ART. IV.—GLACIAL TRANSPORTATION IN NOVA SCOTIA AND BEYOND.—*(Problem of 1873 solved.)* BY PROF. D. HONEYMAN, D. C. L., &c. *Hon. Member of the Geol. Assoc., London.*

(Read Feb. 12, 1883.)

[*Substance of this and of preceding Paper on the same subject, communicated to the Geologists Association of London at July meeting.*]

PICTOU COUNTY.

LAST summer I extended my observations from West River railway station, eastward as far as the Albion mines. Syenitic boulders were observed on both sides of the railway, as far as Hopewell station. At the new workings of the Albion mines I collected boulders from the drift—syenitic gneisses and syenites. The position of the drift having these boulders is intermediate between the Cobequid mountains and the Archæan rocks of East River. The source of the boulders is therefore problematical. They may have been brought to their present position by floods occurring at the close of the glacial period. One of the boulders is a very beautiful syenite. I found a large boulder of a similar character near Merigomish harbour in 1868. It was composed of white and pale red orthoclase, light green hornblende and hyaline quartz. I have not seen a syenite like it *in situ.*

ANTIGONISH COUNTY.

On the shore at Morristown, (Antigonish) boulders, large and small, of Diorite of strongly-marked character, attracted my attention upwards of twenty years ago. Much speculation was indulged in regarding their source. It was concluded that they had been transported from the Labrador coast.

When I discovered the typical "Archæan" Arisaig rocks on Northumberland Strait shore in 1868, I was pleased to find a rock precisely similar to the boulders in question as one of the rocks of the series. I may remark that in all my examinations

subsequently of the Archæan rocks of Nova Scotia and Cape Breton, or elsewhere, I have not found another rock like it. On re-examining the shore where the boulders lay, I observed similar boulders rolling down the bank out of the drift which overlies the gypsums and limestones. I consequently concluded that the boulders had been derived from the Archæan rock on Northumberland Strait,—having been transported a distance of 10 miles. A line drawn on the Admiralty Chart from the position of the rock to that of the boulders on the shore, runs S. 20 E., N. 20 W., magnetic. This is parallel to the line of Blomidon amygdaloid transportation. This is a striking coincidence. It is also parallel to the intermediate glacial lines of Gay's River road and the Gore. *(Acadian Geology Table.)*

Further west in the Arisaig Township, we have the jaspideous rocks of Frenchman's Barn and of Arisaig Pier, transported southwardly; massive boulders being found landed on the higher grounds.

ADMIRALTY CHART LINES.

My working chart shows the Strait of Canseau running parallel with the extension of the Northumberland Strait and Morristown (Antigonish) Archæan transportation course, and all the Atlantic coast harbours of Nova Scotia, as far west as Ship harbour, approximately parallel. From Ship harbour to Halifax harbour the harbours follow approximately the course of lines made by local glaciers. *(See preceding Papers. Trans. 1875-6, and 1881. S. and E.)*

Halifax harbour and the estuary of the Avon are in the line of the Blomidon and Halifax glacier, which has transported the triassic amygdaloids. The Archæan transportation glacier converging on Bedford Basin. The Blomidon glaciation lines extended N. W., pass through the depression of the Cobequid mountains.

ANNAPOLIS COUNTY.

As I have noticed in other papers on general geology, triassic amygdaloids, from North Mountain, a continuation of Blomidon, were collected by myself in the drift cuttings of the

Nictaux and Atlantic Railway, on the S. E. side of Cleveland mountain, a part of which is called South mountain, on the south side of the Annapolis Valley. Near the front of Cleveland mountain (N.), an interesting exposure of glaciated argillites occurs where the old or steep road meets the new one. This position is nearly on a level with the general elevation of North mountain. This is the only striation that I have noticed on the north side of Nova Scotia. I remarked of this striation that the agent making it and transporting the amygdaloids from the North mountain, must have had a highway across the tract intervening between the two mountain ranges. I therefore inferred the *non-existence* of the Annapolis Valley in the glacial period.

I also noticed at Nictaux a transportation of granite northwards, from the granites of South mountain towards the Annapolis Valley. I have considered the amygdaloid transportation as during the glacial period, and the granite as occurring towards its close during the formation of the Annapolis Valley, the granite having been transported by sand-slips or avalanches.

KING'S COUNTY.

In the middle of the Annapolis valley, near the Berwick station of the Windsor and Annapolis Railway, numerous boulders of granite were found. These, too, have been transported northerly from the granite region of South mountain. The time of transportation, and the agency, may possibly have been the same as referred to in the preceding case.

At Kentville, trappean boulders from the North Mountain were observed, and a beautiful specimen of fortification agate collected.

On the south side of Wolfville—on the side of the road that passes Acadia College—abundance of amygdaloids and other trappean boulders were observed. At the south-east they were very abundant, near, and in the Gaspereaux Valley. The size and number of these were such as might be expected in sight of Blomidon, and without any apparent obstruction in the path of transportation. I was disappointed, however, in observing their

rarity in the space intervening between Wolfville and Blomidon. I do not recollect of seeing any trappean boulders until approaching the latter. I found on Blomidon the amygdaloid rocks,—the source of supply—far from exhausted by the enormous levy that had been made to supply so liberally the drift between Wolfville and the Atlantic.

I noticed, also, another great granite transportation. Granite boulders were first observed in Halfway River, at the line between the Counties of King's and Hants. Approaching their source, the extension of the granites of South mountain, already referred to, the size and number of the boulders was so great as to lead to the belief that the solid granite was underneath, while the underlying rocks were found to be argillites. The transportation is like the cases already referred to northerly. Amygdaloids of the southerly transportation were also observed among the granite boulders among the argillites of Greenfield.

HANTS COUNTY.

On the estuary of the Avon, from Horton Bluff to Windsor, amygdaloids are seen in great abundance, and often of considerable size. Besides the lower carboniferous limestones, above the old Avon bridge are abundance of small amygdaloid boulders. It was when examining these limestones, and collecting their fossils, in 1861, that I first noticed the amygdaloid boulders. Prof. How then informed me that they were from Blomidon. On every subsequent visit to this locality, I made a more intimate acquaintance with them and their minerals. It was this acquaintance that led me to recognize their fellows at Cow Bay and elsewhere.

BEYOND.

While some of the movements were undoubtedly local, others —*e. g.*, the Archæan transportation of Antigonish—could not possibly originate on the border of Northumberland Strait. This conviction left me to consult the record of observations made in Canada by Sir Wm. E. Logan and others, in the table of glaciation grooves in "Geology of Canada, 1863." Pp. 890, 1–2. Here I found Nova Scotian courses S. E. prevailing over S. W., up to

Lon. 80° 54, in the ratio of 2·1. This convinced me that the Nova Scotia courses were part of a system having their beginning in the distant N. W. To illustrate the relation of these to the general transportation of Nova Scotia, S. E., I added a sheet to my chart, so as to be able to locate the groove lines of the table as far as Lon. 38° W. The illustration is very striking. The variations from the S. E. course are probably like those of Nova Scotia,—deviations arising from local causes.

About the 80° meridian the arrangement of glacial lines is peculiarly striking. Here we have a point of general divergence. West of this the glaciation has a S. W. course, S. E. lines being the exception.

Lake Temiscamang has 10 localities with S. E. striation. East Bay of this lake, Lon. 79° 30, seems to be about the point of divergence. Here the striation has a course S. 53° E. Beyond the lake the courses are S. W. This is one of the lakes of Ottawa river. The sources of the river lie to the north of it, nearer Hudson's Bay. Lake Nepissing, S. E. Bay, Lon. 79° 33 has striation course S. 35° W., and a westerly water course, so that the point of glacial divergence seems to be also that of water.

Last summer I had repeated opportunities of making a *reconnaissance* of the superficial and other geology of the region traversed by the Intercolonial Railway as far as Point Levis. I observed frequently boulders which doubtless were transported from the Archæan region north of the River St. Lawrence.

OTTAWA.

At Ottawa I made a closer examination of Archæan transportation when making acquaintance with the geology of the district. On the Rideau river, at the shooting range, I examined the large boulders lying around. The majority of these were gneisses, and foreign to Trenton limestone and Utica slate of the district. There were boulders of syenite, diorite, granite and syenitic gneisses. One syenitic gneiss boulder was replete with magnetite. Of these I secured Museum specimens. In Sir W. E. LOGAN'S table, there is reported striation at Barrack-hill,

having a course S. 45° E., and at Rideau river, Stegman's rapids, S. 45° E. I located and extended this striation course on VENNOR'S map, and found it to run between the Hull and LAYCOCK'S Iron Mines, situate in the Laurentian (Archæan) range to the north of Ottawa, where we might expect magnetite to exist in gneisses. In the same table there is striation noted at Hull, having also a course S. 45° E.

KINGSTON.

I had also an opportunity of making a *reconnaissance* of the Geology of Canada between Montreal and Kingston, and between Kingston and Ottawa. The Archæan, near Kingston, with the Trenton limestone directly overlying it, was a point of special interest observed. When preparing the Nova Scotia department at the Dominion exhibition, I observed numerous and massive Archæan boulders on and around the exhibition grounds. These very much resembled the Ottawa boulders, being granitic and syenitic gneisses, syenites, &c., transported from the Archæan region on the north. Specimens of these were also collected for the Museum. Among the boulders was a piece of Trenton limestone, beautifully glaciated. Of this I also secured a specimen. In my search for glaciation, I observed Trenton limestone, deeply furrowed, near the entrance to the Royal Military College. The course of the furrows was found to be S. 45° W. In Sir W. E. LOGAN'S table there is Kingston lat. 44° 14′, lon. 76° 29. Direction of grooves S. 45° W., other grooves S. 85° E. I observed the phenomena of glacial transportation to a distance of 3° short of the longitude of Lake Temiscamang. The longitude of Archæan transportation of Antigonish being 61° 53′; the field which I here traversed and found boulders by Archæan transportation is 14° 36′ from east to west. The great transportation lines of Nova Scotia extending N. W., reach Hudson's Bay at James' Bay, on the east side.

In my investigations I have thus added to the region of Canadian observers the Province of Nova Scotia, and given the great south-eastern transportation of North America an Atlantic terminus.

BOULDERS.

On New Year's day, Mr. NOLAN, whose name has already been mentioned in connection with Observatory Hill, H. M. Dockyard, showed me a boulder broken into four pieces, as something interesting. The boulder is of triassic amygdaloid. Its colour is gray, its amygdals are numerous; their minerals are heulandite and stilbite. It is altogether a striking specimen. The piece in my possession weighs $12\frac{3}{4}$ lbs. The weight of the whole seems to have been about 25 lbs. It has been an associate of Observatory Hill amygdaloid boulders referred to in a preceding paper. Its character is unmistakable. The North Mountain, Blomidon and Five Island rocks are the only series in British America that could produce it. The striation in the vicinity of the Dockyard points to Blomidon as the locality whence it came, I have already referred to rocks of Blomidon as similar to our boulder. I have no hesitation in affirming that this boulder and its associates have travelled over-land from Blomidon, a distance of 64 miles. While I believe this, I can excuse the incredulity of those who are not educated to appreciate the convincing nature of the evidence upon which my faith is founded. As I survey the present appearance of the way over which our boulder has travelled, its transit appears to be an evident impossibility. To prepare a way for its passage, we assume that there are heights, hollows and dead level, where in pre-glacial times there was necessary altitudes and more or less incline. To restore this state of things I made two postulates: 1st. That all the boulders and rock detritus which were carried from their original position and cast into the Atlantic, or scattered broadcast as we have found them over the length and breadth of the Province, should be restored to their pre-glacial position. 2nd. That the action of post glacial agencies should be annulled. We can then see in the visions of the past a great highway over which special agencies of speculative character advance, it may be slowly but surely, and irresistibly in a S. E. direction, accumulating freight in their progress and discharging it into the Atlantic. Then in process of time the same agencies

are seen in their alternate retreat, advance and retreat, unloading their freight, raising drift accumulations, and obstructing or destroying the great highway so as to render it impossible for any like agency to accomplish similar work. This is the condition in which we now find it, unless where the condition has been aggravated by the operations of agencies at work in post glacial times.

HISTORY OF THE PROBLEM.

In the summer of 1872, Judge (in Equity) JAMES showed me, in the Museum, a beautiful specimen of agate, which he found at Cow Bay. I recognized it at once as an agate from the Blomidon series of rocks, and said so. I thought no more about it. On the 24th of May the following year—the Queen's birthday—I went to Cow Bay with my late lamented friend—W. S. STIRLING, Esq., of Halifax, to spend a holiday. Wandering along the shore, my attention was attracted to the amygdaloid boulders washed by the sea. I recognized them as Blomidon rocks. Their occurrence here was perplexing, until abundance of like boulders and a beautiful specimen of agate, were seen and collected out of the lofty section of drift on the east side of the bay. Masses of quartzite, curiously furrowed, also fallen from the drift, suggested a connection with the striation of Point Pleasant. An interesting problem in glacial transportation thus presented itself for solution. I forthwith commenced investigations. I communicated two papers to the Institute containing the results of these investigations. One was read in December, 1875, and the other in March, 1876. At the request of my friend, Prof. LESLEY, the substance of these was communicated to the American Philosophical Society in May 16, 1876. The Paper was illustrated by a sketch map, and an extensive suit of boulders, derived from the various formations over which the transporting agent had passed. This collection, of which there is a list in my paper read to the Institute "On Nova Scotian Geology at the Centennial Exhibition of Philadelphia, 1876," was awarded a prize medal by the International Judges of Class I. Further investigations were recorded in my paper "On the

Geology of King's County." *Trans.* 1877–8. In my paper "On the Superficial Geology of Halifax and Colchester Counties," read last session, I recorded other investigations. In the present paper is a record of the last steps which I consider necessary for the solution of the problem. By going *beyond* Nova Scotia, I have done more than I expected to accomplish.

ART. V.—AN ANALYSIS OF A PICTOU COAL SEAM.

By EDWIN GILPIN, JR., A.M., F.G.S., M.R.S.C. *Inspector of Mines.*

(Read April 9, 1883.)

THROUGH the courtesy of Mr. H. A. BUDDEN, Vice-President of the Intercolonial Coal Mining Company, I am permitted to lay before you the following analysis of a seam of coal, recently opened by them at Westville, Pictou County. Through the kindness of Mr. ROBERT SIMPSON, General Manager of the Company, who furnished me with a complete column of the seam, I was enabled to make a very careful and exact measurement of the various layers comprising the seam.

The following is the section of the seam in inches and tenths of an inch, beginning at the top:—

	INCHES.		INCHES.
Coal, coarse and shaley	....	....	5·4
" good, with two thin layers of shale, each 1-20th of an inch thick	4·4	....	....
" good, but coarse	6·7	....	....
Shale	....	....	·2
"	....	....	1·7
Coal, good	6·3	....	....
" shaley, with nodules of iron pyrites.	·5	....	....
" good, with four bands of shale, up to one-half inch thick	1.4	....	....
Shale	....	....	6