paper "On the Rise of Land" &c., in the Phil. Trans. for 1835. Among the species most abundant in these remote regions (Scandinavia and Canada), were *Saxicava* *rugosa*, *Mya truncata*, *M. arenaria*, *Tellina calcarea*, *T. grœnlandica*, *Natica clausa*, and *Balanus Uddevallensis*. All of them are species now living in the northern seas; and whereas I had found them fossil in latitudes 58° and 60° N. in Sweden, Capt. Bayfield sent them to me from part of Canada, situated in latitude 47° N. In both hemispheres, they are most abundant at moderate elevations above the sea, not exceeding usually 200 or 300 feet, but occasionally, in Norway, they attain, as at Montreal, much higher levels. As some of them belonged to species now living in the Greenland and other seas in high latitudes, Dr. Beck and I immediately concluded that this fossil fauna, having an almost arctic character, must formerly have had a wider range than the same assemblage of species at present.

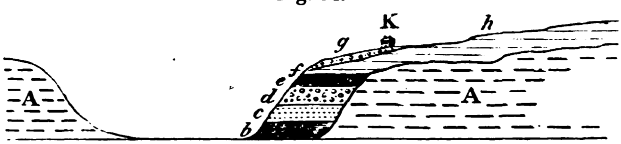
Captain Bayfield had called my attention in his letter to the fact, that boulders accompanied the shells in such a manner as to imply, that they had been dropped from melting icebergs to the bottom of a sea, in which the mollusca lived and died. He also furnished me with evidence, that the testacea now inhabiting the Gulf of St. Lawrence, differed widely as a whole from the fossil fauna of Beauport.*

The village of Beauport is about a quarter of a

* See my paper on this subject, Geological Trans. vol. vi. Second Series, p. 135., read 1839.

mile distant from the St. Lawrence, on its left bank, and about three miles below Quebec. Near it, a small streamlet flows in a narrow ravine, about 110 feet deep, partly excavated in the drift, which, like that of St. David's before described (p. 95.), had filled a more ancient hollow in the Silurian strata. By examining the cliff immediately below Mr. Ryland's house, and again a few hundred yards to the west, where lower beds were laid open by the river, and then ascending to the higher grounds northwards and towards St. Michel, I obtained the annexed section, the different parts of which I shall now describe.

Fig. 14.



Position of shelly drift in the ravine at Beauport, near Quebec.

A. Horizontal Lower Silurian strata.
b. Laminated clay.
c. Yellow sand.
d. Drift with boulders.
e. *Mya*, *Terebratula*, &c.
f. Mass of *Saxicava rugosa*.
g. Gravel with boulders.
h. Clay and sand of higher grounds, with *Saxicava*, &c.
K. Mr. Ryland's house.

The lowest mass of drift (*b*, fig. 14.), having a thickness of twenty-five feet, consists of fine, laminated, stiff blue clay, without fossils, similar to that containing shells on the Jacques Cartier, before mentioned. Next above, the beds *c* are composed of incoherent yellow sand, in regular layers, about twenty-five feet thick, also without shells. In the next mass, *d*, of loam and blue clay, having also a thickness of twenty-five feet, large boulders of dark syenite are frequent. I found no contemporaneous fossils, but fragments of Encrinus and Trilobite, derived from the older formations. Above this, in *e*, the fossils commenced. In the lowest five or six feet, they are rare, but become more abundant above. They are imbedded in layers of sand and loam with pebbles. The *Tellina calcarea* is most common, after which may be mentioned *Mya truncata*, *Terebratula psittacea*, with both valves united; *Mytilus edulis*, *Scalaria borealis*, *S. grœnlandica*, and several others.

To these succeeds a remarkably compact mass of shells, *f*, twelve feet thick, rudely stratified, consisting almost entirely of the *Saxicava rugosa*, most of them having the valves united. They are disposed in layers in every position, oftentimes end upwards, and are intermixed with a slight quantity of earthy matter and pebbles, some of the latter being eight inches in diameter. Most of the shells are bleached white, but there is one layer, an inch thick, in which they are stained of a ferruginous colour, as in the English Crag. The individuals of the Saxicava are smaller in their average size than those of the same species in the great bed of Uddevalla, in Sweden. With the Saxicava is associated *Balanus miser*, and more rarely *Natica clausa* and *Mytilus edulis*.

The topmost bed, *g*, in this vertical section, is two or three feet thick, and consists of sand, gravel, and boulders of granite, distinct from the boulders in *d*; but the mass *g* appeared to me to be superficial, and not to belong to the shelly drift. The bed of Saxicava, *f*, is about 150 feet above the level of the St. Lawrence, but is by no means the newest part of the drift of this region, for I found the ground immediately above, or north of K, to consist of a sloping terrace, in which are horizontal strata of clay and yellow sand, as at *h*, containing *Saxicava rugosa*, *Tellina grœnlandica*, and other marine shells. Some of these fossiliferous beds were within a quarter of a mile of Mr Ryland's house, K, and about 200 feet above the St. Lawrence; but I observed other similar beds without shells several miles inland, in a north-westerly direction, from 300 to 400 feet above the sea.

The following is a list of twenty-three species of fossils which I procured at Beauport:—

Tritonium anglicanum. Syn. Buccinum undatum, var.?
T. fornicatum. Syn. Fusus carinatus.
Trichotropis borealis.
Natica clausa. N. septentrionalis, Beck.
5. Velutina.
Scalaria grœnlandica.

S. borealis.
Littorina palliata, Say.
Mya truncata.
10. M. arenaria.
Saxicava rugosa.
Tellina grœnlandica.
T. calcarea. Agrees with recent species from Boston.
Astarte Laurentiana. New species: see description in note.*
15. Cardium grœnlandicum.
C. islandicum.
Nucula. Agrees with recent species found by Capt. Bayfield in the St. Lawrence.
Mytilus edulis.
Pecten islandicus.
20. Terebratula psittacea.
Balanus miser.
B. Uddevallensis. Syn. B. scoticus. Found recently in the German Ocean, off Scarborough.
Echinus granulatus, Say.

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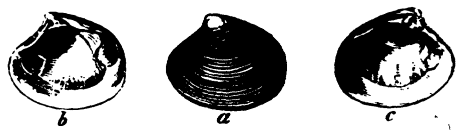
* Fig. 15. Astarte Laurentiana.



a. Outside. *b*. Inside of right valve.
c. Inside of left valve.

This must be regarded as an Astarte, although somewhat different from the usual form; it is comparatively *thin*, it is more *longitudinal*, it is *deeper or more gibbous*; the posterior lateral tooth in one, and the anterior lateral tooth in the other valve, are more than usually prominent. The shell has all the usual characters of the Astarte; among others, the small second vascular impression placed above the anterior adductor muscle. The following are its characters:—

At the falls of Montmorenci, the most north-eastern place which I visited in this neighbourhood, I saw on the right bank of the river, above the falls, and close to the bridge, a bed of gravel and sand, containing large boulders of gravel and syenite, some of them three feet in diameter. In this coarse gravel the *Saxicavarugosa* and *Tellina grœnlandica* occurred. The whole mass rested on Lower Silurian limestone.

I did not examine the valley of the Ottawa River (see map); but I may mention that Mr. Logan obtained near Bytown concretions of clay similar to those called fairy stones, which occur without fossils in the clay at Albany, New York, and at Burlington, Vermont, and in Massachusetts, as described by Professor Hitchcock. In the centre of one of these nodules was the entire skeleton of a fossil fish, allied to, if not identical with, that named *Mallotus villosus* by Professor Agassiz, which now lives in the Greenland seas, and is also found fossil in Greenland.

The only remaining district seen by me where shells have been discovered in the boulder formation, is on the borders of Lake Champlain, about eighty miles south of Montreal. The basin of this lake

A. testâ subovali, sublongitudinali, tenuiusculâ, gibbosulâ, extûs concentricè confertim sulcatâ; dente laterali utriusque valvæ prominentiori.

may be considered as a southern branch of the valley of the St. Lawrence, and the locality is important, as being the most southern latitude (44° 25′ N.) to which this assemblage of arctic fossils has been traced. Professor Emmons has given an account of the spot where the shells occur, south of Port Kent, in the county of Essex, State of New York, at a point where a small brook enters on the western side of the lake. In this place I observed, at the bottom of the section, first, clay, thirty feet thick, with boulders of gneiss, granite, limestone, and quartzose (Potsdam) sandstone, some rounded blocks of the latter being *nine feet in diameter;* secondly, loam with shells, six feet thick; thirdly, sand, twenty feet thick. Although the shells in the second bed, or the loam, were very numerous, I could only detect four species, namely, *Mytilus edulis, Saxicava rugosa, Tellina grœnlandica,* and *Balanus miser.*

Travelling inland from this spot to Keeseville, I found the boulder formation of great depth, covering the older rocks, and the ascent to an elevation of about 500 feet is by a succession of terraces, composed chiefly of beds of sand. I consider the whole of these strata to be upper members of the same deposit, doubtless all marine, although no shells have yet been met with at a greater height than forty feet above the lake.

At Burlington, in Vermont, on the opposite or east side of Lake Champlain, the drift consists chiefly of clay, laminated and micaceous, or unlaminated and without mica. In this clay, argillaceous concretions of curious forms occur. In some places beds of brick earth, sand, and gravel are associated, pebbles and boulders being scattered sparingly through the loam. Professor Benedict pointed out to me several spots where this loam behind the town, at the height of thirty and forty feet above the lake, contains shells of the *Tellina grœnlandica*, without any other species. In like manner, I afterwards observed this Tellina in a recent state, on the shores of the Bay of Fundy, in Nova Scotia, strewed for miles along the beach unmixed with other species. At the Falls of the Winouski or Onion River, near Burlington, the boulder clay attains a thickness of 200 feet. Although in great part marly and calcareous, it is barren of shells. There has evidently been great denudation of the drift around Lake Champlain, and I conceive that most of the large boulders of granite, syenite, and sandstone, which now rest upon the surface, may once have been dispersed through the mass. Nothing, however, is clearer than that here, as well as in the valley of the St. Lawrence, between Kingston and Quebec, the marine shells of recent species are referable to the same geological period as that to which the boulders belong. The shells occur both below and above far-transported fragments of rock, and the fundamental granite, limestone, and other rocks, which support the shelly drift of the St. Lawrence and Lake Champlain, are smoothed and furrowed on their surface by glacial action.

In my first memoir on the fossil shells sent to me by Capt. Bayfield, from the drift near Quebec, I called attention to the fact, that the number of species was small, while the individuals were numerous, a character belonging to the fauna of seas in high latitudes. At the same time it was shown, that there was a far greater variety in the shells now living in the Gulf of St. Lawrence. Dr. Gould, the eminent conchologist of Boston, suggested to me, that on examining a greater number of localities, especially at wide distances from each other, I might find the number of species gradually to augment. This has not been the case, and when we reflect, that at Burlington in Vermont, which, as before stated, is situated in latitude 44° 25′ N., or corresponding to the latitude of Bordeaux in France, we meet with the same assemblage as near Quebec, latitude 46° 48′ N., and at some points on the coast of Labrador, in latitude 50°, most of them being identical with fossils of the Scandinavian drift, in latitudes

58° and 60° N.; we shall be inclined to acquiesce in the views which I formerly advanced, respecting the prevalence of a colder climate in these regions at the time when the boulder formation originated.

July 5th. — Returning to Montreal after our excursion to Quebec, we crossed the St. Lawrence on our way southward to La Prairie. On looking back over the river at Montreal, the whole city seemed in a blaze of light, owing to the fashion here of covering the houses with tin, which reflected the rays of the setting sun, so that every roof seemed a mirror. Behind the city rose its steep and shapely mountain, and in front were wooded islands, and the clear waters of the St. Lawrence sweeping along with a broad and rapid current. In the barracks at La Prairie, a regiment of hussars was exercising — a scene characteristic of the times. On our way to Lake Champlain we slept at St. John's, where I counted under the eaves of the stable of our inn more than forty nests of a species of swallow with a red breast. The head of a young bird was peeping out of each nest, and the old ones were flying about, feeding them. The landlord told me, that they had built there for twenty years, but missed the two years when the cholera raged, for at that time there was a scarcity of insects. Our host also mentioned, that in making an excavation lately near Prattsburg, about 1000 of these birds were found hybernating in the sand: a tale for the truth of which I do not vouch, but it agrees with some old accounts of the occasional hybernation of our swallows in similar situations.

We next crossed Lake Champlain to Burlington, in Vermont, in a steam-boat, which for neatness, elegance, and rapidity exceeded any we had yet beheld. The number of travellers has been sensibly thinned this year by the depressed state of commerce. The scenery of this lake is deservedly much admired. To the west we saw the principal range of mountains in the State of New York, Mount Marcy, the highest, attaining an elevation of upwards of 5400 feet. It is still (July 6th) capped with snow, but the season is unusually late. From the survey of this part of New York by Professor Emmons, it appears that hypersthene rock rises up in the central part of this chain, and forms the nucleus, around which masses of gneiss, crystalline limestone, and other formations are disposed. To the eastward were the Green Mountains, chiefly composed of chlorite schist, the Camel's Hump, and the still loftier Mount Mansfield, being very conspicuous.

We landed at Burlington, finely situated on the east shore of the lake; its streets adorned with avenues of the locust tree, (*Robinia pseudo-acacia*), now covered with white blossoms, and affording an agreeable shade. After examining the rocks in the neighbourhood, and at the Falls of the Wisconsin, with Professor Benedict, I crossed the lake to Port Kent, and, after seeing the boulder formation with shells already described, I went to Keeseville, to examine a deep cleft in the sandstone, through which the Ausable river flows for two miles. This chasm is only from forty to fifty feet in width, while its perpendicular walls are 100 feet high. A flight of wooden stairs has been placed so as to enable one to reach the bottom, and the geologist may observe, as he descends, the numerous horizontal strata of siliceous sandstone. In many places, this most ancient of the fossiliferous rocks of New York (the Potsdam sandstone) is divided into laminæ by the remains of innumerable shells of the genus *Lingula*. They are in such profusion as to form black seams like mica, for which they were at first mistaken.* With the Lingula occurs another small placunoid shell, allied to, if not identical, according to Professor E. Forbes, with a fossil which occurs in company with a small Lingula in the lowest beds of the English Silurian series at Builth, in Brecknockshire. As this is perhaps the most ancient fossiliferous rock of which the position

* See Emmons's Report on the Geology of New York, p. 218.

has been well determined in North America, it is highly interesting that one of its commonest organic remains should belong to a living genus (*Lingula*), and that its form should come very near to species now existing. Throughout so vast a series of ages has Nature worked upon the same model in the organic world! Nor are the signs of uniformity confined to these phenomena, for they extend equally to the shape of the ripple mark on the ledges of sandstone laid open to view above the chasm, where two beautiful waterfalls are seen on the Ausable river. The ripple-like ridges and furrows exhibit their usual parellelism and ramifications as sharp as if they had been made yesterday. On my way back over the lake to Burlington, I saw, on looking from our boat through the clear and shallow water near the shore, a similar ripple in the light yellow-coloured, loose sand, extending over hundreds of acres, and proving that it is not merely on the beach between high and low water mark that the movement of the water can produce those sinuous ridges, but also to a certain depth below.

Some of the freshwater shells inhabiting Lake Champlain are of species peculiar to this lake, as, for example, *Limnæa gracilis*, specimens of which were presented to me by Professor Benedict. Among the flowers and plants which enlivened the borders of this lake was the Virginia raspberry, with its large red blossoms, the Kalmia, (*K. angustifolia*), a beautiful tiger lily, the oderiferous shrub called sweet fern, (*Comptonia asplænifolia*), an Hypericum, and a blue Campanula.

July 9th.—From Burlington, I crossed the Green Mountains of Vermont, composed of chlorite schist, gneiss, and other crystalline rocks, passing by Concord and Montpelier, to Hanover. Here we paid a visit to Professor Hubbard, at Dartmouth College, and then returned through New Hampshire to Boston. Since we had left that city in May, we had travelled in little more than two months a distance of 2500 miles on railways, in steamboats, and canoes, in public and private carriages, without any accident, and having always found it possible so to plan our journey from day to day, as to avoid all fatigue and night travelling. We had usually slept in tolerable inns, and sometimes in excellent hotels in small towns, and had scarcely ever been interrupted by bad weather. I infer, from the dismay occasionally expressed by Americans when we pursued our journey, in spite of rain, that the climate of the States must be always as we found it this year—wonderfully more propitious to tourists than that of the "old country," though it is said to be less favourable to the health and complexion of Europeans.

I ventured on one or two occasions in Canada, when I thought that the inns did not come up to the reasonable expectations of a traveller, to praise those of the United States. I was immediately assured that if in their country men preferred to dine at ordinaries, or to board with their families at taverns, instead of cultivating domestic habits like the English, nothing would be more easy than to have fine hotels in small Canadian towns. This led me to inquire how many families, out of more than fifty which we had happened to visit in our tour of eleven months in the United States, resided in boarding-houses. I found, that there was not one; and that all of them lived in houses of their own. Some of these were in the northern and middle, others in the southern and western States; some in affluent, others in very moderate circumstances: they comprised many merchants as well as lawyers, ministers of religion, political, literary, and scientific men.

Families who are travelling in the U. S., and strangers, like ourselves, frequent hotels much more than in England, from the impossibility of hiring lodgings. In the inns, however, good private apartments may be obtained in all large towns, which, though dear for the United States, are cheap as contrasted with hotels in London. It is doubtless true that not only bachelors, but many young married couples, occasionally escape from the troubles of house-keeping in the United States, where servants are difficult to obtain, by retreating to boarding-houses; but the fact of our never having met with one instance among our own acquaintances inclines me to suspect the custom to be far less general than many foreigners suppose.

It was now the fourth time we had entered Boston, and we were delighted again to see our friends, some of whom kindly came from their country residences to welcome us. Others we visited at Nahant, where they had retreated from the great heat, to enjoy the sea-breezes. The fire-flies were rejoicing in the warm evenings. Ice was as usual in abundance; the iceman calling as regularly at every house in the morning as the milkman. Pine-apples from the West Indies were selling in the streets in wheelbarrows. I bought one of good size, and ripe, for a shilling, which would have cost twelve shillings or more in London. After a short stay, we set sail in the Caledonia steam-packet for Halifax.

CHAPTER XXIII.

Halifax.—Glacial Furrows in Nova Scotia.—Difference of Climate of Halifax and Windsor.—Tracts covered with Kalmia.—Linnæa borealis.—High Tides of the Bay of Fundy.—The Bore.—Recent Deposits of Red Mud hardened in the Sun.—Fossil Showers of Rain.—Footprints of Birds, and Casts of the same.—Cracks caused by Shrinkage.—Submerged Forest.—Recent Glacial Furrows at Cape Blomidon.—Loaded Ice.—Ice-Ruts in Mud.

July 16. 1842.—WHEN I went on board the Caledonia at Boston, I could hardly believe that it was as large as the Acadia, in which we had crossed the Atlantic from Liverpool, so familiar had I now become with the greater dimensions of the steamers which navigate the Hudson and other large American rivers.

We soon reached Halifax, and I determined to devote a month to the geology of Nova Scotia. About three miles south of Halifax, near "the Tower," I saw a smooth surface of rock, formed of the edges of curved and highly inclined strata of clay-slate. This surface was crossed by furrows about a quarter of an inch deep, having a north and south direction, and preserving their parallelism throughout a space 100 yards in breadth. Similar phenomena are observed in other parts of this peninsula, on ther emoval of the drift, which occurs both stratified and unstratified, and much resembles that of Scotland. I may mention here, that afterwards near Pictou (at Dixon's quarry), I observed polished a surface of quartzose grit of the coal measures, with distinct furrows running nearly E. and W. or E. 15° N., magnetic; while in some other places I saw them having nearly the same direction as at Halifax.

Nova Scotia is usually known to strangers by its least favourable side,—its foggy southern coast, which has, nevertheless, the merit of affording some of the best harbours in the world. We left Halifax for Windsor in a drizzling rain and fog, and were told that we should probably find fair weather on the other side of the hills. Accordingly, when we had travelled about thirty miles, and crossed a low chain called the Ardoise Hills, we found the sun shining on a region sloping towards the Bay of Fundy, where a rich vegetation clothes the rocks of red sandstone, marl, and limestone.

Great was the contrast between the climate and aspect of this fertile country, and the cold barren tracts of granite, quartzite, and clay-slate which we had passed over on our way from Halifax. The sterility of that quartziferous district had not been relieved by any beautiful features in the scenery, the plants alone affording us some points of interest and novelty, especially a species of Kalmia (*K. angustifolia*), now in full flower, which monopolised the ground in some wide open spaces, as heaths take exclusive possession of barren tracts in Europe. In the woods near Windsor, I saw several kinds of *Pyrola* and other flowers, differing, for the most part, from British species, but among them the *Linnæa borealis* appeared here and there, matting the ground with its green leaves under the shade of the fir-trees, and still displaying some of its delicate pink flowers. I had gathered it some years before in the mountains of Norway, north of Christiania, and have since seen it growing in Scotland, where it is very rare. Linnæus, when this small and elegant plant had been named after him by a friend, accepted it as his emblem, comparing it to himself when struggling with difficulties; he described it as "a humble, despised, and neglected Lapland plant, flowering at an early age." Eventually, the last only of these points of resemblance remained true, for few men of science have ever risen to greater honours in their own country than he did, and his diary has laid him open to the charge of no ordinary share of vanity, a fault which we forget in our admiration of his original genius, and the important reforms which he introduced into the study of every branch of natural history.

More than half of the southern portion of the peninsula of Nova Scotia consists of granitic rocks, clay-slate, quartzite, and other crystalline formations without fossils, the strata having an east and west strike. Granite also occurs, intruding itself in veins into every part of this series. Towards their northern limits, the slaty formations become less metamorphic, and contain fossils, some of which I collected at New Canaan near Wolfville in King's County, and others on the East River of Pictou, consisting of *Encrinites*, and *Trilobites*, and shells of the genera *Orthoceras*, *Spirifer*, *Orthis*, and *Leptæna*. Some few of them agree specifically with fossils of the Hamilton group or uppermost Silurian division of the United States, No. 10. of map, Pl. II.

After crossing the Ardoise Hills above mentioned, I left these older rocks, and entered upon strata which constitute, as I shall show in the sequel (ch. 25.), a lower carboniferous formation, containing subordinate beds of gypsum and marine limestone. These rocks I examined on the banks of the Avon, in the neighbourhood of Windsor, and in the cliffs at Horton Bluff. I then passed by Kentville and Cornwallis, skirting the western shores of the Basin of Mines. Into this basin, or inner estuary, the tides of the Bay of Fundy pour twice every day a vast body of water through a narrow strait, converting every small streamlet into the appearance of a large tidal river. The tides are said to rise in some places seventy feet perpendicular, and to be the highest in the world. They often come up at first with a lofty wave called the Bore, of which I saw a fine example in the largest river of Nova Scotia, the Shubenacadie, where the waters seemed to be rushing down a much steeper slope than the St. Lawrence at its rapids. They roared too as loudly over their rocky bed, but could not compete inbeauty ; for instead of the transparent green waters and white foam of the St. Lawrence, they resembled a current of red mud in violent motion.

The waters of the Bay of Fundy become charged with this red sediment, by undermining cliffs of red sandstone and soft red marl; and in places where they overflow the alluvial plains, they throw down red mud wherever the velocity of the current is suspended at the turn of the tide. Many extensive and level flats of rich land have been thus formed naturally, and many thousand acres of the same have been excluded artificially from the sea by embankments. When I arrived in this region it was the period of the lowest or neap tides, so that large areas, where the red mud had been deposited, were laid dry, and in some spots had been baking in a hot sun for ten days. The upper part of the mud had thus become hard for a depth of several inches,

Fig. 3. Transverse Section of Slab

and in its consolidated form exactly resembled, both in colour and appearance, some of the red marls of the New Red sandstone formation of Europe. The upper surface was usually smooth, but in some places I saw it pitted over with small cavities, which I was told were due to a shower of rain which fell eight or ten days before, when the deposit was still soft. It perfectly recalled to my mind those "fossil showers" of which the markings are preserved in some ancient rocks, and the origin of which was first correctly explained to an incredulous public by Dr. Buckland in 1838. I have already alluded to such impressions of rain-drops when speaking of the ripple-marked flags of the New Red sandstone at Newark in New Jersey. I saw several other examples, during my tour, of similar phenomena, particularly in a bright red deposit of mud thrown down at the mouth of the Patapsco at Baltimore, of which I was able to bring away some consolidated layers. On these, in addition to the smaller cavities due to rain, there are larger ones, more perfectly circular, about the size of large currants, which have been formed by air-bubbles in the mud.

On the surface of the dried beds of red mud at Wolfville on the Bay of Fundy before mentioned, I observed many worm-like tracks, made by *Anne-*

Recent Footprints of Birds.

The Sandpiper, (Tringa minuta ?) on the red mud of the Bay of Fundy, Nova Scotia

Natural Size

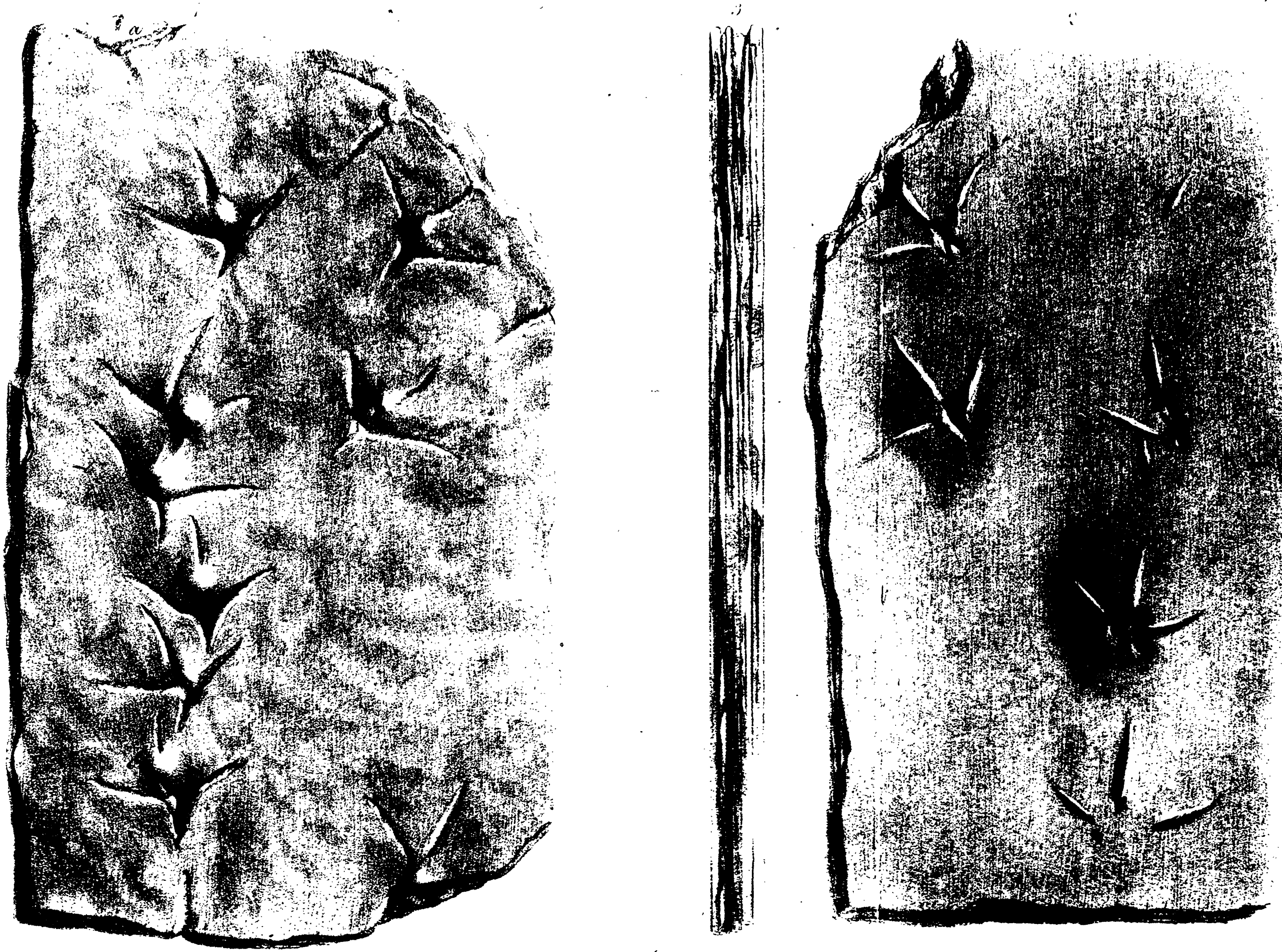


Fig 1 Upper Surface of Slab. Fig 2 Lower Surface with Casts of Footprints in relief. Fig 3 Transverse Section of Slab.

lides which burrow in the mud; and, what was still more interesting to me, the distinct footmarks of birds in regular sequence, faithfully representing in their general appearance the smaller class of Ornithicnites of high antiquity in the valley of the Connecticut before described. (Vol. I. p. 252.)

I learnt from Dr. Harding of Kentville, and Mr. Pryor of Horton, who were my guides, that these recent footprints were those of the sandpiper (*Tringa minuta*), a species common to Europe and North America, flights of which I saw daily running along the water's edge, and often leaving thirty or more similar impressions in a straight line, parallel to the borders of the estuary. The red mud had cracked in hardening in the sun's heat, and was divided into compartments, as we see clay at the bottom of a dried pond, and I was able to bring away some pieces to England. One of these I have figured in the annexed plate (VII.). In fig. 1. we see the upper surface of the slab, on the left side of which are six perfect foot-marks in the same line, with part of a seventh, and another, *a*, probably belonging to a distinct line. A small ball or protuberance will be seen near the base of the middle toe, as at *a*, *b*, or sometimes about the middle of the impression of the middle toe, as at *c*. This is caused by the mud which is displaced by the prominent metatarsus or instep bone, which has thrust forward a small mound of earth, in consequence of the slanting position of the leg as the bird advances. On splitting the slab, and reducing it to the thickness expressed in the transverse section, fig. 3., I was fortunate enough to lay open an under surface, on which two other lines of foot-prints appeared in relief, fig. 2. These are the casts of impressions which had been made on an inferior layer, deposited several tides before; and I ascertained that on the upper and under surfaces of several other thin laminæ, shown in the cross section No. 3., there exist similar foot-marks, each set made by birds at different times. It will be seen that the toes which are indented in No. 1. are represented by protuberances in No. 2., and that at *d* the mark of a single toe occurs in relief, and quite isolated. This occurrence was not unfrequent, and Mr. Waterhouse has suggested to me in explanation that these waders, as they fly near the ground, often let one leg hang down, so that the longest toe touches the surface of the mud occasionally, leaving a single mark of this kind. The slabs here figured have been presented by me to the British Museum, in order that those naturalists who are still very sceptical as to the real origin of the ancient fossil ornithicnites, of which there are some fine examples in our national repository, may compare the fossil products of the month of July, 1842, with those referable to feathered bipeds which preceded the era of the Icthyosaurus, Iguanodon, and Pterodactyl.

On several wide areas, comprising many hundreds of acres each, I saw the surface of the red mud fissured in all directions by the shrinkage accompanying desiccation, and I was surprised to find some of the cracks several inches wide, and no less than two or three feet deep. Occasionally, a fresh tide had deposited sediment in the older cracks, filling them up, and this mud having in its turn become hardened, together with a new contemporaneous superficial layer, I found, on taking up the slab, the casts of the old fissures standing out in relief, as we occasionally see them on the under surfaces of flags of sandstone, which rest on layers of clay or shale.

Before quitting the subject, I may state that hard nodules of a red clay-ironstone are occasionally met with in the red mud, some of which I was shown as having been found near Minudie at low water. The nucleus of the concretion often consisted of recent littoral shells, *Mya arenaria* and *Tellina grœnlandica.* I was also informed that there was a submerged forest buried in this red mud, and exposed to view in the Cumberland Basin at low tide, not far from Fort Cumberland. I regret that I had no time to examine this forest of upright trees, as the accounts

I received of it appeared to imply that there must have been some subsidence of land in modern times. In estimating the changes in progress in nature's laboratory beneath the sea, we must not forget that by far the greater part of the red sediment of the Bay of Fundy is carried out by a strong current into the depths of the Atlantic.

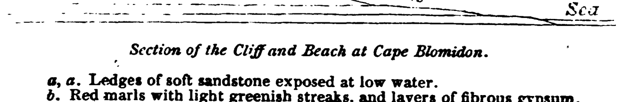
July 24. — Continuing my course along the western borders of the Basin of Mines, I at length reached Cape Blomidon, where cliffs of soft red sandstone, in nearly horizontal beds, are capped by a mass of basalt, greenstone, and amygdaloid. This mass of igneous rock, after presenting fine ranges of rude columns in the bold precipices facing northwards, is continuous, in a narrow strip of high land, for no less than 130 miles east and west, extending as far as Annapolis, and beyond it to Briar Island. Its structure and characteristic minerals have been well described by Messrs. Jackson and Alger, in their elaborate paper, read in the year 1831, to the American Academy.* Although this trap is generally parallel to the subjacent red sandstone, it appears in reality to form a great dyke rather than a contemporaneous bed.

* On the Mineralogy and Geology of Nova Scotia. Mem. of Amer. Acad. of Arts and Sci. vol. i. New Series, 1833. Cambridge, Mass.

As I was strolling along the beach at the base of these basaltic cliffs, collecting minerals, and occasionally recent shells at low tide, I stopped short at the sight of an unexpected phenomenon. The solitary inhabitant of a desert island could scarcely have been more startled by a human foot-print in the sand, than I was on beholding some recent furrows on a ledge of sandstone under my feet, the exact counterpart of those grooves of ancient date which I have so often described in this work, and attributed to glacial action. After having searched in vain at Quebec (see p. 136.) for such indications of a modern date, I had despaired of witnessing any in this part of the world. I was now satisfied that, whatever might be their origin, those before me were quite recent.

The inferior beds of soft sandstone, *a*, *a*, fig. 16.,

Fig. 16.

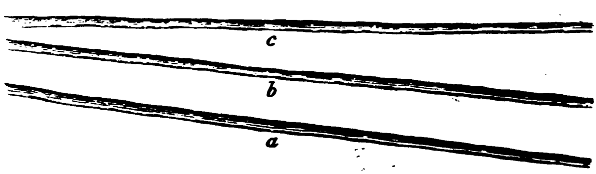


Section of the Cliff and Beach at Cape Blomidon.

a, *a*. Ledges of soft sandstone exposed at low water.
b. Red marls with light greenish streaks, and layers of fibrous gypsum.
c. Capping of trap.
d. Talus of blocks and pebbles of trap, amygdaloid, greenstone, &c.

which are exposed at low water at the base of the cliff at Cape Blomidon, form a broad ledge of bare rock, to the surface of which no sea-weed or barnacles can attach themselves, as the stone is always wearing away slowly by the continual passage of sand and gravel, washed over it from the talus of fallen fragments, *d*, which lies at the foot of the cliff on the beach above. The slow but constant undermining of the perpendicular cliff forming this promontory, round which the powerful currents caused by the tide sweep backwards and forwards with prodigious velocity, must satisfy every geologist that the denudation by which the ledge in question has been exposed to view is of modern date. Whether the rocks forming the cliff extended so far as the points *a*, 10, 50, or 100 years ago, I have no means of estimating; but the exact date and rate

Fig. 17.



Recent furrows on ledge of sandstone at Cape Blomidon.

of destruction are immaterial. On this recently formed ledge, I saw several straight furrows half an inch broad, some of them very nearly parallel, as *a*, *b*, fig. 17., others diverging, as *c*, the direction of *a*, *b*, being N. 35° E., or corresponding to that of the shore at this point. After walking about a quarter of a mile, I found another set of similar furrows, having the same general direction within five degrees; and I made up my mind that if these grooves could not be referred to the modern instrumentality of ice, it would throw no small doubt on the glacial hypothesis. When I asked my guide, a peasant of the neighbourhood, whether he had ever seen much ice on the spot where we stood, the heat was so excessive (for we were in the latitude of the south of France, 45° N.) that I seemed to be putting a strange question. He replied that in the preceding winter of 1841 he had seen the ice, in spite of the tide, which ran at the rate of 10 miles an hour, extending in one uninterrupted mass from the shore where we stood to the opposite coast at Parrsborough, and that the icy blocks, heaped on each other, and frozen together or "packed," at the foot of Cape Blomidon, were often fifteen feet thick, and were pushed along when the tide rose, over the sandstone ledges. He also stated that fragments of the "black stone" which fell from the summit of the cliff, a pile of which, *d*, fig. 16., lay at its base, were often frozen into the ice, and moved along with it. I then examined these fallen blocks of amygdaloid scattered round me, and observed in them numerous geodes coated with quartz crystals. I have no doubt that the hardness of these gravers, firmly fixed in masses of ice, which, although only fifteen feet thick, are often of considerable horizontal extent, have furnished sufficient pressure and mechanical power to groove the ledge of soft sandstone.

In Nova Scotia the term "loaded ice" is in common use for large sheets of ice several acres in area, which are sometimes floated off from the rivers as the tide rises, with sedge and other salt-marsh plants frozen into their lower surfaces; also with mud adhering plentifully to their roots. In our speculations, therefore, on the carrying power of ice, we ought always to remember that, besides gravel and large fragments of rock, it transports with it the finest mud.

Dr. Harding informed me that the surface of mud-banks along the estuaries near Wolfville, are often furrowed with long, straight, and parallel ruts, as if large waggons had passed over them. These conform in their general direction to the shore, and are produced by the projecting edges of irregular masses of packed ice, borne along by the tidal current.

CHAPTER XXIV.

Coal Formation of Nova Scotia.—Productive Coal Measures.—Erect Fossil Trees in the Cliffs of the Bay of Fundy.—Section from Minudie to the South Joggins.—Ten buried Forests, one above the other.—Connexion of upright Trees with Seams of Coal.—Stigmaria.—Sigillaria.—Evidence of repeated Submergence of dry Land.—Theory to explain the Evenness of the ancient Surface.—Pictou Coal-field.—Bed of erect Calamites, compared to those of St. Etienne in France.—List of Species of Nova Scotia Coal-plants.—Four-fifths of these Fossils identified with European Species.—Carboniferous Flora of the United States.

ABOVE the granite, clay-slate, quartzite, and Silurian formations of Nova Scotia, there occur, in the northern part of the peninsula, as stated in the last chapter, strata referable to the carboniferous group, occupying very extensive tracts, and resting unconformably on the rocks of the older series. They may be divided into three formations; the middle one, comprising the productive coal-measures, agreeing precisely with those of Europe in their lithological characters and organic remains; an upper one, composed of sandstone and shale with fossil plants, but without coal; and a lower carboniferous group, chiefly made up of red sandstone and red marl, with subordinate beds of gypsum and marine limestone.

In this lower series there are also occasionally some beds of shale with plants, and some coal-grits, and thin seams of impure coal.

A variety of opinions have been entertained respecting the true age and position of the last-mentioned or gypsiferous formation, which has been generally presumed to be newer than the coal,—by some referred to the New Red sandstone, and even thought to overlie the coal-measures unconformably. Immediately after my return to England, I communicated to the Geological Society my opinion; 1st, that the gypsiferous formation, with its accompanying fossiliferous limestones, is a true member of the Carboniferous group; 2dly, that its position is below the productive coal-measures.*

I shall now give some account of these middle or productive coal-measures, which contain valuable seams of bituminous coal, at various places, especially near Pictou. I was particularly desirous, before I left England, of examining the numerous fossil trees alluded to by Dr. Gesner as imbedded in an upright posture at many different levels in the cliffs of the South Joggins, near Minudie. These cliffs belong to the Cumberland coal field, on the southern shores of a branch of the Bay of Fundy, called the Chig-

* See Proceedings of Geol. Soc., vol. iv. p. 184. 1843.

necto Channel, which divides part of New Brunswick from Nova Scotia. The first allusion to the trees which I have met with, is that published in 1829 by Mr. Richard Brown, in Halyburton's Nova Scotia, and he attributed their fossilisation to the inundation of the ground on which the forests stood. I felt convinced that, if I could verify the accounts of which I had read, of the superposition of so many different tiers of trees, each representing forests which grew in succession on the same area, one above the other; and if I could prove at the same time their connexion with seams of coal, it would go farther than any facts yet recorded to confirm the theory that coal in general is derived from vegetables produced on the spots where the carbonaceous matter is now stored up in the earth.

At Wolfville I hired a schooner, which soon carried us across the Basin of Mines to Parrsborough. We had a side wind, and the deck was inclined at about an angle of 45°, in spite of which we admired a splendid view of the coast, and the range of basaltic rocks which extend from Cape Blomidon to Cape Split. At Parrsborough I was joined by Dr. Gesner, who had come expressly from New Brunswick to meet me; and we went together to Minudie, a thriving village, where we were hospitably received by the chief proprietor and owner of the land, and of many of those fertile flats of red mud before described, which he has redeemed from the sea.

From Minudie, a range of perpendicular cliffs extends in a south-westerly direction along the southern shore of what is commonly called the Chignecto Channel. The general dip of the beds is southerly, and the lowest strata near Minudie consist of beds of red sandstone, with some limestone and gypsum, *a*, *b*, fig. 18. The section is then very obscure for about three miles, or from *b* to *c*, the rocks consisting chiefly of red sandstone and red marl, after which, at *c*, blue grits are seen, inclined to the S.S.W. at an angle of 27°, affording an excellent grindstone, and attaining a thickness of forty-four feet. These beds are succeeded to the south by a vast series of newer and conformable strata, all dipping the same way, and, for the first three miles which I examined, inclined nearly at the same angle, upon an average about 24° S.S.W. Within this space, or between *d* and *g*, all the upright trees hitherto found occur; but the same set of strata is still continuous, with a gradually lessening dip, many miles farther to the south.

If we assign a thickness of four or five miles to this regular succession of carboniferous strata, which, as I shall afterwards show, must have been originally quite horizontal, our estimate will probably be rather

Fig. 18.

Section of the cliffs of the South Joggins, near Minudie, Nova Scotia.

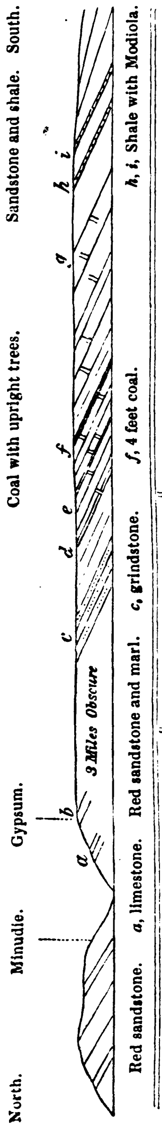


Fig. 19.

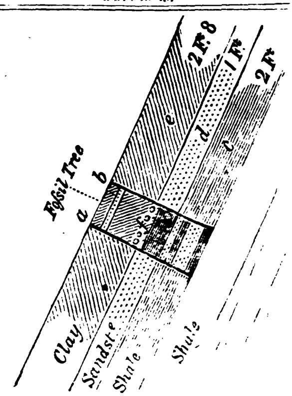
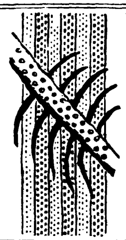
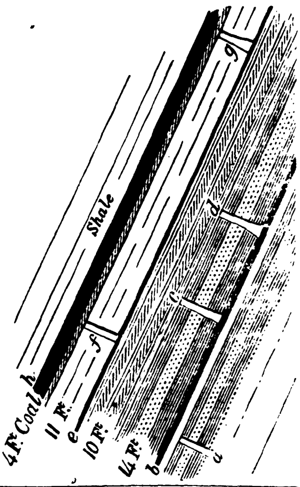


Fig. 20.



Stigmaria in micaceous sandstone.

Fig. 21.



under than over the mark. For the first mile south of the grindstones, or from *c* to *d*, I observed no coal in the cliffs, after which the first of the upright trees appears at *d*, at the distance of about six miles from Minudie. Then followed a series of coal-bearing strata, consisting of white freestone, bituminous shale, micaceous sandstone, sandy clays, blue shale, and clays with and without nodules of ironstone, all resembling the carboniferous rocks of Europe. They occupy a range of coast about two miles long, the vertical height of the cliffs being from 150 to 200 feet; and about nineteen seams of coal have been met with, which vary in thickness from two inches to four feet. At low tide, we had not only the advantage of beholding a fine exposure of the edges of these beds in the vertical precipices, but also a horizontal section of the same on the beach at our feet.

The beds through which erect trees, or rather the trunks of trees, placed at right angles to the planes of stratification, are traceable, have a thickness of about 2500 feet; and no deception can arise from the repetition of the same beds owing to shifts or faults; the section being unbroken, and the rocks, with the exception of their dip, being quite undisturbed. The first of the upright trees which I saw, in the strata *d*, fig. 18., is represented in the enlarged section, fig. 19. No part of the original plant is preserved except the bark, which forms a tube of pure bituminous coal, filled with sand, clay, and other deposits, now forming a solid internal cylinder without traces of organic structure. The bark is a quarter of an inch thick, marked externally with irregular longitudinal ridges and furrows, without leaf-scars, and therefore not resembling the regular flutings of Sigillariæ, but agreeing exactly with the description of those vertical trees which are found at Dixonfold, on the Bolton railway, of which Messrs. Hawkshaw and Bowman have given an excellent account in the Proceedings of the Geological Society.* On comparing Mr. Hawkshaw's drawings of the British fossils, in the library of the Geological Society, as well as a specimen of one of the Dixonfold trees presented by him to their museum, with portions of the bark brought by me from Nova Scotia, I have no hesitation in declaring them to be identical.

The diameter of the tree, *a. b*, fig. 19., was fourteen inches at the top and sixteen inches at the bottom, its height five feet eight inches. The strata in the interior of the tree consisted of a series entirely different from those on the outside. The lowest of the three outer beds which it traversed consisted of purplish and blue shale, *c*, fig. 19., two feet thick, above which was sandstone, *d*, one foot thick, and above this clay, *e*, two feet eight inches. In the

* London, 1839—40; vol. iii. pp. 139. 270.

interior, on the other hand, were nine distinct layers of different composition: at the bottom, shale four inches; then, in the ascending series, sandstone one foot, shale four inches, sandstone four inches, shale eleven inches, clay with nodules of ironstone, *f*, two inches, pure clay two feet, sandstone three inches, and, lastly, clay four inches.

Mr. Bowman has explained in the Manchester Transactions the causes of the frequent want of correspondence in the strata enclosing a buried tree, and the layers of mud and sand accumulated in the interior, which vary according to the more or less turbid state of the water at the periods when the trunk decayed and became hollow, and according to the height to which it was prolonged upwards in the air or water after it began to be imbedded externally in sediment, and various other accidents It is not uncommon to observe in Nova Scotia, as in England, that the layers of matter in the inside are fewer than those without. Thus, a "pipe" or cylinder of pure white sandstone, representing the interior of a fossil tree, will sometimes intersect numerous alternations of shale and sandstone. In some of the layers in the inside of the trunk, *a*, *b*, fig. 19., and in other trees in this line of cliffs, I saw leaves of ferns and fragments of plants which had fallen in together with the sediment.

Continuing my survey, I found the second of the erect trees, *e.* fig. 18., or *a*, fig. 21., separated from the first, or from *a*, *b*, fig. 19., by a considerable mass of shale and sandstone. This second trunk was about nine feet in length, traversing various strata, and cut off at the top by a layer of clay two feet thick, on which rested a seam of coal, *b.*, fig. 21., one foot thick. This coal formed a foundation on which stood two large trees, *c* and *d*, fig. 21., about five yards apart, each about two and a half feet in diameter and fourteen feet long, both enlarging downwards, and one of them, *d*, bulging considerably at the base. The beds through which they pass consist of shale and sandstone. The cliff was too precipitous to allow me to discover any commencement of roots, but the bottom of the trunks seemed to touch the subjacent coal. Above these trees were beds of bituminous shale and clays with Stigmaria, ten feet thick, on which rested another bed of coal, *e*, one foot thick, and this coal supported two trees, *f*, *g*, each eleven feet high, and sixty yards apart. They appeared to have grown on the coal, *e*. One of these, about two feet in diameter, preserved nearly the same size from top to bottom, while the other, which was about fourteen inches in diameter at the top, enlarged visibly at the base. The irregular furrows of the bark were an inch and half one from the other. The tops of these trees were cut off by a bed of clay, on which rested the main seam of the South Joggins coal, four feet thick, above which is another succession of strata, very similar to those already described, with occasional thin seams of coal, and with vertical trees at five or six different levels.

I observed in all at least seventeen of these upright trunks, but in no instance did I see any one of them intersecting a layer of coal, however thin, nor did I find any one of them terminating downwards in sandstone, but always in coal or shale. Their usual height was from six to eight feet, but one which was more than a hundred feet above the beach, and which I could not approach to measure, seemed to be twenty-five feet high, and four feet in diameter, with a considerable bulge at the base. They all appear to be of one species, the rugosities on the surface producing the effect of a rudely-fluted column, and they were placed very accurately at right angles to the planes of stratification. I found numerous flattened trunks of large Sigillariæ with their flutings and leaf-scars in the shales, but none of them resembled the erect trees with their irregularly furrowed exterior.

Stigmariæ are abundant in the argillaceous sandstones of these coal-measures, often with their leaves attached, and spreading regularly in all directions from the stem. It commonly happens here, as in Europe, that, when this plant occurs in sandstone, none of its leaf-like processes (or rootlets?) are attached, but I saw one remarkable exception in strata of micaceous sandstone, between the site of the upright tree represented in fig. 19. and those given in fig. 21. The stem was about four inches thick (see fig. 20.); and it traversed obliquely several layers of fine white micaceous sandstone two feet in vertical thickness. Mr. Binney of Manchester seems now to have proved that these Stigmariæ are really the roots of Sigillaria, by finding them actually proceeding from the bottoms or stools of the trunks of Sigillariæ which occur erect in the British coal-measures. We may therefore conclude that the dome-shaped mass represented by Messrs. Lindley and Hutton in their Fossil Flora, pl. 31., and figured by Dr. Buckland in his Bridgewater Treatise, pl. 56. vol. ii., was nothing more or less than a section of the stump of a fossil Sigillaria, from which the roots extended in all directions through the ancient soil. It should be remembered that M. Adolphe Brongniart, when he obtained from Autun the first and only example yet discovered of a Sigillaria exhibiting internal structure, pronounced it to agree so nearly with Stigmaria, that he inferred on botanical considerations alone, that both must belong to the same plant, and that the Stigmaria was probably the root. In some of the specimens of the latter plant obtained in Nova Scotia, and cut in thin slices so as to transmit light, the woody fibre of the internal cylinder surrounding the axis from which the pith has disappeared, shows, under the microscope, the vascular tissue, and the fern-like or scalariform vessels, which are so conspicuous in European Stigmariæ. By aid of the silicified fossil from Autun, M. Ad. Brongniart has been enabled to demonstrate that this structure, or the scalariform vessels, so distinguishing a character of the living Ferns and some other cryptogamous plants, is united in Sigillaria with rings of growth peculiar to dicotyledonous trees, so that we have here, in this extinct genus, a link between classes of plants standing widely apart from each other in the arrangement of existing vegetables.

I have stated that I counted seventeen upright trees in the strata of the South Joggins, and I was assured by Dr. Gesner, and by residents at Minudie, that other and different individuals were exposed a few years ago; the action of the tides of the Bay of Fundy being so destructive as continually to undermine and sweep away the whole face of the cliffs, so that a new crop of fossils is laid open to view every three or four years. I saw the erect trees at more than ten distinct levels, one above the other; they extend over a space from two or three miles from north to south, and more than twice that distance from east to west, as I am informed by Dr. Gesner, who has explored the banks of streams intersecting this coal-field. For the names of Sigillariæ, Lepidodendra, Ferns, and Calamites collected by me in the cliffs of the South Joggins, and in other coal-measures of Nova Scotia, I refer to the list given at the end of this chapter, calling the reader's attention to the extraordinary amount of specific identity in fossils so widely separated from each other in their "habitations." It appears that, out of forty-eight species, without enumerating the different kinds of *Stigmaria*, which agree perfectly with the varieties found in England, there are no less than thirty-seven which have been identified. The greater part of the remaining eleven might perhaps have been found to agree with known European fossils, had not most of the specimens been in too imperfect a state to admit of close comparison.

Out of fifty-three species obtained by me from the coal-fields of the United States, (almost all of them from Pennsylvania, Maryland, and Ohio,) I have been able to identify thirty-five with European fossils, chiefly species found in Great Britain. Of the remaining eighteen, only four can be said to be peculiar forms, the other fourteen being all closely allied species, or geographical representatives of European coal plants. When it is considered that all the *genera* of these fossils are likewise common to North America and Europe, we seem entitled to declare, that so great a degree of uniformity in the flora of regions equally remote is without parallel, whether in the other ancient strata or in the geographical distribution of plants, in the present condition of the globe.

Continuing our survey of the cliffs of the South Joggins, we observe, not far above the uppermost coal-seams with vertical trees, or, *g*, fig. 18., two strata, *h*, *i*, perhaps of freshwater or estuary origin, composed of black calcareo-bituminous shale, chiefly made up of compressed shells, of two species of *Modiola* and two kinds of *Cypris*. Above these beds are innumerable strata of red sandstone or shale, without coal-seams, and with few or no fossils, on which it will be unnecessary to dwell.

Many curious conclusions may be deduced from the facts above enumerated.

1st. The erect position of the trees, and their perpendicularity to the planes of stratification, imply that a thickness of several thousand feet of strata, now uniformly inclined at an angle of 24°, were deposited originally in a horizontal position. But for the existence of the upright trees it might have been conjectured, that the beds of sand and mud had been thrown down at first on a sloping bank, as sometimes happens in the case of gravel and coarse sand. But, if we are compelled to assume the original horizontality of beds 2500 feet thick, through which the erect trees are dispersed, we can hardly avoid extending the same inference to the greater part of the strata above and below them. It by no means follows that a sea four or five miles deep was filled up with sand and sediment. On the contrary, repeated subsidences, such as are required to explain the successive submergence of so many forests which grew one above the other, may have enabled this enormous accumulation of strata to have taken place in a sea of moderate depth.

Secondly. The evidence of the growth of more than ten forests of fossil trees superimposed one upon the other prepares us to admit more willingly the opinion, that the Stigmaria with its root-like processes was really the root of a terrestrial plant fossilised *in situ*. Yet, if we embrace this opinion, it follows that all the innumerable underclays with Stigmaria in North America and Europe, which I have alluded to at pp. 62. and 84. Vol. I., and p. 18. Vol. II., &c., are indications of an equal number of soils, whether of dry land or freshwater marshes, which supported a growth of timber, and were then submerged. If this be true, and the conclusion seems inevitable, the phenomenon of the upright trees in Nova Scotia, marvellous as it may be, shrinks into insignificance by comparison.

At the same time, it is quite intelligible, that we should find hundreds of cases where the soil has remained with the roots fixed in their original matrix for one instance where the trunk has continued to stand erect after submergence. Many favourable circumstances must concur, to allow of such an exception to the general rule. There must, for example, be an absence of waves and currents of sufficient strength to loosen and overturn the trees, and the water must be charged with sediment ready to envelope the plants before they have had time totally to decay. I have shown (p. 164. Vol. I.) that on the coast of S. Carolina and Georgia the land has sunk in modern times, and that buried trees are occasionally found in strata containing shells of recent species. The formation of low islands of sand off the shore, breaking the force of the Atlantic, has probably allowed many of these trees near the mouths of estuaries to continue erect under water, until they were silted up and preserved. Similar low islands and sandbanks skirt nearly the whole of the eastern coast of the United States, and may assist the geologist in explaining some of the phenomena of the Carboniferous period, especially the manner in which superficial beds of vegetable matter, as well as upright trees, escaped the denuding forces.

Thirdly. It has been objected to the theory which refers the origin of seams of pure coal to plants which grew on the exact spaces where we now find coal, that the surfaces of ancient continents and islands ought to undulate like those we now inhabit. Where, they ask, are the signs of hills and valleys, and those river-channels which cut through deltas? These apparent difficulties will, I think, be removed, if we reflect that the fossilisation of successive forests presupposes both the subsidence of the ground and the deposition of sediment going on simultaneously. If so, the accumulation of mud and sand furnishes us with the levelling power required, and, had there been extensive denudation capable of producing valleys, it could readily have swept away all the coal. In regard to ancient river-courses, the late Mr. Buddle often assured me, that he had in many places met with them in the coal-fields of the North of England, and he has given a detailed account of one which intersected a seam of coal in the Forest of Dean. Even in these cases, however, the general evenness of the surface is immediately restored by a new sinking of the delta, and the deposition of fresh sediment, so that the succeeding seam of coal has grown on as perfectly flat a surface as if there had been no partial destruction of the beds below.

If it be objected that, according to the analogy of recent subterranean movements, some areas ought to have sunk down at a more rapid rate than others, producing irregularities in the ancient level of the dry land, we reply, that there are abundant proofs in the arrangement of the carboniferous strata, that the amount of local subsidence was actually not uniform. Mr. Bowman has clearly pointed out, that the wedge-shaped or lenticular masses of sandstone and shale, which sometimes intervene between the upper and lower portions of a seam of coal, are the natural result of such inequalities in the downward movement. In those areas which sink so fast as to be submerged, the growth of terrestrial plants is suddenly arrested, and the depressed region becomes the receptacle of sediment, until its level is again raised. Then the growth of the former vegetation is resumed, and the result is, the intercalation of strata for a certain space between two beds of coal, which unite and become one, if they are followed to a certain distance in every direction.

In our excursion to the fossil trees, Dr. Gesner and I were joined by several volunteers, some of whom separated from us on their way home. I asked a cottager, whether he h seen them pass.

He said, that "a party of Jogginers on horseback had come by his house half an hour before." As I had heard of a North Joggins on the other side of the bay, I asked whether there was any meaning in this term. He immediately pointed to the salient and retiring angles of the cliffs, observing, "You see that they jog in and jog out."

The coal-field of Pictou, the only one in Nova Scotia where a large quantity of this valuable mineral has been worked, lies about a hundred miles to the eastward of the Cumberland or Minudie coal-measures. An examination of the strata of the Albion Mines, near Pictou, convinced me that the coal-bearing formation there is the equivalent of that already described, although it may be impossible to identify the different strata in detail. They contain the same fossil plants, and similar shales, with the same species of Modiola and Cypris, as at the South Joggins. At the latter place, the largest seam is only four feet thick, whereas that at the Albion mines is estimated at thirteen yards in thickness. In both localities there is a vast series of beds of red sandstone and red marl, with limestone and gypsum underlying the principal coal-seams, and an enormous thickness of sandstones and shales, without coal, above them.

The only spot in the Pictou coal-field where plants have been observed in an erect position is at Dickson's Mills, a mile and a quarter west of Pictou. Here, a bed of upright Calamites was discovered by Mr. J. W. Dawson, with whom I visited the locality. But the section in 1842 was almost entirely concealed by water. The strata consisted of red and grey sandstones and shales, with imbedded fern leaves, and numerous fragments of Calamites and Sternbergia. The sandstone in which the upright Calamites were enveloped was about ten feet thick, and all these terminated downwards at the same level, where the sandstone joined a layer of coarse grey limestone with pebbles. The tops of the Calamites were broken off at different heights, where the grit became coarser. Mr. Dawson states that he observed in the same bed, in a prostrate position, a lepidodendron, with leaves and lepidostrobi attached to its branches.

Since my excursion to Nova Scotia, I have examined the French coal-field of St. Etienne near Lyons, where M. Alexandre Brongniart first described a great bed of erect Calamites, inclosed in sandstone, which he believed to have grown where they have become fossil. The section of the beds of which he published a drawing, representing the erect fossil stems, has been since entirely destroyed by the quarrying away of the sandstone, but I obtained so much evidence, in 1843, of the occurrence of various upright trees, Sigillariæ and others, at different levels in the same coal formation, as to incline me fully to believe M. Alex. Brongniart's conclusions, and to retract the objections I formerly urged against his inferences, on the ground of the different heights at which the Calamites terminated downwards.* This may perhaps be explained by a slight obliquity in the direction of the trunks, or a want of perpendicularity in the vertical face of the cliffs to the planes of stratification.

The following list of plants comprises several species which I did not meet with in Nova Scotia, but which occur in the neighbouring island of Cape Breton, and were presented, at different times, to me and to the Geological Society, by Mr. Richard Brown. For several specimens from Nova Scotia I have been indebted to Mr. J. W. Dawson, of Pictou, and to Mr. Alison, F. G. S. I have also included in the catalogue one or two fossils from the New Brunswick coal-field (which may be considered as another part of that near Minudie) presented to the Geological Society by Mr. Henwood.

* See Elements of Geol., vol. ii. p. 137.

In determining the specific characters and names, I have been principally indebted to Mr. Samuel Woodward, of the Geological Society, who has been occasionally assisted by Mr. Morris, and I have referred, in some points of difficulty, to M. Adolphe Brongniart. After the list was completed, it was revised, so far as relates to the ferns, by Mr. Chas. Bunbury, some of whose corrections have been adopted, and his comments cited.

LIST OF FOSSIL PLANTS FROM THE COAL-MEASURES OF NOVA SCOTIA AND CAPE BRETON.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
1. Flabellaria *Sternb.* Fragments of large palm-like leaves, such as are figured by Sternberg under the name of Flabellaria, are common in many British and Continental localities.	Horton Bluff, near Windsor, — South Joggins, and Pictou in Nova Scotia.
2. Cyperites *Lindl.* Identical with the grass-like leaves of C. bicarinata, as far as the specimens admit of comparison.	Cape Breton.
3. Trigonocarpum *Brongn.* An undescribed and new species of this genus, so common in the European coal-fields, was given me by Mr. Dawson.	Pictou.
4. Artisia approximata *Brong.* This plant (the Sternbergia of *Brong.*) is considered by Mr. Dawes as the cast of the medullary cavity of stems of trees. *Quarterly Journ. Geol. Soc.*, No. 1. p. 91.	Pictou and South Joggins, Nova Scotia.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
5. Asterophyllites, allied to A. tuberculata. Mr. Binney considers the specimen from Sydney to differ from A. tuberculata, but to be identical with a species found at Manchester.	Sydney, Cape Breton.
6. A. galioides? *Lindl.* British.	Pictou, Nova Scotia.
7. Sphenophyllum Schlottheimii? *Brong.* A common British coal-plant, of which I found only one specimen.	Pictou, Nova Scotia; Sydney, Cape Breton.
8. Pinnularia capillacea *Lindl.* Also British.	Sydney, Cape Breton.
9. Lepidophyllum lanceolatum (*Lindley* and *Hutton*) t. 7. fig. 3, 4. Also British species.	Pictou, Nova Scotia.
10. Lepidodendron Rhodianum *Sternberg.* Also British.	Cape Breton.
11. L. obovatum *Sternberg*, t. 6. f. 1.; *Lindley* and *Hutton*, pl. 19. bis. Also British. The L. aculeatum which I found abundantly associated with this in the U. S. coal-fields appears to Mr. Woodward not specifically distinct from L. obovatum.	Sydney, Cape Breton.
12. L. undulatum *Sternberg.* This species, also British, was found by Mr. Henwod in New Brunswick.	Bathurst, New Brunswick.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
13. Lepidodendron elegans (*Lindley* and *Hutton.*) Extremely common in the coal-fields of Nova Scotia down to the lower or gypsiferous coal-measures.	Horton and Windsor, Nova Scotia; Sydney, Cape Breton.
14. L. gracile? Also a British species.	South Joggins, Nova Scotia; Cape Breton.
15. L. (new species.) Not known in Europe or elsewhere; the specimen is in the Museum of the Geol. Society.	Cape Breton.
16. L. In the same fissured state as L. ornatissimum, figured by *Brongniart*.	South Joggins, Nova Scotia.
17. Lycopodites? selaginoides (Lepidodendron selaginoides *Sternberg*). Common in the British and Bohemian coal-measures.	Cape Breton.
18. Lepidostrobus. I met with no species myself in Nova Scotia, but Mr. Dawson has observed it associated as in Europe with Lepidodendron.	Pictou, Nova Scotia.
19. Sigillaria Saullii *Brong.* pl. 151. A British species found at Manchester.	Windsor, Nova Scotia; Sydney, C. B.
20. S. allied to S. Schlotthermii *Brong.* pl. 152. fig. 4.	South Joggins, Nova Scotia.
21. S. scutellata *Brong.* pl. 163. fig. 3. Also British. *Quære*. Same as S. undulata of Sternberg, tab. 15.	South Joggins, Nova Scotia.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
22. Sigillaria reniformis *Brong.* pl. 142. *Lindley* & *H.* pl. 57. and 71. This British species I have obtained from Cape Breton in a decorticated state, and found it common, with its bark, at Frostburg in Mayland.	Sydney, Cape Breton.
23. S. organum *Lindley* & *H.* t. 70. Syriogodendron? *Brong.* A British species.	Sydney, Cape Breton.
24. Lyginodendron, I found various fluted stems without scars in the lower coal formation near Windsor, and elsewhere in Nova Scotia. Perhaps these fossils may be only lower portions of the stems of Sigillariæ, in which the scars are obliterated by age and growth.	
25. Stigmaria ficoides, and numerous varieties. These seem to agree well with the different British kinds, probably the roots of distinct species of Sigillaria.	Nova Scotia, passim.
26. Neuropteris cordata, *Brongn.* pl. 64. f. 5. *Lindley* and *Hutton*, 41. Extremely common in the middle or productive coal measures of Nova Scotia; also British.	Dickson's Mill, Pictou, Nova Scotia, and Cape Breton.
27. N. angustifolia, *Brongn.* t. 61. f. 3, 4. Also British.	Cape Breton.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
28. Neuropteris flexuosa *Brongn.* t. 65. f. 2. The most abundant fern in the coal-measures of Nova Scotia, the U. S., and Europe. Also British.	Cape Breton.
29. N. acutifolia? allied to Odontopteris minor *Brongn.* t. 77.	Sydney, Cape Breton.
30. Cyclopteris dilatata? *Lindley* and *Hutton*. See Neuropteris ingens, t. 91. A. *Quære*, if variety of N. cordata. The only indication of a Cyclopteris which I have met with in Nova Scotia. I found the same species at Pomeroy, Ohio.	Sydney, Cape Breton.
31. Pecopteris muricata *Brongn.* pl. 95. & 97. Perfectly identical with common British specimens.	South Joggins, and Dickson's Mill, Pictou; also Bathurst, New Brunswick.
32. P. abbreviata *Brongn.* pl. 115. Common British species.	Cape Breton.
33. P. arborescens *Brongn.* pl. 102. Also British.	Cape Breton.
34. P. lonchitica *Brongn.* pl. 84. The most characteristic British species of Pecopteris in the coal-measures.	South Joggins, Nova Scotia.
35. P. pteroides *Brongn.* pl. 99. f. 1. Also British.	Bathurst, New Brunswick.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
36. Pecopteris æqualis *Brongn.* Also British.	Cape Breton.
37. P. ——— ? A remarkable species, with anastomozing veins, resembling in this respect the P. Defrancii of Brongniart. Mr. Charles Bunbury observes respecting this species, that "its venation is completely reticulated, the midrib evanescent," and "it would form the type of a new genus, standing in the same relation to Lonchopteris as Neuropteris does to Pecopteris."	Sydney, CapeBreton.
38. P. Sillimanni?. *Brongn.* pl. 96. f. 5. A single pinna, collected by Mr. Henwood.	Bathurst, New Brunswick.
39. P. villosa *Brongn.* pl. 104. f. 3. Also British.	Dickson's Mill, Nova Scotia.
40. P. Serlii *Brongn.* pl. 85. Also British.	Sydney, Cape Breton.
Calamites. The specimens of this genus scarcely afford satifactory specific characters to the botanist, but all the Nova Scotia fossils agree with common European forms from the coal-measures.	
41. C. cannæformis *Schlot.*	South Joggins, Nova Scotia, and Cape Breton.
42. C. Suckowii *Brongn.*	South Joggins, Nova Scotia.

NAMES OF FOSSIL PLANTS.	LOCALITIES.
43. C. approximatus *Artis.*	Cape Breton, Nova Scotia.
44. C. arenaceus? *Jæger.*	Nova Scotia.
45. C. Steinhaueri *Brongn.*	South Joggins, Nova Scotia.
46. C. dubius *Brongn.*	Sydney, Cape Breton.
47. C. nodosus *Schlot.*	Pictou, and South Joggins, Nova Scotia.
48. C. Cistii *Brongn.* Also British.	Sydney, Cape Breton.

CHAPTER XXV.

Lower Carboniferous or Gypsiferous Formation of Nova Scotia — Why formerly considered as newer than the productive Coal. — Determination of its true Age. — Sections near Windsor. — Supposed Reptilian Footsteps. — Section on the Shubenacadie. — Large Masses of Gypsum. — Their Origin. — Volcanic Action contemporaneous with Nova Scotia Coal Measures. — Limestone with Marine Shells. — Table of Organic Remains of the Carboniferous Limestone of Nova Scotia and Island of Cape Breton.

THE productive coal-measures near Minudie, described in the last Chapter, may be regarded as the middle of the carboniferous series of Nova Scotia; while the strata above them, including the beds with *Modiola*, *h*, *i*, (fig. 19. p. 180.), and the sandstones and shales farther to the south, in the same region, together with a corresponding series near Pictou, and the lower sandstone of Prince Edward's Island, ascertained by Mr. Dawson to contain coal-plants, may be all classed as the Upper Carboniferous division, in which no seams of coal have yet been found. Lastly, we may regard an enormous mass of red and brown sandstones and red marls, the lower portions of which include beds of gypsum, and limestones charged with marine shells and corals, as the Lower Carboniferous or gypsiferous series. In this division grits and shales, with some true coal plants and some thin seams of impure coal are occasionally met with.

Before my visit to Nova Scotia, the group last mentioned had been considered, chiefly, I believe, from its resemblance to the gypsiferous red marls above the coal in Europe, as the uppermost formation in Nova Scotia. Mr. Logan, in his first brief excursion in 1841 to the Windsor district, where the beds are greatly disturbed, had little more than time to collect some of the most abundant fossils; and these, when submitted to several able palæontologists, (to M. de Verneuil among others), were thought to confirm the opinion previously entertained, that the strata were newer than the coal. That geologists should at first have arrived at this result will surprise no one who is aware how many of the fossils of our Magnesian limestone and coal resemble each other, or who studies the list given at p. 218., in which several species both of shells and corals from Nova Scotia, identical or closely allied to well-known Permian or Magnesian limestone forms, are enumerated. By these considerations my friend Mr. Murchison was induced, in his Anniversary Address to the Geological Society of London, in 1843, to pronounce the gypsiferous rocks of Nova Scotia as the equivalents in age of the Permian group of Russia.

My first inspection of the country near Windsor, followed by an examination of the cliffs near Minudie, described in the last Chapter, led me to an opposite view, strengthened by discussions with Mr. Richard Brown of Sydney, and Mr. J. W. Dawson of Pictou, with whom I explored the cliffs of the East River, south of the Albion Mines, near Pictou. I then examined with care, in company with Messrs. Dawson and Duncan, the fine section laid open in the cliffs of the Shubenacadie, a river which intersects Nova Scotia from south to north, cutting through the gypsiferous strata for a distance of twenty miles. Lastly, I had an opportunity of studying at my leisure in London the fossils collected from various localities, and I had then no longer any hesitation in announcing to the Geological Society my conviction, that the gypsiferous strata were older than the productive coal-measures, whether of the South Joggins or of Pictou. I also stated at the same time my opinion that I considered them as constituting a lower member of the Carboniferous group, containing fossil plants of the coal, with shells and corals of the carboniferous limestone.

Mr. Richard Brown, after our meeting at the Albion Mines in 1842, kindly undertook, at my request, to make a re-examination of part of Cape

Breton, and the result was published in a letter, dated October 20. 1843, addressed to me*, in which this experienced observer declared that he had been able "to confirm my views as to the relative age of the coal and gypsum," and that the gypsiferous strata of Cape Breton, agreeing in character with those of Nova Scotia, were inferior in position to the productive coal-measures of Sydney. Mr. Dawson also, soon after my visit, published several memoirs on the neighbourhood of Pictou and the northern parts of Nova Scotia, in which he adopted and extended the same views. Mr. Logan, after seeing my fossils and sections, and examining in 1844 the cliffs near Minudie, and at the South Joggins, which he had not seen on his first visit to Nova Scotia, communicated to me his opinion that the gypsum and accompanying marine limestones, (in which he found several of the characteristic fossils of Windsor,) and the red sandstones near Minudie, were older than the productive coal-measures. Dr. Gesner, however, has not abandoned the opinion at which he had previously arrived on this point, having recently, in a letter addressed to the President of the Geological Society, and read May, 1845, declared his belief that the true order of super-

* See "Quarterly Journal of the Geological Society of London," No. I. p. 23.

position is not as I have represented it, and that other geologists have been misled by me.

As this question affects the geological structure of a large portion of Nova Scotia, I shall give a brief outline of the data which favour the classification I have proposed. In the first place, I found everywhere that the gypsiferous formations were much more disturbed than those strata which I have called the Middle and Upper coal-measures, and that their outcrop was always nearer to the region occupied by the older rocks, whether Silurian or Metamorphic. Thus, for example, if we pass from the granitic mountains and older slates of the Cobequid Hills to the coal of the South Joggins, we find the gypsum and limestone nearest the Hills: or, if we descend the East River, we pass from the Silurian strata, cross the region in which limestones and gypsums occur, and then come to the coal-measures of the Albion Mines. Mr. Richard Brown has shown, in the Memoir above cited, that the same arrangement holds good in Cape Breton. Secondly, the regular dip of all the beds seen near Minudie (see section above, p. 180.) would carry the strata to which the limestone and gypsum are subordinate under the workable coal of the South Joggins. Thirdly, geologists before and since my visit, who have carefully examined the East River, south of Pictou, including

Mr. Logan, are agreed that the sandstones and marine limestones, some of them having an oolitic structure, occurring to the south of the Albion Mines, are older than the coal of those mines. Now I found that most of the fossils of those limestones agreed with shells and corals obtained by me in the limestones near Windsor, or in those of the Shubenacadie, accompanying the principal masses of gypsum. Fourthly, both in the Windsor district, and on the Shubenacadie, I found an intimate association between strata containing mountain limestone fossils, masses of gypsum, and coal grits, with *Sigillaria* and *Lepidodendron*, but no seams of pure coal in this part of the series. Fifthly, I observed that, in the Pictou region, as well as at the South-Joggins, the strata which I class with Mr. Dawson as the Upper coal-measures, although several thousand feet thick, and respecting the position of which above the productive coal there is no question, contain no marine limestones, or great masses of gypsum. Sixthly, there is a formation of unconformable red sandstone without fossils, which appears on the Salmon River six miles above Truro, lying on the edges of the inclined Carboniferous strata. In this series of beds no limestone with marine shells or gypsum have been discovered.

In illustration of the first of these points, namely, that the gypsiferous rocks occur nearest to the older formations, I may cite, in addition to the Minudie and East River sections already adverted to, the structure of the first country which I observed near Windsor. I saw, for example, the gypsum near the Halifax Road almost in contact with the old slates of the Ardoise Hills, and afterwards traced the gypsiferous beds of the Saint Croix River up to their junction with the older slates. I also found, in going southwards from Windsor to a small tributary of the Avon, on which is situated Snides Mill, that the gypsiferous series incloses, before its junction with the older rocks, coarse sandstones with a seam of impure coal two inches thick, also clay-iron-stone, and shales with *Lepidodendron elegans*, but no strata resembling the productive coal-measures.

I consider the inclined and bent rocks near the town of Windsor, consisting of soft red, yellow, and purple marls, with conformable beds of limestone and gypsum, as higher in the series than the coal-grits above mentioned. In some of these limestones of Windsor, one of which having an oolitic texture occurs near the bridge, and another on the farm of Belvidere on the Avon, the following fossils occur, *Terebratula sufflata*, *T. elongata*, two other species of *Terebratala*, *Producta Martini*, *P. Lyelli* (De Verneuil) *Pecten plicatus*, *Avicula*, *Modiola*, allied to *M. Pallasi*, *Cirrus spiralis*, *Euomphalus lævis, Natica, Fenestella membranacea,* and *Ceriopora spongites,* almost all of which I afterwards found on the Shubenacadie, and some of them on the Debert River near Truro, associated with gypsum, also in strata on the East River, decidedly lower than the productive coal-measures.

I consider the highly-inclined and curved strata of Horton Bluff, near Windsor, as affording another fine section of the Lower Carboniferous series associated with the gypsum. In the cliffs here I found Lepidodendra, and other coal plants, and scales of fish of the genera *Holoptichius* and *Paleoniscus,* both of them common to the English coal-measures. Mr. Logan detected in the same strata masses of concretionary limestone, which I had overlooked, and which are interesting, as they contain the *Terebratula elongata, Avicula,* and other marine fossils identical with those of Windsor. He also found, in one of the ripple-marked slabs of Horton what appear to be the impressions of the footsteps of an animal, perhaps a Reptilian, having five claws. There are two of these tracks, and they resemble considerably some footprints in the New Red sandstone of England, but, as they are on a stratum containing fucoids, and are not very sharp in their outline, like tracks formed above water, and as there is no series of them, Mr. Owen does not feel himself entitled to decide positively on their reptilian character.* Mr. Dawson has also found impressions resembling trifid footsteps in several parts of the carboniferous series of Nova Scotia, in ripple-marked sandstones, so sharp as to imply that they were not made above water; but I have not yet been able to decide that any of them belong to vertebrate animals.

The gypsiferous strata are best disclosed in the cliffs which bound the estuary of the Shubenacadie, for a distance of about 14 miles from north to south, or between Fort Ellis and the mouth of the river, where they are several thousand feet in thickness. The rapid tides of the Bay of Fundy continually undermine and sweep away the fallen detritus at the base of these cliffs, otherwise the section would soon be obscured, so rapid is the disintegration of the soft red marls, with which the gypsum and fossiliferous limestones are interstratified. The general strike of the beds on the Shubenacadie, as at Windsor, is nearly east and west, the strata seeming to have been first folded into numerous parallel wrinkles, running east and west, and then part of these folds tilted at

* Dr. A. King has lately published an account in the Proceedings of the Academy of Natural Science of Philadelphia, Nov. 1844, of footsteps, referable, some of them to birds, others to batrachian reptiles, from the true carboniferous strata of Westmoreland county, Pennsylvania. — *Silliman's Journal*, vol. xlviii. p. 343, 1845.

considerable angles, sometimes towards the east, and sometimes to the west, while the rocks were fissured in the direction of their strike, and shifted vertically. By such complicated movements the strata have been thrown into the greatest confusion. At the Big Rock, a mass of gypsum or alabaster of a pure white colour and no less than 300 yards thick, is exposed and forms a conspicuous object in the vertical cliff, and has been followed continuously east and west for 12 miles through the country. Below it are alternations of anhydrous gypsum with yellow shale and bituminous limestone. Among the dislocated strata which alternate with the gypsiferous series, are three masses consisting of coal-grit, shale with lepidodendra, and red sandstone, which I refer to the same formation. In five cases where Mr Dawson and I traced the junction of these sandstones with the gypsiferous beds, visible only at low water, we found a line of fault at the point of contact, and one wall of the fault was in every case formed of gypsum; yet I do not believe that the gypsum has filled rents, for it has all the appearance of having been an original and integral part of the stratified series, formed contemporaneously with the beds of red marl and marine limestone. If we endeavour to account for the origin of the gypsum by the subsequent conversion of carbonate into sulphate of lime, we encounter this difficulty, that beds of limestone full of fossils are intimately associated with the gypsum and yet have undergone no alteration. I saw nowhere any passage from the one to the other even at points where the gypsum and limestone alternate. On the other hand, there are abundant proofs in various parts of Nova Scotia of the intrusion of trappean rocks of contemporaneous origin with the lower carboniferous strata, so that I have little doubt that the production of gypsum in the carboniferous sea was intimately connected with volcanic action, whether in the form of heated vapours (or stufas), or of hot mineral springs, or any other kind of agency accompanying submarine igneous eruptions. To the influence of these latter I also ascribe the remarkable mineralogical difference between the inferior carboniferous rocks of Nova Scotia and those of the coal-fields of the United States, which are free from trappean rocks.

The gypsum of Nova Scotia when burnt is used for manure, and is shipped in great quantities for the United States. There are many indications of metalliferous ores in the rocks of the Shubenacadie, and the neighbouring districts, and among other places, I observed near the mouth of the river and on its left bank, a limestone called the Black Rock containing disseminated crystals of galena with one of magnesia, copper, lead and cobalt.

The limestones containing marine shells on the

Shubenacadie occur, 1st, at a place north of Rose's Point, about 7½ miles above the mouth of the river; 2dly, at the point called Anthony's Nose, nearly opposite, in both cases near beds of gypsum; 3dly, at Admiral's rock, 4 miles higher up the river, on its left or western bank. One dark bed in the latter locality is made up entirely of the broken stems of a small species of encrinus. Some layers at Anthony's Nose are almost exclusively composed of a small coral, *Ceriopora spongites*, Goldf., while in other beds Productæ are very abundant. The greater number of species are common to the different limestones of the Shubenacadie, the district round Windsor and that of Brookfield, a locality 8 or 9 miles to the east of Anthony's Nose, and probably in the strike of that fossiliferous rock. For a set of fossils from the place last mentioned, enumerated in the list at page 218., I was indebted to Mr. Duncan of Truro. The limestone of Gay's River, having many shells in common with the above-mentioned rocks, occurs near the outcrop of the gypsiferous formation, 8 miles south of Fort Ellis, where the Shubenacadie section above alluded to terminates, and near which older formations make their appearance.

In addition to the places above mentioned, I also discovered during my tour with Mr. Dawson, to whose active operations I was much indebted, a series of strata below the bridge on the Debert River, 13 miles east of Truro, consisting of highly inclined beds of red limestone and black slaty limestone, red sandstone, and red marl, in which a large number of the Windsor shells occurred, together with some small bivalves, and a fragment of a Limulus, or a genus intermediate between Limulus and Trilobite, resembling that of the coal-measures of Colebrook Dale, figured by Mr. Prestwich. We also saw beds similar to the above in the district of Onslow, about 12 miles N. E. of the Debert River bridge, where there is also a black slaty limestone, with similar small bivalve shells in it.

The annexed Table will show in one view the fossils of the various localities of the gypsiferous limestone of Nova Scotia, together with a few others from Cape Breton, decidedly of the same formation, which I received from Mr. Richard Brown and Mr. James Dawson. Mention is made in the Table of the geological position, when known, of the same species in other countries. I am indebted to M. de Verneuil for the determination of the greater part of the shells. On considering this table we shall not hesitate to pronounce the gypsiferous formation of Nova Scotia to be a member of the carboniferous group, instead of the trinssic or magnesian limestone formation, to both of which it had been severally conjectured to belong. The presence of the genera Orthoceras, represented by two species, the

Nautilus and Conularia, the Limulus or Tribolite, and the Cyathophyllum are opposed to the opinion that the beds are newer than the coal. The following species are either identical or scarcely distinguishable from well known mountain limestone fossils; Euomphalus lævis, Pileopsis vetustus, Pecten plicatus, Isocardia unioniformis, Phil. Producta Martini, P. Scotica? The Ceriopora spongites also occurs in the mountain limestone of Ireland; and the coral which has been compared to *Retepora flustracea* of the magnesian limestone is not the same, but more nearly allied to if not identical with Fenestella membranacea of the mountain limestone, according to Mr. E. Forbes. The abundance of this coral and three shells, namely, *Terebratula elongata, Modiola* allied to *M. Pallasi*, and *Avicula antiqua*, brought by Mr. Logan from Windsor, first led to the presumption that the gypsiferous beds were newer than the coal; but M. de Verneuil now informs me that T. elongata has also been found in the mountain limestone of Yorkshire. The other genera mentioned in the Table accord well with the Carboniferous fauna, a result which we might expect from the association before mentioned of the Gypsiferous marine Limestone with sandstones and shales, containing Lepidodendron elegans. It will be seen that the agreement of species from various and often distant localities is quite as great as could have been expected, when we consider the small number of the fossils hitherto obtained.

LIST OF FOSSILS OF THE LOWER CARBONIFEROUS OR GYPSIFEROUS FORMATION OF NOVA SCOTIA AND CAPE BRETON.

NAME OF FOSSILS.	LOCALITIES.
1. Trilobite or Limulus.	Debert River, near Truro.
2. Cypris or Cytherina.	South Joggins and Pictou, Nova Scotia.
3. C ——. Second species.	South Joggins.
4. Nautilus. Allied to N. Leplayi, Demidoff, and to N. bidorsatus, Fischer. (Oryctol. of Warsaw.) A fossil of the Mountain Limestone of Europe.	Brookfield, Nova Scotia.
5. Cyrtoceras. A genus not known above the coal.	Windsor, Nova Scotia.
6. Orthoceras. Analogous to O. Gesneri, Martin, with longitudinal striæ, and with the syphon between the centre and the border.	Brookfield.
7. O ——. Second species. Larger and different, but specimens imperfect.	Windsor.
8. Conularia. New species, distinct from C. quadrisulcate, by size, distance of striæ, and other characters.	Brookfield, and Gut of Canso, Cape Breton.

NAME OF FOSSILS.	LOCALITIES.
9. Littorina? Analogous to a Permian species.	Gay's River.
10. Cirrus spiralis (or C. rotundatus?)	Windsor.
11. Enomphalus lævis. A fossil also of the Devonian and Carboniferous formations of the Eiffel.	Windsor.
12. Natica. New species, like N. plicistria, but smaller; found also by De Verneuil in the Permian rocks of Russia.	Windsor and Gay's River, Nova Scotia.
13. Cypricardia. New species, (aff. C. transversa) fossil in the mountain limestone of Belgium.	Windsor.
14. Isocardia unioniformis *Phil.* A shell of the carboniferous limestone.	Brookfield.
15. Cardiomorpha Archiacana. Found in the coal of Belgium.	Windsor.
16. Bivalve. Numerous impressions, genus not determinable, common to several localities.	Debert River and Onslow District, Nova Scotia.
17. Cucullæa. New species, (aff. C. obtusa *Phil.*)	Windsor.
18. Modiola (aff. M. Pallasi). Like one in Permian formation of Russia.	Windsor, Brookfield, and Gay's River.
19. M ——. A second species.	Gay's River.

NAME OF FOSSILS.	LOCALITIES.
20. Avicula antiqua *Munst.* In Zechstein of Europe.	The Shubenacadie and Gay's River.
21. A ——. New species allied to the preceding, but more gibbous.	Gay's River.
22. A ——. With forty-five narrow ribs.	Debert River.
23. A ——.	Debert River.
24 & 25. A ——. Two other species.	Windsor.
26. Pecten plicatus. Or very analogous.	Windsor, Brookfield. and Shubenacadie.
27. P —— (or Avicula). Smooth.	Debert River.
28. P ——. New species.	Brookfield.
29. P ——. New species, allied to P. granosus, found in the carboniferous limestone.	Shubenecadie.
30. Terebratula elongata *Schlot.* Occurs in the Zechstein in Europe, and in the mountain limestone of Yorkshire.	Windsor, Brookfield, Shubenecadie, Gay's River, Debert River, and Cape Breton.
31. T. sufflata. *Quære.* Gibbous variety of preceding, *De Verneuil.*	Windsor, Brookfield, Shubenacadie, and Debert River.
32. T ——. Small, like T. diodonta with sinus.	Debert River.

NAME OF FOSSILS.	LOCALITIES.
33. T ——. With one fold in the sinus.	Windsor and Shubenacadie.
34. T ——. New species.	Windsor.
35. Terebratula. New species, with sinus reaching very nearly to the beak, very like one described by Von Buch, as T. canidea.	Brookfield.
36. Spirifer glaber. Fossil of mountain limestone and Zechstein of Europe.	East River of Pictou, and Cape Breton.
37. S. cristatus? Fossil of English magnesian limestone.	Windsor.
38. S. minimus *Sow.* Or new species? A fossil of the Permian of Russia.	Windsor, Brookfield, Shubenacadie, and Debert River.
39. S. octoplicatus. Silurian of Europe?	Windsor.
40. Producta Martini. A fossil of the mountain limestone of Europe.	Windsor, Brookfield, Shubenacadie, East River of Pictou, and Cape Breton.
41. P. concinna *Sow.* Or allied species; carboniferous limestone of Europe.	Cape Breton.
42. P. Lyelli, *De Verneuil.* Shell with fine striæ, and with long and slender tubes, the most characteristic fossil of the lower carboniferous formation.	Windsor, Horton Bluff, Shubenacadie, Gay's River, Debert River, Minudie, and Cape Breton.

NAME OF FOSSILS.	LOCALITIES.
43. Producta Scotica. Smaller than European, if identical; carboniferous limestone, Europe.	Windsor, Brookfield, Shubenacadie, East River of Pictou, and Cape Breton.
44. P. Spinosa *Sow.* *Quære.* Var. of P. Martini. Carboniferous limestone, Europe.	Cape Breton.
45. P. antiquata de Koninck. Coal measures, Europe.	Brookfield.
46. Encrinus.	Shubenacadie, and East River, Pictou.
47. Fenestella membranacea? (Retepora membranacea, *Phil.*) Carboniferous limestone, Europe.	Windsor, Brookfield, the Shubenacadie and East River, Pictou.
48. Ceriopora spongites, *Goldfuss.* (pl. 64.) Eiffel, Silurian, and mountain limestone, Ireland.	Windsor and Brookfield.
49. Favosites ramosa?	Shubenacadie.
50. Cyathophyllum.	Cape Breton.

CHAPTER XXVI.

Progress and Resources of Nova Scotia.—Highland Settlers.—Timber Duties.—Cobequid Hills.—Conflagration of Forests.—Albion Mines.—Humming Birds.—Estuary of the Shubenacadie.—Stakes cut by Beavers.—Promotion of Science.—Social Equality.—Nova Scotians "going home."—Return to England.

THE day after my arrival in Nova Scotia, a fellow-passenger in the coach from Halifax to Windsor, a native of the country, and who, from small beginnings, had acquired a large fortune, bore testimony to the rapid strides which the province had made, within his recollection, by deploring the universal increase of luxury. He spoke of the superior simplicity of manners in his younger days, when the wives and daughters of farmers were accustomed to ride to church, each on horseback behind their husbands and fathers, whereas now they were not content unless they could ride there in their own carriage.

In spite of the large extent of barren and siliceous soil in the south, and, what is a more serious evil, those seven or eight months of frost and snow which crowd the labours of the agriculturist into so brief a season, the resources of this province are extremely great. They have magnificent harbours and fine navigable estuaries, large areas of the richest soil gained from the sea, vast supplies of coal and gypsum, and abundance of timber.

Not a few of the most intelligent and thriving inhabitants are descended from loyalists, who fled from the United States at the time of the declaration of independence. The picture they drew of the stationary condition, want of cleanly habits, and ignorance of some of the Highland settlers, in parts of Nova Scotia and Cape Breton, was discouraging, and often so highly coloured as to be very amusing. They were described to me as cropping the newly cleared ground year after year without manuring it, till the dung of their horses and cattle accumulated round their doors, and became, even to them, an intolerable nuisance. They accordingly pulled down their log-cabins and removed them to a distance, till several of their more knowing neighbours offered to cart away the dung for a small remuneration. After a time, when the Highlanders perceived the use to which the manure was put, they required those who removed it to execute the task gratuitously; and my informants thought that the idea might possibly occur to some of the next generation of applying the material to their own fields.

I heard frequent discussions on the present state of the timber duties both here and in Canada, and great was my surprise to find the majority of the small proprietors, or that class in whose prosperity and success the strength of a new colony consists, regretting that the mother country had legislated so much in their favour. They said that a few large capitalists and shipowners amassed considerable fortunes, (some of them, however, losing them again by over-speculation) and that the political influence of a few such merchants was naturally greater than that of a host of small farmers, who could never so effectively plead their cause to the Government. But, on the other hand, the labourers engaged during the severe winter, at high pay, to fell and transport the timber to the coast, became invariably a drunken and improvident set. Another serious mischief accrued to the colony from this traffic: as often as the new settlers reached the tracts from which the wood had been removed, they found, instead of a cleared region, ready for cultivation, a dense copsewood or vigorous undergrowth of young trees, far more expensive to deal with than the original forest, and, what was worse, all the best kinds of timber, fit for farm buildings and other uses, had been taken away, having been carefully selected for exportation to Great Britain. So that, while the English are submitting to pay an enhanced price for timber inferior in quality to that of

Norway, the majority of the colonists, for whom the sacrifices are made, feel no gratitude for the boon. On the contrary, they complain of a monopoly that enriches a few timber merchants, at the expense of the more regular and steady progress of agriculture.

After my visit to the district of Windsor, Cape Blomidon, and Minudie, I went by Amherst to the Cobequid Hills, the nucleus of which consists of granite. Their outline, though rounded and not picturesque, formed a striking contrast to that of the low, long, flat-topped and uniform ridges, with straight intervening valleys, into which the Cumberland coal-field near Minudie is divided. On the highest part of the Cobequid Hills, we crossed a fine wild forest covering the granite, and then, on the southern flanks of those hills, I observed clay-slate cut through by trap dikes. We then went by Londonderry to Truro, at the head of the Bay of Fundy, and from thence took places for Pictou in an open four-wheeled vehicle, here termed a waggon, which carried the mail. The road was cut through an endless forest of fir-wood, parts of which had lately suffered much by conflagrations. These fires often spread for leagues in the summer season, and cause great devastation. The more resinous species of fir, when they have been heated by the burning of the surrounding timber, blaze up suddenly when the fire at last reaches them, and are enveloped from top to bottom in brilliant flames, presenting in the night a most splendid spectacle.

I had arranged with Captain Bayfield, whom I had not seen for many years, that we should meet at Pictou, and the day after my arrival there, his surveying ship, the Gulnare, sailed into the harbour. I spent a day on board that vessel, and we then visited together the Albion Mines, from whence coal is conveyed by a railway to the estuary of the East River, and there shipped. Mr. Richard Brown, whose able co-operation in my geological inquiries I have before acknowledged, had come from Cape Breton to meet me, and with him and Mr. Dawson I examined the cliffs of the East River, accompanied by the superintendent of the Albion Mines, Mr. Poole, at whose house we were most kindly received. Here, during a week of intense heat, in the beginning of August (1842), I was frequently amused by watching the humming-birds, being able to approach unperceived, by aid of a Venetian blind, to within a few inches of them, while they were on the wing. They remained for many seconds poised in the air, while sucking the flowers of several climbers trailed to the wall on the outside of the window, and in this position the head and body appeared motionless, brilliant with green and gold plumage, and the wings invisible, owing to the rapidity of their motion. The sound was somewhat like that of our humming hawk-moths or sphinges, but louder. When they darted away, they seemed to emit a flash of bright colour. Following them into the garden, I sometimes saw them perched upon the dry stakes on which peas were trained, and there plume themselves. It is wonderful to reflect on the migrating instinct which leads these minute creatures from the distant Gulf of Florida to a country buried constantly under deep snow for seven or eight months in the year.

After leaving Pictou, I made an expedition with Mr. Dawson to the Shubenacadie (see above, p. 166.), and at Truro we were joined by Mr. Duncan, by whose advice we started at an early hour each morning in a boat, after the great tidal wave or bore had swept up the estuary, and were then carried ten, fifteen, or twenty miles with great rapidity up the river, after which as the tide ebbed, we came down at our leisure, landing quietly wherever we pleased, at various points where the perpendicular cliffs offered sections on the right or left bank.

On one occasion, when I was seated on the trunk of a fallen tree, on a steep sloping beach about ten feet above the level of the river, I was warned by my companion that, before I had finished my sketch, the tide might float off me and the tree, and carry both down to the Basin of Mines. Being incredulous, I looked at my watch, and observed that the water remained nearly stationary for the first three minutes, and then, in the next ten, rose about 3 feet, after which it gained very steadily but more slowly, till I was obliged to decamp. A stranger, when he is looking for shells on the beach at low tide, after the hot sun has nearly dried up the sandy mud, may well be surprised if told that in six hours there will be a perpendicular column of salt water sixty feet high over the spot on which he stands.

The proprietor of one of the large quarries of gypsum on the Shubenacadie showed me some wooden stakes, dug up a few days before by one of his labourers from a considerable depth in a peat bog. His men were persuaded that they were artificially cut by a tool, and were the relics of aboriginal Indians; but having been a trapper of beavers in his younger days, he knew well that they owed their shape to the teeth of these creatures. We meet with the skulls and bones of beavers in the fens of Cambridgeshire, and elsewhere in England. May not some of the old tales of artificially cut wood occurring at great depths in peat and morasses, which have puzzled many a learned antiquary, admit of the like explanation?

I never travelled in any country where my scientific pursuits seemed to be better understood, or were more zealously forwarded, than in Nova Scotia, although I went there almost without letters of introduction. At Truro, having occasion to go over a great deal of ground in different directions, on two successive days, I had employed two pair of horses, one in the morning, and the other in the afternoon. The postmaster, an entire stranger to me, declined to receive payment for them, although I pressed him to do so, saying that he heard I was exploring the country at my own expense, and he wished to contribute his share towards scientific investigations undertaken for the public good.

We know, on the authority of the author of "Sam Slick," unless he has belied his countrymen, that some of the Blue Noses (so called from a kind of potato which thrives here) are not in the habit of setting a very high value, either on their own time or that of others. To this class, I presume, belonged the driver of a stage-coach, who conducted us from Pictou to Truro. Drawing in the reins of his four horses, he informed us that there were a great many wild raspberries by the road-side, quite ripe, and that he intended to get off and eat some of them, as there was time to spare, for he should still arrive in Truro by the appointed hour. It is needless to say that all turned out, as there was no alternative but to wait in the inside of a hot coach, or to pick fruit in the shade. Had the same adventure happened to a traveller in the United States, it might have furnished a good text to one inclined to descant on the inconvenient independence of manners which democratic institutions have a tendency to create. Doubtless, the political and social circumstances of all new colonies promote a degree of equality which influences the manners of the people. There is here no hereditary aristocracy —no proprietors who can let their lands to tenants— no dominant sect, with the privileges enjoyed by a church establishment. The sects are too numerous, and too fairly balanced, to admit of the possibility of such a policy; and the Baptists, who predominate greatly in number and position in society, are opposed on principle to all ecclesiastical endowments by the state. The influence of birth and family is scarcely felt, and the resemblance of the political and social state of things to that in the United States is striking.

The longer, indeed, that I remained here, the larger were the deductions I found it necessary to make from those peculiarities that I had imagined, during my sojourn in the United States, to be the genuine fruits of a republican as contrasted with a monarchical constitution, — of an American as distinguished from a British supremacy. They who lament the increased power recently acquired by the democracy in the United States ascribe to it, and I believe not without reason, the frequent neglect of men of the greatest talent and moral worth, and the power which it gives to envy, concealing itself under the cloak of a love of equality, to exclude such citizens from the most important places of trust and honour. In our American colonies, on the other hand, we hear complaints that very similar effects result from the habitual disregard of the claims of native merit, all posts of high rank and profit being awarded to foreigners, who have not their hearts in a country where they are but temporary sojourners. The late revolution in our colonial system, obliging the responsible executive to command a majority in the colonial parliaments, must, it is to be hoped, remove this cause of dissatisfaction.

It is no small object of ambition for a Nova Scotian to "go home," which means to "leave home, and see England." However much his curiosity may be gratified by the tour, his vanity, as I learn from several confessions made to me, is often put to a severe trial. It is mortifying to be asked in what part of the world Nova Scotia is situated — to be complimented on "speaking good English, although an American" — to be asked "what excuse can possibly be made for repudiation" — to be forced to explain to one fellow countryman after another "that Nova Scotia is not one of the United States, but a British province." All this, too, after having prayed loyally every Sunday for Queen Victoria and the Prince of Wales — after having been so ready to go to war about the Canadian borderers, the New York sympathisers, the detention of Macleod, and any other feud!

Nations know nothing of one another — most true — but unfortunately in this particular case the ignorance is all on one side, for almost every native of Nova Scotia knows and thinks a great deal about England. It may, however, console the Nova Scotian to reflect, that there are districts in the British isles, far more populous than all his native peninsula, which the majority of the English people have never heard of, and respecting which, if they were named, few could say whether they spoke Gaelic, Welsh, or Irish, or what form of religion the greater part of them professed.

August 18. — We left Halifax in the steam-ship Columbia, and in nine days and sixteen hours were at the pier at Liverpool. This was the ninetieth voyage of these Halifax steamers across the Atlantic, without any loss, and only one case of detention by putting back for repairs. As we flew along in the railway carriage between Liverpool and London, my eye, so long accustomed to the American landscape, was struck with the dressy and garden-like appearance of all the fields, the absence of weeds, and the neatness of the trim hedgerows. We passed only one unoccupied piece of ground, and it was covered with heath, then in full blossom, a plant which we had not seen from the time we crossed the Atlantic. Eight hours conveyed us from sea to sea, from the estuary of the Mersey to that stream which Pope has styled "The Father of the British Floods." Whatever new standard for measuring the comparative size of rivers I had acquired in my late wanderings, I certainly never beheld "the swelling waters and alternate tides" of Father Thames with greater admiration than after this long absence, or was ever more delighted to find myself once more in the midst of the flourishing settlement which has grown up upon his banks.

DESCRIPTION

OF

PLATES AND MAPS.

Plate I.

Bird's-eye View of the Falls of Niagara and adjacent Country, coloured geologically.

Frontispiece of Vol. I.

I HAVE stated in the second chapter, Vol. I., that Mr. Bakewell, Jun., son of the distinguished geologist of that name, gave me his original coloured sketches of the Niagara district in 1841. He had previously published an outline of them in some wood-cuts in "Loudon's Magazine" for 1830, at a time when the geological structure of the country had not been worked out as it has since been by the State surveyors of New York. When I visited the Falls of Niagara in 1841, I conceived the idea of combining Mr. Bakewell's pictorial view with a correct geological representation of the rocks as determined by Mr. Hall, who accompanied me to the Falls. A copy of the view thus made I sent off in the same year to the Geological Society, and exhibited another in illustration of a lecture delivered at Boston in the autumn.

A reference to the section at p. 45. Vol. I., and to map, Pl. III., and to the observations made at p. 93 and 95., Vol. II., will enable the reader to understand the details exhibited in this view. The numbers on the right-hand margin from 1 to 6 correspond with those referring to similar colours in the map of the Niagara district, Pl. III. Vol. I. p. 30., in which the usual position of North and South have been reversed, that it might correspond with the bird's-eye view. In the latter, Lake Erie is seen in the distance, or to the South, and the river Niagara flowing out of it. This river at its exit is about 330 feet above Lake Ontario, and has a fall of about one foot in a mile for the first fifteen miles, until, after passing the larger or Grand Island, and approaching Goat Island, it descends rapidly about fifty feet in less than a mile, and is then thrown down about 165 feet perpendicularly at the Falls. For the dimensions of these and the ravine, see Vol. I. p. 31. The river then flows for seven miles in the ravine with a fall of 100 feet. The first notch on the left bank marks the western side of the whirlpool, where the drift occurs, described in Vol. II. p. 93., as connected with the valley of St. David's. The next notch and projection, half a mile lower down on the opposite bank, marks the site of the Devil's Hole (see map, Pl. III.) where the Bloody Run enters. I have speculated upon this indentation, p. 42. Vol. I., as a spot where there are clear signs of the great cataract having been once situated. About four miles still lower down, the platform terminates suddenly in the escarpment, at the base of which are seen the towns of Lewiston and Queenstown, standing on the Medina sandstone, No. 6., which forms the low ground extending for about seven miles to Lake Ontario, as shown in the map Pl. III., the river having a fall of only four feet from Queenstown to its entrance into that lake.

The site of the town of St. David's is seen on the right hand side of the bird's-eye view, and I have stated, at p. 95. Vol. II., that the opening here is represented, for want of more space, as of small width, but it is in fact nearly two miles broad at its mouth, forming a strong contrast to the narrowness of the ravine (about 400 yards wide) from which the Niagara escapes at Queenstown. This remarkable difference is doubtless connected with the entirely distinct mode of origin which I have ascribed to the two openings, that of the Niagara having been formed by the excavating power of the river as it receded, that of St. David's by the antecedent denuding action of the waves of the sea during the upheaval of the land.

The two chapters to which this bird's-eye view principally refers are Ch. 2. Vol. I. and Ch. 19. Vol. II.

Plate II.

Geological Map of the United States, Canada, &c., compiled from the State Surveys of the U. S., and other sources.

Frontispiece of Vol. II.

The route which I followed through the United States and Canada will be found indicated by a double line or road, and by a white streak through the Ohio or Appalachian coal-field, and by a dotted line where I went by water, on the sea or the lakes.

Section I. *Authorities.*

I have given an alphabetical list on the map itself of the principal authorities for the geological colouring of this map, which, although very imperfect, will, it is hoped, be useful, in conveying a general idea of the distribution of the principal groups of rocks, especially in that portion of the territory of the United States in which so many admirable State surveys have been made under the direction of the State governments. The manner in which the map has been composed, and the relative approach to correctness of its several parts, will best be understood by the observations which I shall offer on the sources of my information, and by my explanation of the groups of rock represented by different colours.

Maclure, William.

The earliest geological survey of America referred to in the construction of the present map is that accompanying Maclure's "Observations on the Geology of the United States," published at Philadelphia in 1817. In this map, he has represented, with great general accuracy, the "Alluvial Plain," (see p. 93. Vol. I.) bordering the Atlantic, and extending from Long Island to Louisiana and Texas. This plain includes the areas of the tertiary formations represented on my map. Parallel to the Alluvial Plain Maclure has described the great "Hypogene," or "primary" district of the *Atlantic Slope* (see p. 93. Vol. I.), and has indicated its northern extension over the whole of New Hampshire, and over nearly all Maine, Vermont, and Connecticut; he has also coloured in the detached mass occupying the northern part of the State of New York, between Lakes Ontario and Champlain. The broad belt of "Palæozoic rocks" stretching from Lake Champlain through the Appalachian ridges to the river Coosa in Alabama, and the isolated basin of Rhode Island, he has represented under the older epithet of "Transition." The sandstone of Connecticut and Pennsylvania, now classed as New Red sandstone, is coloured by him as Old Red; whilst, in the absence of positive information respecting the Western States, he coloured them all as "Secondary."

BAYFIELD, H. W., Captain R. N.

The earliest contribution of this indefatigable explorer of the geological structure of the northern parts of America, is contained in a paper on Lake

Superior, published in 1829 in the First Volume of the Transactions of the Literary and Historical Society of Quebec. In this memoir the position and extent of the sandstone, and various trappean and primary rocks which surround the lake and compose its numerous islands, were described from a careful personal survey. The representation given on my map is taken from a coloured copy laid down by Captain Bayfield for me.

Since 1829, Captain Bayfield has explored a great part of the Lake and River coast between Lake Superior and the Gulf of St. Lawrence; and in the present year he communicated to the Geological Society of London a paper "On the Junction of the Transition and Primary Rocks of Canada and Labrador," in illustration of which he presented an extensive suite of fossils to the Society, and supplied me with coloured maps of the district in question.

On these maps he has laid down the great region of hypogene or granitic formations extending from Labrador along the northern coast of the Gulf and River St. Lawrence to the northern shores of Lakes Huron and Superior; at intervals along this he has traced the oldest fossiliferous limestone (No. 15.) forming the northern extremity of Newfoundland, the island of Anticosti, and the Mingan islands, the outlying mass on Lake St. John, many points on the river St. Lawrence, above and below Quebec, some of the Thousand Isles, and thence, crossing to Cabot's

Head and the Manitoulins, where it appears to bend southward across Lake Michigan to the Wisconsin river.

From these maps I have also taken the coast of Chaleur Bay, Gaspe, the southern shore of the St. Lawrence, and many points in addition to, or confirming the information derived from other sources.

FEATHERSTONHAUGH, G. W.

In his "Tour in the Slave States," Mr. F. refers to his earlier geological surveys made in various parts of the United States.

From this work, and verbal communications, I have obtained much valuable information respecting the Alleghany Mountains, the Arkansas, and other Western territories; likewise in regard to the line of junction of the Primary and Silurian rocks on St. Peter's River, Missouri, and around the Ozark mountains. On Mr. F.'s authority I have extended the Cretaceous colour for a considerable distance along both banks of the Arkansas River; and he informs me that he has seen the same formation characterised by the abundance of Exogyra costata extending all the way to the sources of the Yellowstone river and Miscou.

CONRAD, T. A.

Mr. C. published in 1832, "Fossil Shells of the Tertiary Formations of North America," in which he alludes to the extent of these deposits. He has also kindly presented me with a map of Alabama, in which, besides the limits of the Primary and Silurian districts of North Alabama and Tennessee, he has traced out those of a Lower Cretaceous region explored by him, extending from Tuscaloosa and Montgomery on the north to Claiborne and Columbia, where it joins and is covered up by the *Eocene* tertiary.

JACKSON, C. T. and ALGER, F.

A map of the geology of Nova Scotia was published by these authors in 1833, to accompany a memoir communicated by them to the American Academy of Arts and Sciences, vol. i., Cambridge; in which a great portion of the leading features of the structure of the country are exhibited. The first account of their survey was published in Silliman's Journal of Science for 1828–9.

Dr. Jackson is also the author of a Report on the Geological and Agricultural Survey of Rhode Island, 1840. From his map it appears that the western part of the State consists entirely of Primary rocks, which also form its eastern boundary. Rhode Island itself, and the bays and islands northwards, are coloured as Greywacke and coal, which I have represented as Old Red sandstone and coal.

In 1841 and subsequent years Dr. Jackson published various Reports, succeeded in 1844 by one large 4to volume, entitled "Final Report on the Geology and Mineralogy of the State of New

Hampshire." The State consists entirely of Hypogene and Metamorphic rocks. The non-fossiliferous limestones of Haver Hill and Francisca are the only additions which, owing to the *wholesale* grouping of the rocks in the present map, I have been able to make, beyond the single colour used for the whole State in Maclure's map.

In the years 1837, 1838, and 1839, Dr. Jackson published three Reports on the Geology of Maine, from which it appears that that great region consists almost entirely of Hypogene and Silurian rocks. As the latter have not yet been subdivided, or referred to their equivalents in other States, I have coloured all the fossiliferous tracts with one tint. (Nos. 10—13.)

HITCHCOCK, EDWARD.

Professor Hitchcock published his first Report on the Geology of Massachusetts in 1833, but the map of which I have availed myself appeared in 1841, accompanying a new edition of his Report.

In this, the boundaries of the various metamorphic and primary rocks are laid down in great detail. The small scale of my present map only allows me to correct the general outline originally given by Maclure.

TAYLOR, R. C., F. G. S.

In Mr. Hall's map of the Middle and Western States, published in his Geology of New York, he acknowledges his obligation to Mr. Taylor of Philadelphia for a coloured map of the eastern part of Pennsylvania, recording his own observations previous to the year 1834. I have adopted this part of Mr. Hall's map, and have also before me that of Mr. Taylor, published in 1840, on which he laid down the position and extent of the outlying coal basins on the north-east of the great Appalachian coal-field.

Mr. Taylor is also the author of models to explain the geological structure of some of the ridges in the Alleghanies of Pennsylvania.

Rogers, H. D.

This eminent geologist published in 1839 his map of the geology of New Jersey, the result of a State survey, of which I have availed myself. Although the Final Report and map of Pennsylvania, constructed during another elaborate survey under the direction of the same geologist, has not yet been published, and consequently was not directly available for the present map, it is probable that some of the information obtained during the Pennsylvanian survey, and made public through various Reports, has found its way into the channels to which I have been indebted in the construction of my map.

Rogers, W. B.

Mr. Hall acknowledges his obligations to Mr. Slade, a member of the geological corps of the State survey of Virginia, so ably conducted by Professor W. B. Rogers, for the limits of the formations in Virginia, on which Reports have been published from the years 1836 to 1840 by Professor R.

In regard to the newer coal of Eastern Virginia, the relation of which to the New Red sandstone was hinted at by Maclure, Mr. Rogers infers from the fossil plants that it is of the age of the Oolite. See Paper in Trans. of Assoc. of Amer. Geol., 1842, p. 298.

OWEN, DAVID DALE, M.D.

In November, 1842, Dr. Owen, the State Geologist of Indiana, communicated to the Geological Society an important paper on the Geology of the Western States, with a large suite of fossils and a map, which he most liberally gave me permission to make use of for this work, without waiting for the publication of the original. His map comprises the whole of the Illinois coal-field, and a considerable part of the Ohio or Appalachian coal-field. It comprehends indeed the geology of all the Western States watered by the rivers Ohio, Wabash, Illinois, Rock, Wisconsin, Cumberland, and Tennessee, lying between 35° and 43° of north latitude, and 81° and 91° of west longitude. It includes the states of Illinois, Indiana, Ohio, Kentucky, Tennessee, and the Dubuque and Mineral Point districts of the territories of Iowa and Wisconsin. The observations recorded are the results of numerous excursions in those provinces, commenced in the year 1834, and continued to 1841 by Dr. Owen, sometimes alone, at others accompanied by Dr. Troost and Dr. Locke, the state geologists respectively of Tennessee and Ohio. The territory under consideration occupies an area of about half a million of square miles (Proceedings of Geol. Soc. of London, November, 1842, Vol. iv. p. 1.), and meets Mr. Taylor's Survey of the Pennsylvanian coal-field on the north-east, and the Cretaceous plain described by Conrad and Featherstonehaugh to the south.

New York State Survey, 1836—1842.

The State of New York having been divided into four districts, the geological survey of the first of these, comprehending the southern counties, was assigned to Mr. Mather, that of the second or northern counties to Dr. Emmons, the third district or central counties to Mr. Lardner Vanuxem, and the fourth or western region to Mr. James Hall.

The large map comprising the result of their joint labours, has not appeared, but a compendium of it has been given by Mr. Hall in his geological map of the Middle and Western States, published in his Final Report, Albany, 1843. To this map, by Mr. Hall, and to that already mentioned by Dr. Dale Owen, I have been indebted for the principal portion of that part of my map which contains the Government Surveys of the Union.

Mr. Hall's map comprehends a sketch of the geology of Michigan, with which he was furnished by Dr. Houghton, the government surveyor of that State, who must ~~therefore be considered as my~~ authority for this region.

The observations of Dr. Hildreth, in the twenty-ninth volume of Silliman's Journal "on Ohio," &c., of Professor J. T. Ducatel, in Maryland, and Professor J. C. Booth, the geologist of Delaware, have been embodied by Mr. Hall in his map, which I have followed in regard to each of those States.

That portion of Mr. Hall's map which relates to Pennsylvania and Virginia, especially the ridges of the Appalachian mountains, is necessarily imperfect, in consequence of the unavoidable delay which has attended the publication of the splendid maps, now nearly ready, by Professors H. D. and W. B. Rogers, the surveyors of those States.

I have not had the advantage of seeing a geological map of the Western States, published by Mr. Byrem Lawrence, to which Mr. Hall refers.

Dr. Emmons published his "Final Report on the Second District of New York" in 1842. It contains geological maps of the counties of Jefferson and Clinton, and many detailed sections, extending from the great primary or hypogene district of New York across the Silurian basin of Lake Champlain into Vermont, where the primary reappears; giving, upon several different lines, the points at which the various strata appear at the surface. I have also profited by much valuable information respecting the geographical distribution of the rocks of Canada, &c. in the body of Dr. Emmons' book.

PERCIVAL, JAMES G.

In 1842, Mr. Percival's "Report on the Geology of the State of Connecticut" appeared, with a map exhibiting, with great accuracy, the boundary lines of the various hypogene rocks, and the new red sandstone of the valley of the Connecticut, with the remarkable crescent-shaped masses of trap which occupy a considerable portion of its area. These trap-rocks are mentioned by Maclure, but their form, and the singular circumstance that they all lie in one direction, with their points eastward, was first made out by Mr. Percival.

GESNER, DR. A.

In 1836, Dr. Gesner published "Remarks on the Geology and Mineralogy of Nova Scotia," with a small map, geologically coloured, in the construction of which he had been engaged some years before; but I am unable to record the exact date of his earliest observations.

In 1842, he sent a much more detailed map to the Geological Society, to illustrate a memoir on the same subject, an abstract of which appeared in the Proceedings of the Society, and a sketch of the map itself subsequently in the Geological Journ., No. I.

p. 34., 1845. In 1839 and the three following years, he issued four Reports on the Geological Survey of the Province of New Brunswick; but, as no map was published with them, I have only been able to glean a few particulars, sufficient, in connection with the MS. map with which Mr. Henwood has furnished me, to give a general idea of the structure of that province. In the last of these Reports, Dr. Gesner describes the coal-field of New Brunswick as occupying an area of 8,700 square miles, bounded on the south by a primary ridge extending from Shepody on the Bay of Fundy to the Oromoecto Lake, on the east by the Gulf of St. Lawrence, and on the north and west, as far as it has been explored, by palæozoic and primary rocks beyond the river.

The whole of this great region presents a remarkably low and level surface, not averaging an elevation of more than 40 feet above the sea, the coast-cliff of the gulf being only from 12 to 20 feet high; and the central tract, which separates the streams which flow west into the St. John's from those which have an easterly direction to the gulf, scarcely exceeding 150 feet.

Sandstone, containing coal-measure plants and fossil trees, also occurs on the northern shore of the Bay of Fundy, forming cliffs, which are occasionally 200 feet high, and present many remarkable contortions and dislocations of the strata, caused in some instances by protruding masses of trap rock.

Henwood, W. J., F. G. S., of Penzance.

I am indebted to the kindness of this gentleman for a MS. map of New Brunswick, indicating the localities in which coal-measure strata occur all along the south shore of Prince Edward's Island, and on the opposite coast of Northumberland Straits and the Gulf of St. Lawrence, from Pictou Harbour, Nova Scotia, to Miscon Island, and along the south shore of Chaleur Bay. Also at many points in Passamaquoddy Bay, and along the whole course of the rivers Nashwack and Miramichi to Bathurst on Chaleur Bay.

Mr. J. W. Dawson, of Pictou.

From the map of the north-eastern part of Nova Scotia, sent to the Geological Society by this gentleman, of which a sketch was given in the first number of the Journal of the Geological Society, London, 1845, No. I. p. 26., and of which an improved edition will be given in the third number of that journal, I have corrected part of Dr. Gesner's map of Nova Scotia, so far as the small scale of my own could allow. On Mr. Dawson's authority, also, I have coloured Prince Edward's Island as carboniferous, as he has shown that the sandstone there contains coal plants throughout.

Mr. Richard Brown, of Sydney, Cape Breton.

From two papers and a map communicated by him to the Geological Society of London (see Quarterly Journal, No. I. p. 23., and No. II. p. 207.) I have been able to give the geology of the island of Cape Breton.

PRINCE OF NEUWIED.

The valley of the Missouri around the "Great Bend" has been coloured as *Cretaceous* upon the authority of the Prince of Neuwied. Mr. Römer has given the following extracts from his recently published work: — "Reise des Prinzen Maximilian von Wied zu Neuwied in Nord-America."

P. 75. "In the environs of Fort Clark on the Missouri, all the hills consist of sandstone with Baculites and other shells, which are found every where on the Missouri, and on its tributary rivers. Fossil bones have been often found; whole skeletons of Saurian animals, more than fourteen feet long, frequently occur farther down the Missouri: one of these, found near the Big Bend, I brought home, and it has been described as a new species of Ichthyosaurus by Professor Goldfuss."

P. 513. "We found here (near the mouth of the Mussel-shell river, Missouri) many shells, and among them very large and fine Baculites."

Baron Leopold von Buch informs me that the late Mr. Nicollet's map, which I have not seen, would have enabled me to give a greater extension to the cretaceous strata in the Far West.

Section II. *Geological Formations expressed by different Colours and Numbers on the Map.*

No. 1. *Alluvium and Post-Pliocene.* — One tint is employed to represent every thing newer than the chalk. The spaces occupied by tertiary strata are indicated by dotting or by crosses, as in Nos. 2. and 3. I am aware that many parts to which I have been unable to extend these markings are really tertiary.

No. 2. *Miocene.* — The island of Martha's Vineyard has been referred by me to this period, as well as other districts, the area of which is sketched out in the 6th chapter of this work, p. 132. Vol. I., and a more full account of which will be given in the 4th No. of the Quarterly Journ. of the Geol. Soc. London, 1845.

No. 3. *Eocene.* — A short account is given by me of what I observed of these strata, in the 9th chapter, p. 174. Vol. I., and a more detailed paper will be given in the 4th No. of the Quarterly Journ. of the Geol. Soc. London, 1845. I have by no means been able to mark all the points at which Mr. Conrad and others have seen the outcrop of these formations, to which I have also referred the white limestones of the Santee river and some other places, classed by several preceding observers as Upper Cretaceous.

No. 4. *Cretaceous.* — The strata indicated by this colour in New Jersey, are described in the 4th chapter, p. 77. Vol. I., and in my paper in the Quarterly Journal of Geol. Soc. No. I. I have already alluded to the authorities on which various regions of the map have been delineated as cretaceous.

No. 5. *Coal (Oolite?) Virginia.* — I have already mentioned (p. 245.), that Professor W. B. Rogers considers the plants of the newer coal of Virginia to agree very closely with those of the oolitic formations of Europe. I have therefore distinguished the coal field near Richmond in Virginia, which I did not visit, by a different figure (No. 5.) from the formation next in succession, or No. 6.

No. 6. *New Red Sandstone and Trap.* — The probable age of this formation has been discussed by me in the 6th chapter, p. 125. Vol. I., it being still a question whether it should be referred to the upper or lower New Red, to the Trias or Permian groups of Europe. This sandstone, in the valley of the Connecticut and elsewhere, rests on hypogene rocks, and contains the footprints of birds and numerous fish of a genus allied to Paleoniscus.

No. 7. *Coal Measures.* — I have alluded to the Illinois and Appalachian coal-fields at pp. 81. 86. Vol. I.; and at pp. 28, 29. Vol. II. That of Nova Scotia has been mentioned in the 24th and 25th chapters, Vol. II., and in my reference to Dr. Gesner, Mr. Brown, and Mr. Dawson as authorities.

No. 8. *Carboniferous Limestone and Gypsum of*

Nova Scotia.—This formation, when it is represented as forming a belt round the Ohio and Michigan coal-field, as shown by Dr. Dale Owen and Dr. Houghton, consists of limestone containing fossils by which it can be referred to the mountain limestone of Europe. No gypsum is there associated with it, but I have shown in the 25th chapter, Vol. II., that the lower carboniferous rocks of Nova Scotia assume a very different aspect from those in the United States, consisting of sandstone and red marl, with large masses of interstratified gypsum and marine limestone with true carboniferous fossils.

No. 9. *Old Red Sandstone, or Devonian.*—In order to understand the divisions comprehended under this and the following heads, from 10. to 16. inclusive, it will be necessary to refer to the classification adopted by the surveyors of New York in their geological reports, of which the following Table is given by Mr. Hall in his "Final Report," p. 18.

	Geographical subdivisions.	*Systematic subdivisions, founded upon the fossil and lithological characters.*	
NEW-YORK SYSTEM.	CHAMPLIN DIVISION.	1. Potsdam sandstone.	
		2. Calciferous sandrock.	
		3. Black-river limestone group, embracing the Chazy and Birdseye.	
		4. Trenton limestone.	
		5. Utica slate.	
		6. Hudson-river group.	
		7. Grey sandstone.	
		8. Oneida or Shawangunk conglomerate.	
	ONTARIO DIVISION.	9. Medina sandstone.	
		10. Clinton group.	
		11. Niagara group, including shale and limestone.	
	HELDERBERG SERIES.	12. Onondaga-salt group.	
		13. Water-lime group.	
		14. Pentamerus limestone.	
		15. Delthyris shaly limestone.	
		16. Encrinal limestone.	
		17. Upper Pentamerus limestone.	
		18. Oriskany sandstone.	
		19. Cauda-galli grit.	
		20. Schoharie grit.	
		21. Onondaga limestone.	
		22. Corniferous limestone.	
	ERIE DIVISION.	23. Marcellus slate.	
		24. Hamilton group.	Moscow shales. Encrinal limestone. Ludlowville shales.
		25. Tully limestone.	
		26. Genesee slate.	
		27. Portage or Nunda group.	Portage sandstone. Gardeau flagstones. Cashaqua shale.
		28. Chemung group.	

No. 9. of my map includes Nos. 26, 27, and 28., or the Genesee, Portage, and Chemung groups, forming the upper or newer part of the Erie division of the New York system. Some allusion will be found to this formation, Vol. I. p. 58., and Vol. II. p. 9—46.

No. 10. *Hamilton Group.* — This formation includes the Moscow and Ludlowville shales, and the

Marcellus slate of the above table of the New York system, and corresponds in many of its fossils with the Ludlow rocks of Mr. Murchison's Upper Silurian group.

No. 11. *Helderberg Series.* — This division includes that portion of the Upper Silurian rocks of the above Table, which comprises the formations from 22 to 14 inclusive. Mr. Hall mentions that, after leaving the western extremity of Lake Erie, the Niagara limestone, the Onondaga salt group, and the Helderberg limestones (Nos. 13. 12. and 10. of my map), are so blended together, that it is impossible to define their limits in the same manner as in New York. He has therefore united them in his map; and represented them under one colour in Ohio, Indiana, and Illinois; and I have followed the same plan.

No. 12. *Onondaga Salt Group.* — This remarkable formation of red and green argillaceous shale, marl, and shaly limestone, with veins and beds of gypsum, and productive brine springs acquires a thickness of 1000 feet in New York, near the Niagara region, and in the county of Onondaga, where it is largely developed: but it is a group of partial extent in the Upper Silurian division.

No. 13. *Niagara and Clinton Groups.* — These, it will be seen, form the chief part of the Ontario division of the New York system. The Niagara limestone and shale correspond in their fossils with the Wenlock or Dudley limestone of England, and would therefore be classed by Mr. Murchison as Upper Silurian.

The Clinton group, as containing the *Pentamerus oblongus* in abundance, would be considered in England as Lower Silurian; but Messrs. Murchison and De Verneuil regard this fossil in Europe generally as on the dividing line between the Upper and Lower Silurian rocks. I have thought it most convenient in this instance to unite the Clinton and Niagara groups.

No. 14. *Hudson River, Utica, &c.* — In this group I have included the formations from Nos. 5. to 9. inclusive, of the table of the New York system. The Medina sandstone, the Hudson River rocks, and Utica slates, comprise a number of arenaceous and argillaceous strata, which separate the Niagara and Trenton limestones, and which contain fossils corresponding to part of the Lower Silurian of Europe.

No. 15. *Limestone of Trenton, &c.* — This group includes Nos. 3. and 4. or the Trenton and Bird's eye divisions of the New York table, and the blue limestone of Cincinnati. (See p. 49. Vol. II.) The fossils brought by Capt. Bayfield from the island of Anticosti, and by Dr. Bigsby from the Manitoulin Islands, seem to imply that, near the northern limits of the Silurian rocks, the lowest group, containing *Spirifer lynx*, and other ancient fossils, and the newer calcareous formations, abounding in *Pentamerus ob-*

longus and *Favosites Gothlandica,* are closely contiguous, and cannot perhaps be divided.

No. 16. *Potsdam sandstone, &c.* — This group comprehends Nos. 1. and 2., or the Potsdam and calciferous sandstones, of the New York system, being the lowest formation containing organic remains in New York and on the St. Lawrence.—See pp. 127. 159. Vol. II.

Z. *Sandstone of Lake Superior.* — This sandstone was formerly considered as belonging to the Old Red by Capt. Bayfield; but, as he has obtained no fossils from it, its age must ~~be considered as undetermined~~, and he is now inclined to regard it as the equivalent of the Potsdam sandstone. The small oval marks engraved on the area of the hypogene rocks on the north shore of Lake Superior, indicate points where Captain Bayfield has seen this sandstone overlying the granitic rocks.

a. Hypogene, (*Granite, Gneiss, &c.*) — Under this head I have comprehended all the formations formerly called primitive or primary, whether stratified or unstratified, plutonic or metamorphic. They are non-fossiliferous, and I have discussed their chronological relations in the 21st chapter, at p. 128. to 134. Vol. II.

b. Trap Rocks. —Trappean rocks of various ages are indicated by crosses, which it will be observed are different from those used for the Eocene strata.

c. Metamorphic Limestone. — The non-fossiliferous crystalline limestones or marble of the hypogene or primary class are indicated by this character.

Note. — I have to acknowledge the co-operation of Mr. Woodward of the Geological Society, in assisting me in collecting the various maps from which the present one has been compiled, and in selecting and arranging the colours.

Plate III.

Map of the Niagara District.

The signification of the six subdivisions of the Silurian system of New York, represented in this map, will be understood by referring to the preceding description. It will be seen that the Helderberg limestone, No. 1., is the same as one of the Upper Silurian formations, or No. 11. of the large map; that No. 2. corresponds with No. 12., and Nos. 3. and 4. with No. 13., while No. 6., or the Medina sandstone, is included in the large map in No. 14., and considered a member of the Lower Silurian group. In the Niagara district, it is constituted partly of a hard white quartzose sandstone, but chiefly of red sandstone and red marl. This map is referred to at p. 30. Vol. I.

It will be seen that the same Nos. are used in the section at the side.

The usual position of North and South has been reversed in this map, in order that it might correspond with the bird's-eye view, Pl. I.

PLATE IV.

Fac-simile of a View of Niagara Falls, by Father Louis Hennepin. — (From the original Utrecht edition, 1697.)

This view is referred to at p. 35. Vol. I. The ship introduced by Father Hennepin is, I presume, a conventional sign for water, as at that period, Lake Erie had only been navigated by canoes.

PLATE V.

Fossil Mammalian Remains from the Tertiary Strata of Martha's Vineyard, Massachusetts.

An account of the fossil walrus, *fig.* 1., will be found in Vol. I. p. 258. In regard to the two vertebræ of different genera of cetaceans, the whale and dolphin, the reader is reminded that they have been reduced to one fourth of their natural size, so that they must have belonged to individuals of very large dimensions.

PLATE VI.

View of the Great Coal Seam on the Monongahela at Brownsville, Pennsylvania.

A description of this plate is given at p. 27. Vol. II.

Plate VII.

Recent Footprints of Birds, the Sandpiper (Tringa minuta), on the Red Mud of the Bay of Fundy, Nova Scotia — natural size.

A full account of these impressions of the footsteps of birds, fossilized in red marl deposited by the waters of the Bay of Fundy in July, 1842, will be found at p. 167. and the following pages, Vol. II. The specimen has been presented by me to the British Museum.

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