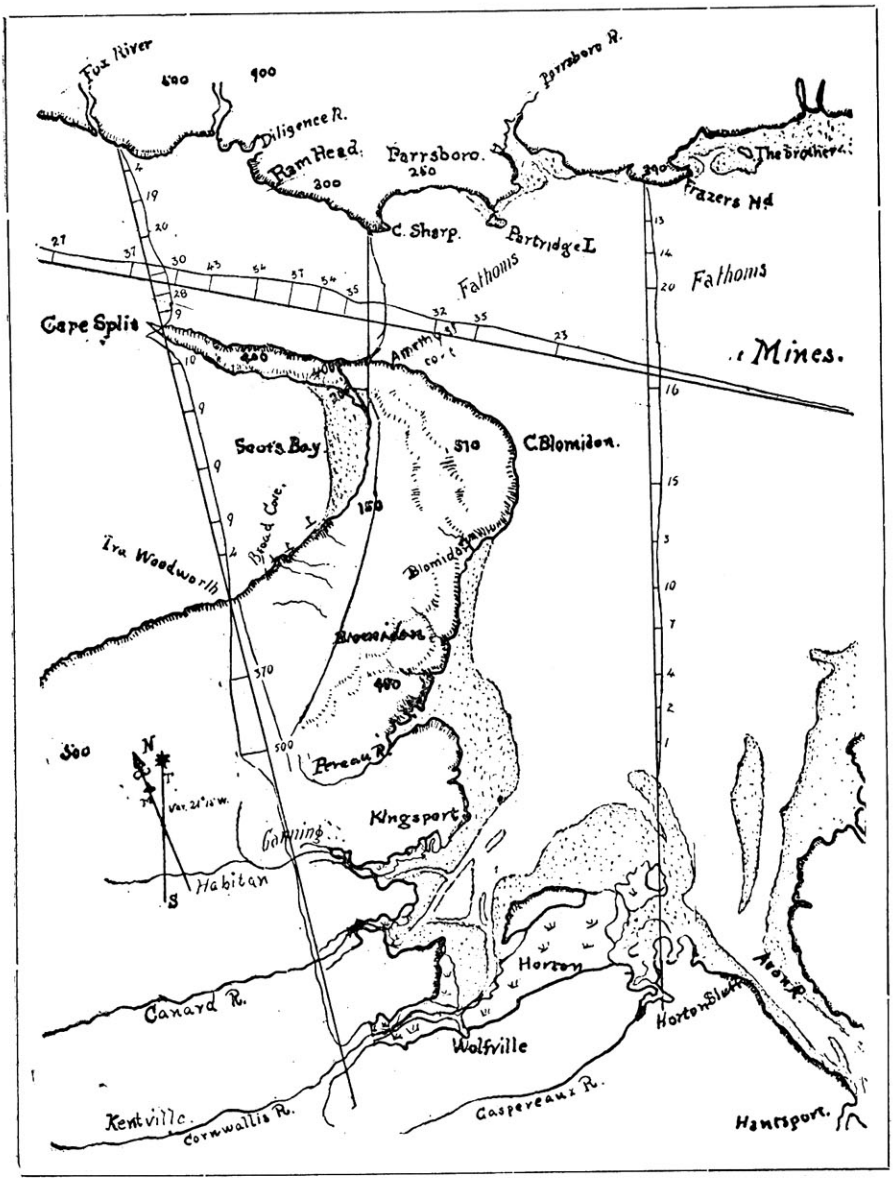
XII.—Records of Post-Triassic Changes in Kings County, N. S.—By Prof. E. Haycock, *Acadia College, Wolfville, N. S.*

(Read 9th April, 1900.)

It was my privilege last Autumn to make a hasty survey of that part of Kings County lying north of Canning, including Cape Blomidon. Several interesting problems were suggested during this trip, which I hope to follow up in the future.

I had in view two definite aims in visiting this region. The first was to look for the contact of the basaltic trap of the North Mountain with the underlying north-westerly dipping sandstone, and I hoped to find this contact laid bare and accessible to observation in the natural cross section formed by the line of cliffs which extends westwardly from Cape Blomidon to Cape Split. This line of cliffs was carefully examined from Amethyst Cove, where the trap extends beneath the sea, eastward to Cape Blomidon where red sandstone cut into many fantastic shapes by wind and water rises nearly two hundred feet and is surmounted by a sheet of black basaltic trap some two hundred feet in thickness ending abruptly in vertical cliffs behind and above the towers and bastions of the sandstone. Although the place where the contact of the two formations reaches the beach is easily determinable, and is marked by a long sloping line of springs, the talus of loose blocks and debris from the trap above is so great that at no point was the actual contact visible or accessible, so that the problem to be settled, whether the trap was poured out on a smooth sea bottom or on an old eroded land surface, remained undetermined.

The second object of the trip was to examine the coast section south-west from Scot's Bay. In the Transactions of the Institute for 1893-94, (Volume VIII., pp. 416, 419,) Mr. R. W. Ells mentions the occurrence, in this vicinity, of a calcareous



NORTH-EAST PART OF KINGS COUNTY, N. S.

Scale: About four miles to one inch. Vertical scale 2400 feet to one inch. Depth of water in fathoms.—*For* Mines, *read:* Basin of Mines.

sedimentary formation overlying the trap of the North Mountain which was hurriedly observed by him in 1876. He states that no fossils had been found in these rocks, but concludes from the superposition of this formation on the trap that it is of more recent date. He does not hint at its probable age further than the above, but remarks that Prof. Bailey has reported rocks of somewhat similar nature in association with the trap of Digby Neck. Having been unable to find the statement in any of Prof. Bailey's writings accessible to me I made inquiry of him and found that he did not know of such a formation, or of having made the statement ascribed to him. This being the state of knowledge in regard to these rocks I hoped to find something that would throw light upon their age and possibly reveal a part of the geological history of this region during that long period so blank in records in Eastern Canada and New England, from early Mesozoic to the Glacial period.

In pursuit of this purpose I examined the shore south-west from Scot's Bay and was pleased to find for about four miles occasional good exposures in the coves of the formation mentioned by Dr. Ells, until Ira Woodworth Bay was reached. This is the exposure mentioned by him and was the most westerly outcrop seen. Beyond this according to local authority none of the rocks mentioned are found. Considerable value can be ascribed to the local accounts in this case owing to the search for amethysts which occur in cavities of masses of red jasper in some of the layers of limestone, and are collected by the inhabitants to supply the tourist trade. Only a hurried survey was made on this occasion and but one fossil was found, which, tho' poorly preserved, was plainly the coiled shell of a gastropod. The general appearance of the strata, however, led me to hope that better results would repay a careful and systematic search.

On November 6th, I left Wolville for a further study of this interesting formation. The results of my observations on this trip I will endeavor to put before you.

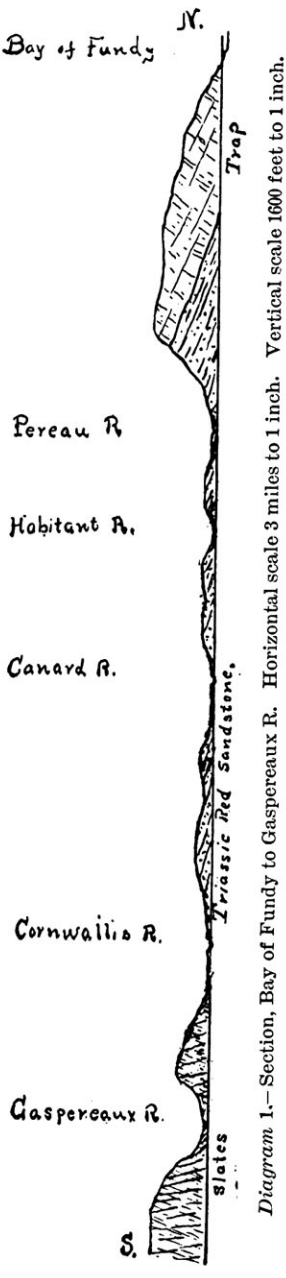


Diagram 1.—Section, Bay of Fundy to Gaspereaux R. Horizontal scale 3 miles to 1 inch. Vertical scale 1600 feet to 1 inch.

The general topography of the region alluded to is probably familiar to you all, as well as the common explanation of the geological structure, which appears to be, in the main, correct. From the parallel east-north-east and west-south-west ridges of slate and sandstone of later Palæozoic age, which extend along the south-east side of the Cornwallis Valley, a slightly undulating rich farming country stretches away to the north-west for some ten miles to the abrupt escarpment bounding the valley on its opposite side. The principal topographic features of this beautiful valley are three low ridges parallel in general trend with the older hills before mentioned and separated from each other and from the bounding ridges by long tongues of fertile dyked marsh in the basins of the Cornwallis, Canard, Habitant, and Pereau rivers. The existence of these ridges seems to be due to the occurrence of coarser harder groups of strata in the underlying red sandstone which dips with considerable uniformity and regularity to the north-west at angles of from eight to ten degrees. The ridges correspond with the strike of the formation and the valley topography is apparently one of erosion. The wearing out of the valleys took place when the country stood at a higher level, and the marsh deposits of

recent times now extend for several miles up the drowned valleys. That this topography is probably Pre-glacial is indicated by the occurence of a layer of Boulder clay of variable thickness mantling both hill and valley. The changes in topography since the disappearance of the ice of the Glacial period are exceedingly slight in this region and are confined almost wholly to the deposition, during a subsequent slight submergence, of some banks of stratified sand and gravel, some wearing away and retreat of the coast cliffs, and the filling-in of the river basins mentioned.

The North Mountain has the prevailing trend of the other ridges, and would appear to owe its present elevation above the valley to the harder and more resistant character of the sheet of volcanic rock, which protects the underlying soft sandstone from the action of the eroding agents that have worked with such effect upon the unprotected sandstone to the south-east. The junction of the sandstone and trap is some two hundred feet or more above the floor of the valley, and the conviction is forced upon the observer, when looking south-eastward from this point that not only the smaller valleys mentioned but also the whole broad depression he has crossed has been worn out of the soft red sandstone, and that excepting minor inequalities of surface the present relief of this part of the Province is wholly due to differential resistance of the underlying rocks.

The trap sheet retreats more rapidly along its edges than the sandstone owing to frostwork and its vertical jointing, and when they both appear in the face of the escarpment the overlying trap is never overhanging but always well behind the sandstone which generally forms a steep slope upon which the fragments of the trap are precipitated, forming broken masses which conceal the contact of the two formations. Because of the soft nature of the sandstone and its calcareous cement it weathers much more rapidly than the trap wherever exposed to the action of rain and wind, but since the jointing is not well developed it is not affected to a very great extent by the action of the frost.

From the top of the divide, which is near the edge of the escarpment, the surface slopes away to the north-west at angles of from eight to ten degrees. This is about the inclination of the beds of trap rock, and the present surface therefore corresponds in general inclination with the original surface of the formation. This ridge is cut by transverse valleys, the bottoms occupied by small brooks which seem altogether too small to have excavated the trenches they now occupy. A bank of boulder clay containing glaciated pebbles was seen resting in the bottom of a ravine on the floor of trap rock over which one of the larger brooks is now flowing. If these depressions were filled with the boulder clay of the Glacial period, the work since that time has been wholly expended in clearing out their ancient channels and the brooks have but just begun to renew their excavation on the Trap rock.

The four miles of coast examined form the south-east shore of Scot's Bay, and from Ira Woodworth Bay, Cape Split, the terminating point of the huge wall of rock forming the opposite side of Scot's Bay, bears nearly north. At this point the shore swings from south-west to about west-south-west which is the general trend of the coast for some sixty or seventy miles. With the exception of the Amygdaloidal character of the Trap, the shore below high water mark is not unlike many other portions of this Bay of Fundy coast. Beachy coves are more common because of the relatively sheltered position, but between these the black rough rocks slope seaward in sheets and reefs with very few outlying rocks and ledges. The sea at high tide washes the bases of a line of low cliffs some twenty to forty feet high, except in the deeper coves, where a narrow strip of gravel beach is left uncovered by all but the highest tides. Several brooks empty in small coves within the area examined and in their beds the extent of the shore formations landward can be traced.

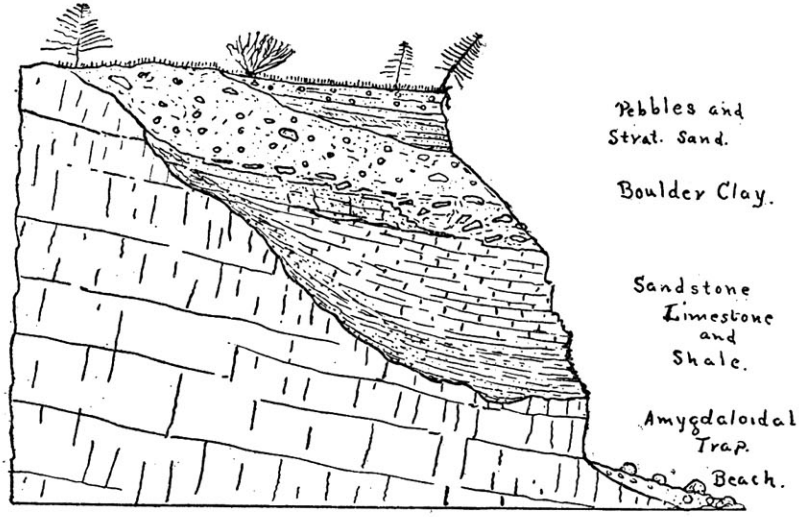


Diagram 2.—Section in Ira Woodworth Bay.

In the shore cliffs four distinct formations are revealed and in the ascending order they occur as follows :—

1. Trap Rock.
2. Sandstone and Impure limestone, 20-30 feet.
3. Boulder clay with striated stones in irregular masses, 20-30 feet.
4. Stratified sand and gravel 4 to 6 feet in thickness about thirty feet above high water mark.

Trap Rock.

The Basaltic Trap is, in this locality mainly amygdaloidal and occurs in sheets varying from two or three to many feet in thickness. The strike corresponds to the general trend of the shore. In many places the beds are intersected by a network of shrinkage cracks which have been subsequently filled with a dark reddish brown jasper. This is more resistant than the trap and the veins form a network of intersecting ridges separating saucer shaped depressions a foot or more in diameter. As the Trap approaches its contact with the limestone it becomes

more and more decayed until at the contact the rock is so loose and unconsolidated that it will scarcely hold together to form a hand specimen.

Sandstone and Impure Limestone.

The lower layers of the calcareous formation are largely made up of this disintegrated material but it is not found more than two or three feet from the contact. These lower layers are poorly defined and conform to the minor inequalities of the eroded surface of the Trap. The Trap debris then gives place to a fine grained light grey to green sandstone with calcareous cement, in thin laminae, which is overlain by beds of impure limestone from one to three feet thick alternating with thinner layers containing flint-like quartz bands. At one spot in Broad Cove a brown sandstone in beds three or four feet in thickness is seen overlying the limestone. The maximum thickness of this sedimentary formation would be about twenty-five feet. Altho several brooks cut across these beds at right angles, in only one can the limestone be traced, and there for a distance of but twenty or thirty yards from the beach where the trap appears in the bed. The other brooks have cut completely through and flow over the underlying trap until the beach is reached. This shows how little remains of what must have been an extensive formation and explains in part why it remained so long unnoticed.

The dip of these beds is, at first, somewhat confusing. On the north-east sides of the coves it is always to the south-west, and at angles as high as twenty degrees. On the south-west sides of the coves it is correspondingly high to the north-east. In the bed of the brook mentioned, which is in the centre of one of the coves, the dip proved to be from three to five degrees to the north-west. At several places the trap was visible beneath the apparent synclines and showed no corresponding deformation. Moreover, the variable inclination of the layers was there seen to be that of the contact surface of the trap on which they rest. As the layers recede from this surface they become more uniform in inclination which is seen to be to the north-west at an angle

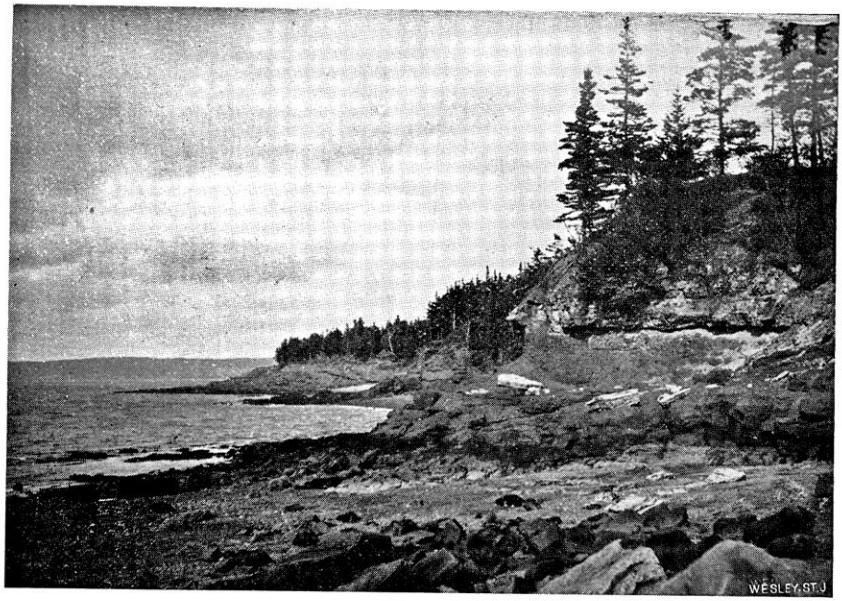


FIG. 1.
BROAD COVE, LOOKING EAST, SHOWING LIMESTONE AND SHALE RESTING ON AMYGDALOIDAL TRAP.

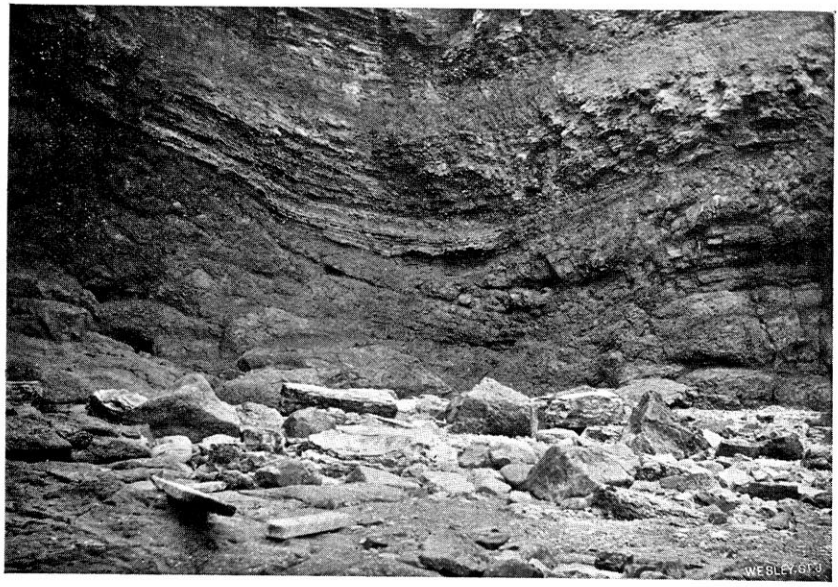


FIG. 2. — UNCONFORMABLE CONTACT OF GREENISH SHALE WITH AMYGDALOIDAL TRAP IN BROAD COVE.

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slightly smaller than that of the trap, or the same as the observation taken in the brook.

In some of the lower fine grained calcareous shales sun cracks frequently occur and together with trail-like markings and carbonaceous impressions of branching fucoid-like plants point to shallow water or tidal conditions prevailing during the deposition of the lowest layers. The fineness of the material of these lowest layers also indicates a very gradual quiet submergence of the disintegrated Trap rock and the absence of heavy waves upon the subsiding beaches. The heavier bedded limestone is quite free from inorganic sediment, and is a deposit in deeper and purer water. The heavy bedded brown sandstone marks some change bringing about a great increase of inorganic sediment. Whether it was a re-elevation bringing the area nearer shore, or advent of currents carrying such sediment is at present undetermined.

Fossils occur in the underlying shale and limestone, altho' they are, as a rule, poorly preserved. Among those collected are fish scales and teeth, objects resembling the seed cones of gymnosperms, marine fucoids, and long, tapering, generally straight, objects that are thought to be the shells of cephalopods. These occur in the limestone and calcareous sandstone often in great profusion and may reach a length of eight or ten feet, and a diameter at the larger end of eight or nine inches. The smaller ends are rounded, and usually about one, though sometimes two or three, inches in diameter. They are cylindrically or longitudinally knobbed, hollow in the centre, and composed mainly of a red jasper. That these forms are of organic origin and are not concretions is indicated by their similarity in form and by their lying, in one bed, in such numbers that they cross each other in every conceivable way, but always the characteristic form of each individual can be determined. In all cases the finer laminæ of the beds are pressed down beneath by the weight of the object, and those deposited after curve up over it without interruption. Other forms occur here also. One of these was twenty-seven inches in diameter and appeared cup-like in shape.

It has been stated that these strata rest unconformably on a surface of decomposed trap, and that the lower layers are made up, in part, of the triturated fragments of the trap. This would indicate that after the pouring out of these lava sheets their surface was above water, was carved into valleys and hills, by the streams of the time, and subjected to the decomposing action of atmospheric agencies and vegetation, until the ancient surface came to present the irregular and weathered aspect that we may now see on portions that have been subjected to similar action during recent geological time. This necessarily long exposure preceded the subsidence and submergence during which the stratified formation was deposited and would indicate, to my mind, that at least a whole geological period had intervened between the outpouring of the trap and the deposition of the marine formation unconformably upon its weathered surface. The trap is considered to be of Triassic age and I would place that of the limestone as probably Cretaceous. Again, from Cape Cod southwards marine deposits were laid down along the Atlantic border during Cretaceous times. Altho' I have as yet been unable to find any traces of foraminifera in the soft greenish sandstone that occurs in one of the coves, yet the general aspect of the fossils so far found is also suggestive of Cretaceous age.

The hollows or depressions in which these remnants are preserved are at present small valleys, occupied by brooks and terminating on the shore in small coves which also owe their existence to the erosion preceding the deposition of this formation. The Topography of this portion of the North Mountain is thus shown to be much older than the Glacial period and not only are the brooks flowing in Mesozoic channels but the Bay of Fundy waves are again washing the shores of coves from which they have been excluded since the Mesozoic period.

The facts observed here are in accord with the conclusion arrived at from a comparison of the present stream beds with the streams that now occupy them. Some of the gorges in this area are equal in magnitude to those of the secondary streams of the South Mountain, although the volume of water now flow-

ing in them is insignificant. The cross trenches in this particular locality are, however, small as compared with those that cross the mountain at intervals of a few miles throughout its length, some of which are scarcely above sea level, others as Digby Gut and Petite Passage 150 to 200 feet below.

These deep gorges are probably Pre-glacial, as well, since they are partly filled with boulder clay and usually, if not always, set opposite to corresponding depressions in the older hills on the opposite side of the valley. The ice of the Glacial epoch flowed over ridge and through hollow alike, and beyond sweeping away the decayed and shattered layer down to the undecomposed rock seems to have had little effect in transforming the general topography of the country. These gorges then are doubtless Pre-glacial, but how much older? Though much larger they are of the same character as the smaller hollows filled with the sedimentary limestone, and are probably of the same, or Mesozoic age. Although direct evidence of this has not yet been obtained it may exist, only awaiting the coming of a careful observer.

The most significant features of these greater gorges is their positions, just mentioned, nearly opposite to corresponding river gorges on the south-east side of the valley. Almost every deep gorge in the North Mountain has its corresponding river valley in the higher ground of the South Mountain opposite. The depressions reaching the Bay of Fundy coast at Parker's Cove, Digby Gut, Sandy Cove, opposite the Lequille, Bear, and Weymouth rivers are striking examples. A possible if not the only plausible explanation of this fact, taken in connection with the evidence of the great age of these depressions, is that they are respectively the old outlets of Mesozoic rivers that flowed northwestwardly across the sandstone and its overlying trap sheet, draining a country more extensive than the present Nova Scotia, because of its greater elevation, and with their greater volume wearing broad channels through the red sandstone but abrupt and precipitous trenches in the trap. The effect would be the same in the basins of the smaller streams such as those now

heading back to a low divide some three or four miles from the coast.

During the submergence of the region in late Mesozoic or early Tertiary times, the streams were drowned by the sea and the silicious and calcareous deposits described were laid down in the old river valleys. Deposits forming in this way would be protected from the disturbances of the open shore, and probably be composed of fine sediment laid bare at each low tide and dried and sun cracked in bright warm days until carried below the tidal limits by the slow subsidence of the whole region. The limestone deposits indicate a submergence great enough to have formed large inland basins in the broad valleys in the sandstone country south-east of the edge of the trap sheet. These were possibly separated from each other by low divides which would be gradually lessened by the rapid vertical decay of this rock referred to earlier in this paper. When once covered by the sea, the swiftly moving north-east and south-west tidal currents characteristic of this region would scour out the valley at a rapid rate, while the trap sheet would not retreat along its edges at a corresponding rate since the frost work had not yet been inaugurated, mild and warm climates extending at this time even within the Arctic Circle. On the re-elevation of the country in middle or late Tertiary times, the rivers would not return to their ancient channels across the trap which were now higher than the valley floor and filled in with deposits of the kind described, but would flow along the valley parallel with the mountain in either direction only discharging at the lowest outlets as Digby Gut at the south-west and Minas Basin and Channel at the north-east.

The colder climates of late Tertiary times were now setting in with winter frosts and snow, and the sheet of trap would begin the rapid horizontal retreat which has continued until the present day.

Boulder Clay.

Boulder clay containing many striated stones from local sources occurs throughout this whole region and is seldom absent

except from the loftier and more exposed portions of the ridges. The prevalence of compact and amygdaloidal trap from the North Mountain in the Boulder clay all over the south side of the valley, as well as the rounded and worn north facing slopes of the elevations indicate that the general movement of the transporting agent was from the north. The general trend of all the striations I have yet seen in this vicinity is in the same direction.

Although Boulder clay is rarely seen along the exposed side of the North Mountain except when sheltered by the precipitous walls of the deep gorges which have been alluded to, on the stretch of shore south-east of Scot's Bay, deposits of considerable thickness rest alike on trap and limestone and contain striated fragments of both formations. In general the mass has the same decided red color as the sandstone cliffs underlying the trap at Cape Blomidon. One exception to this occurs in Ira Woodworth Bay where the underlying portion of this deposit is completely made up of a calcareous light grey clay mixed with angular, occasionally striated fragments of the sedimentary formation. It is wholly composed of the broken and pulverized layers of this sedimentary formation and passes up abruptly into the red clay and trap boulders among which no trace of limestone could be found.

The abundance of boulder clay on this strip of coast proves it to have been a region of deposit rather than of erosion during its burial beneath the ice of the Glacial Period. That deposition was not continuous is shown, however, by the occurrence of the debris of the adjacent calcareous strata at the most westerly point at which these strata were seen. Farther east the red deposits seemed to rest directly upon the light grey limestone and sandstone and these portions do not seem to have suffered as much from the grinding action of the ice sheet.

The evidence from striations and from travelled boulders prove that the general movement of this ice sheet was from the north. From Ira Woodworth Bay, Cape Split bears due north and from this bold Cape a line of vertical cliffs from two to four hundred feet in height extends eastward for eight miles to Cape

Blomidon, offering a huge barrier to the advancing ice sheet which would deflect the main current, and leave a sheltered area behind where the eroding action would be small or absent altogether, and the conditions favorable for deposition during the decline and disappearance of the ice.

This protected area would extend about to Ira Woodworth Bay, whence westwardly the shore would be exposed to the full sweep of the mass passing to the westward of Cape Split. It is significant that east of this Bay occur the heavy deposits of boulder clay while to the west a bold bare coast of black forbidding trap extends for a hundred and twenty miles with but an occasional heap of red boulder clay that has been deposited behind some projecting cliff. Have we not here a simple explanation of the preservation of this fragment of marine limestone, this mere remnant of what must have been a formation of considerable extent, the sole representative in north-eastern America, containing the only known records for that region, of the Geological history of the long period of time between the Triassic and the Glacial periods.

Stratified Sand and Gravel.

But the records preserved in this strip of coast do not end with those of the Glacial period. Overlying the boulder clay is a deposit of stratified sand and gravel several feet in thickness, the base of which is now some thirty feet above high tide level. The upper limit of this formation was not determined, but the coarse and water worn character of the material classes it as a shore deposit, laid down within or but slightly below tidal limits. This formation has been noticed at Wolfville, Pereau and at several localities in Digby County. In the Cornwallis Valley it consists mainly of stratified sands in which the cross bedding indicates that during their deposition the currents flowed strongly both to the north-east and to the south-west, or parallel with the general trend of the valley.

These deposits tell of a submergence succeeding the Glacial period of at least thirty or forty feet and a re-elevation of at

least the same magnitude. It is probable that during the deposition of these beds the waters of Minas Basin, Digby Basin and St. Mary's Bay were connected and that the present flat and fertile valley stretching from the base of the North Mountain to the low Palæozoic hills on the south was a shallow strait through which twice a day the ebb and flood swept swiftly planing down the valley to a uniform level but sweeping up here and there long bars of shifting sands. These still remain but form minor features in the topography of the valley.

This shallow strait was sheltered from the rougher waters of the Bay of Fundy by the protecting barrier of the North Mountain and the deposits in the valley are much finer than those of the same age on the Bay of Fundy coast. The North Mountain itself was cut up into a line of narrow islands by the submergence which brought the bottoms of several of the deeper gorges below sea level, and the old shore lines in some of these may still be seen. The length of the chain was practically the same as at present since Briar Island the westermost extension of the trap ridge then formed two small islands rising some fifty feet above the sea as shown by the old shore line about eighty feet above the present sea level.

When the land again arose, the waters left the valley, the rivers extended seaward removing the sand and gravel from their old channels, wearing them deeper, and the now submerged forests grew.

But again a gradual subsidence followed. The sea slowly advanced up the river channels. The fine sediment brought down by the rivers was arrested by the tidal currents and deposited in their shallow estuaries, and the marine marshes were formed.

This is as we find it at the present day. The changes are still in progress. The history of this region which we have followed from early Mesozoic times to the present, or as much of it as the records known to us reveal, is still being written in the changing surface features of the land, the retreating coast line, and the strata now forming off our shores. Every change,

no matter how small is thus recorded, and this account is merely an attempt to read aright such records as have come under the observation of the writer in a few hasty journeys among the newer formations of our Province.

Brief and limited as these opportunities for observation have been, they have convinced me that the field for Geological investigation, in this region at least, is ample; that it is wonderfully rich in undiscovered facts; and that for variety in lithological, in palaeontological and in structural features, it is unequalled by any area of similar extent in eastern North America. That such is the case is shown by the results achieved by Sir J. Wm. Dawson during the third quarter of the century and set forth by him so clearly and interestingly in his "Acadian Geology," a work which must ever remain for us a model of close observation, broad and scientific induction, and elegant expression.

Because of its exceptional richness, however, the field has not yet been exhausted, in the region of Minas Basin and westward the soil has merely been broken. The broader relations of the great formations to one another have been worked out and their relative age established, but in knowledge of their lithological composition, fossil contents, structural peculiarities, conditions of deposition, relation to present topographic features, etc., we are almost wholly deficient. The field is alluring and full of promise to the Geologist. Let us who are native born reap the rich harvest of facts before we are anticipated by workers from the over-crowded fields of New England.