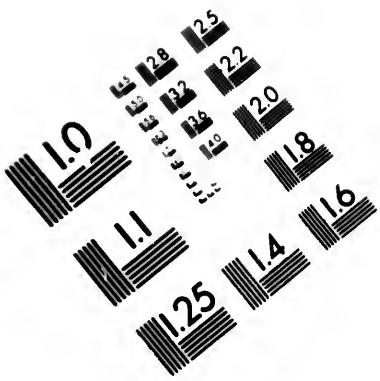

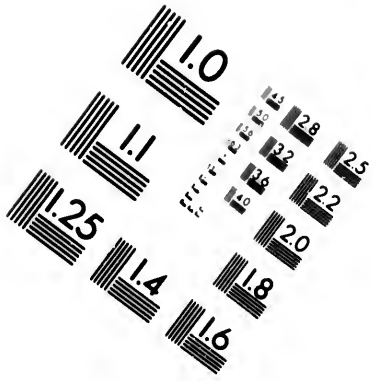

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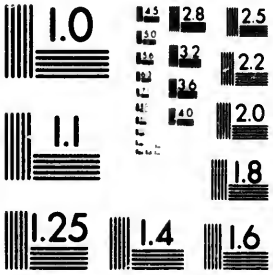

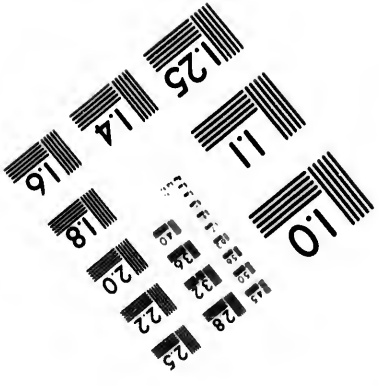

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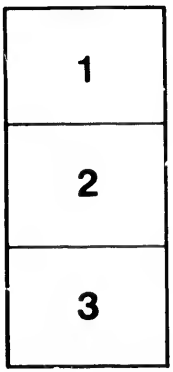
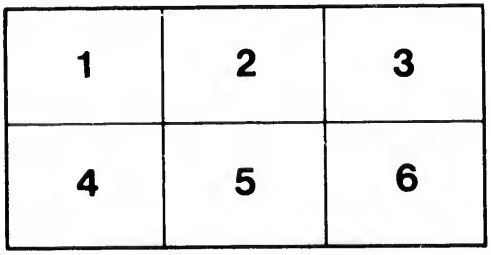




Some Nova Scotian Illustrations of Dynamical Geology.

BY PROF. L. W. BAILEY, Ph.D., LL. D.,
University of New Brunswick.

From the Transactions of the Nova Scotian Institute of Science, Vol. IX, Session 1895-96.

VIII.—Some Nova Scotian Illustrations of Dynamical Geology.

—By Prof. L. W. Bailey, Ph. D., LL. D., *University of New Brunswick.*

(Read 9th March, 1896.)

The following notes and accompanying photogravure plates are designed to present to students of the geology of Nova Scotia a few phenomena and results which seem to the writer sufficiently remarkable to deserve some special notice. The notes and pictures were all taken in connection with the work of the Geological Survey of Canada, and are reproduced here by the kind permission of the Director.

I. Sand Hills or Dunes of the Southern Coast.

At several points along the shores of Queen's and Shelburne Counties the attention of the traveller is attracted, even in mid-summer, by what appear, in the distance, to be great drifts of snow. Especially is this the case in driving along the post-road at the head of Port Mouton Harbor, whence, though at a distance of a mile or more, such drifts, in reality of blown sand, are readily seen, forming indeed a conspicuous feature of the landscape. They here occur upon the *west* side of the indentation named, stretching along the latter, though somewhat interruptedly, for nearly a mile, and attaining in places a height of thirty or forty feet. They conceal for the most part from view the underlying rocks, but these, as seen in several islands near by, are undoubtedly granitic, and such as, by their decomposition, might readily afford the pure white siliceous sand of which the dunes consist. This sand is almost wholly incoherent, and readily blown to and fro by the winds, while, near the water's edge, quicksands occasionally become a source of danger to the incautious traveller; but why so great an accumulation of such material should take place at this particular spot is not directly obvious.

The difficulty referred to, as to the location of the Port Mouton sand-hills, is enhanced when with these we compare the similar hills of blown sand which form portions of the shore of Barrington Bay. The accompanying Plates, VII and VIII, will give a good idea of these, as regards both the extent of the area they cover, the height to which in places they have been heaped up and the fact that they are still travelling inland, burying bushes and even forests as they go. I am without any exact measurements as to the area covered, but think that this cannot well be less than fifteen or twenty acres, while the height of the hills, which is greatest at the inner margin of the area, is probably not less than forty feet. It is said that a portion of the area, (which is on the lower part of Village-Dale,) was once occupied by a French village. However this may be, it is certain that the hills are gradually travelling inland, and that each year adds appreciably to their height as well as to their distance from the sea. In all these features they nearly resemble the sand hills of Port Mouton, but in two other important respects there is a noticeable difference. In the first place, while the dunes of the harbor last named are upon its *western* side, those of Barrington Bay are upon the *eastern* side of that indentation; and, secondly, while in the former instance the rocks at hand are granitic, and well adapted to yield the necessary material for these accumulations, the sand-drifts of Barrington Bay rest on beds of Cambrian slate and quartzite. It is true that there is abundance of granite at the head and upon the west side of this latter Bay, but this is several miles distant.

It is therefore again difficult to see what have been and are the special circumstances which have led to the production of such large deposits of such material at this particular spot. It is also difficult to see wherein either of these spots differs materially, either as regards exposure to the winds, nature of the rocks, or in other respects, from innumerable other localities along the shore, in which no trace of such deposits is to be found. Possibly further and closer study may remove the difficulties of explanation which now exist.

II. GLACIAL TROUGHS.

It is probable that most observers are familiar with glacial markings or striations, the scores left by the great ice-sheet of the Glacial Period in the course of its movement southward, and which are abundantly exhibited in the Park and elsewhere about the City of Halifax. But probably few, if any, have seen such a proof of the power of ice action to carve the surface over which it moves as is afforded in the photographic plate No. IX. This remarkable view was taken on Lockeport Island, within ten or fifteen minutes walk of the town of Lockeport. The rocks at the place are Cambrian slates and quartzites, the latter predominating, in beds 10 to 15 feet in thickness, and dipping south-easterly at an angle of about 50°. The trough, which is plainly shown in the picture, runs in the direction of the beds, and, no doubt, owes its origin in part to that fact, and to the unequal hardness of the two kinds of rocks which the strata contain; but even with all allowance for such favoring circumstances, the magnitude of the result is not only unusual but phenomenal. Not having any means of exact measurement at hand, the writer is unable to give precise data as to the dimensions of the trough, but is safe in saying that its length was at least 30 feet, its depth at centre at least 4 feet, and its breadth as much as 4 or 5 feet, the larger part being in massive quartzite. The form of the trough, as seen in the view, was in section not unlike that of a canoe, the sides curving gracefully down to the middle line, while, along the same sides and parallel with the axis of the trough, were numerous striations of the ordinary kind, also clearly seen in the photograph, and leaving no doubt as to the nature of the agent to which the trough itself is to be ascribed.

A trough of such magnitude, due to glacial erosion, is certainly a very unusual occurrence, at least in this part of the world; but, remarkable as it is, it in turn sinks into insignificance in comparison with some other troughs, due to the same agency, which were subsquently seen. These occur about midway between Port-la-Tour and Baccaro, on the coast of Shelburne County, and upon a small point, which is almost an island,

locally known as Crow's Neck Point. The rocks here are mica-schists, conspicuously studded with staurolitic crystals, as well as with irregular knobs or blotches, (some 6 x 3 or 4 inches in size,) which are in part at least half-formed crystals of andalusite. The rocks are massive but distinctly bedded, with a S. W. dip of 20°; and at right angles to this dip runs a trough or gully, similar in character and doubtless in origin also, to that of Lockeport Island described above, but in this instance *not less than 20 feet broad and 20 feet deep!* The sides, as before, curve regularly to the axis, and are everywhere smoothed and striated along lines parallel to the latter.

It is to be regretted that the writer, at the time of his visit to this locality, was unprovided with a camera. A view of this trough would, however, be less satisfactory than that of Lockeport Island, as in this instance the trough is in part occupied by a large boulder (possibly concerned in its origination), which somewhat obscures the prospect. Other troughs of less magnitude, but yet of unusual size, are found in the same neighbourhood.

III. ERRATICS, MORAINES, KAMES, ETC.

Nova Scotia presents, almost everywhere, abundant opportunities for the study of surface geology, more particularly as dependant upon the ice-movements and probable general glaciation of the Pleistocene Era; but nowhere are such opportunities more forcibly pressed upon one's attention than in the south-western counties. Some of the facts there exhibited have already been made the subject of comment by the writer, as well as by others, in the Proceedings of the Institute. It is not the intention of this paper to discuss them further here, but only to direct attention to a few localities in which they are especially noticeable.

Boulders.—Of boulder-strewn districts probably none is more remarkable than that of the tract lying to the north-west of Lake Rossignol in Queen's County, and along the county lines separating Digby County from Shelburne and Yarmouth. Here, over an extensive tract, including the so-called Blue Mountains,

boulders of granite completely hide from view the underlying ledges, and attain immense size. One, north of Pescowess, according to observations by Mr. W. H. Prest, was 35 feet in height above the debris in which it was imbedded, while another in the same vicinity, was 47 feet long, 22 feet wide, and 15 feet high, or 15,000 cubic feet, and would weigh over 1000 tons. Only those, who, like Mr. Prest, have traversed this district, can form any idea of the extreme difficulty involved in so doing, or of the wild, weird and indescribably desolate aspect which it everywhere presents.

A boulder of somewhat smaller dimensions, but still a giant, and one which is more accessible, occurs upon the Liverpool River, about four miles above Milton. It is composed of grey micaceous sandstone, with slaty layers, and is 30 feet long, 15 feet wide, and 20 feet high.

In the vicinity of Shelburne there are also many large boulders, particularly on the west side of the harbor, towards its head, where they have, in many instances, been the basis of the quarrying and stone-cutting operations carried on here.

Finally, on the west side of Petite Passage, between Digby Neck and Briar Island, and overlooking the village of Tiverton, is a very remarkable assemblage of detached blocks of rock. Like the beds on which they rest they are composed of trap, but in what way they acquired their present position and character is by no means obvious. They are of immense size, and both individually and in their grouping, exhibit features which border upon the grotesque. Were they at the base of a cliff they might well be the fragments detached from its brow and piled one upon another, but here they are at the top, not the base, of the cliff, and most numerous near its edge, where they stand like sentinels, 100 feet or more above the swirling waters which they overlook Are they the remains of a lateral moraine, formed in connection with a glacier which once traversed and perhaps made the Petite Passage? The occurrence of glacial striæ along this passage and *at the water's edge*, as seen at Israel Cove, lends some countenance to this supposition.

It is not probable, in any of the cases above cited, that the distance of boulder travel has been great, the rocks being similar in nature to those occurring *in situ* at points not widely removed. Of true *erratics*, or long distance boulders, the most noticeable, perhaps, was one of dark grey felsite-conglomerate, seen in Tiverton, near the middle of Petite Passage, and probably not more than 20 or 30 feet above the level of the tide. No rock of this character has yet been observed in south-western Nova Scotia, but it is common in southern New Brunswick, whence in all probability it was derived. Granite boulders were also observed in this vicinity, as well as on Briar Island, which may also have come across the Bay, though possibly derived from the granite of the Blue Mountains in Nova Scotia, some 40 miles distant. Boulders of the traps of Digby Neck are occasionally met with over all the south-western counties, even as far as the Atlantic shore.

Of ordinary terminal *Moraines*, the interior of Queen's, Shelburne, and Yarmouth Counties affords many examples, and to their presence and influence many features in the drainage of the country are no doubt due. The headwaters of the Port Medway, Liverpool, Jordan, and other rivers may be cited in illustration. In a similar way some of the islands off the coast, and particularly those which, in such large numbers, dot the surface of Tusket Inlet, are, in all probability, of morainic origin.

In addition to moraines, the peculiar accumulations known as *Kames* or "*Horse-backs*," are abundant in south-western Nova Scotia, and are, in some instances, of remarkable character. A ridge, which is probably of this nature, crosses the Liverpool and Annapolis road in the northern part of Maitland Settlement, whence it was followed by W. H. Prest in a direction E. or ENE., across the Maitland River to Gull Lake, and then northerly, by Gull Lake Stream, to the south of Perrot's Settlement, while in the opposite, or westerly direction, it was similarly followed, westerly or west by south, by way of Long Lake to Frozen Ocean, finally crossing into Digby County, south of the Sissaboo. A peculiarity in this case is that, while consisting, like other

kames, partly of sand and gravel, the main source of its materials, blue slate, would seem to have been derived from the south, not from the north, and from beds which are somewhat remote. The course of the ridge, across the general slope of the country and parallel with the coast, is also peculiar, suggesting a possible beach origin.

Other good examples of kames or gravel ridges are to be seen in Shelburne County, between Clyde Village and Port Clyde, and at the head of a long, narrow promontory separating Negro Harbor from Port la Tour. In each of these cases the ridges are several miles in length, somewhat tortuous in their course, but with a general southerly trend, are from 20 to 40 feet high, and usually just broad enough at top to afford room for a roadway, a use to which, in both of the instances given, they have been applied.

But by far the most remarkable of such ridges is the so-called "Boar's Back" of Digby County, the total length of which, though somewhat interrupted, cannot well be less than twenty miles. The best place for its examination (where also are the "moving stones" referred to in Lord Dunraven's account of his travels in Nova Scotia, regarded by him as inexplicable, but the result, probably, of the expansion of lake ice), is on the "Hectanooga Road" in Yarmouth County, a short distance north-west of where this joins the Weymouth Road, near Wentworth Lake.* As usual this kame consists of sand and gravel, with some imbedded boulders, and also, as usual, it is bordered on either side by extensive low and flat tracts, occupied mainly by bogs and barrens. In a few instances, as on the Jordan River, above Jordan Falls, the kames are found to bifurcate, or to enclose deep circular or oval depressions, forming "kettles."

IV. UPLIFTS AND DISLOCATIONS.

Marine and River Erosion.—No finer opportunity for the study of disturbed strata could readily be found than that afforded by the south coast of Nova Scotia. Almost every

* See Church's Map of Digby County.

variety of folding, and through a scale equally various, is here exhibited; while the outline of the coast, distinguished by long projecting tongues of land and intervening narrow valleys or fiords, affording natural sections, make their examination unusually easy and attractive. The erosive action of the sea, as modified by the unequal hardness and the varying altitude of the beds, together with the positions, equally various, of bedding planes, cleavage, joints and fault planes, is also strikingly exhibited. Upon the coasts of Queen's and Shelburne Counties the rocks are either Cambrian quartzites and slates, or granite, and the former are generally, though not always, titled at high angles, the result of orogenic movements of which the date has not as yet been definitely fixed. A characteristic example of such tilted beds is to be seen on Lockeport Island, not far from the point exhibiting the glacial furrows already described. The ledges here exposed are composed of quartzite, dipping 40° or 50°, while the parallel troughs by which they are separated correspond to the softer and more easily removed slaty beds. A feature of additional interest in the case of this quartzite ledge, is the fact that, notwithstanding the metamorphism of the quartzite, which glistens with scales of mica, its surface shows a number of unmistakeable impressions of what have elsewhere been described as fossils under the name of *Asteropolithon*. The real nature of these impressions, however, (which may be well studied in the quartize ledges on the summit of the hills overlooking Bedford Basin,) whether really organic or only imitative forms of concretionary origin, is still disputed. If of organic derivation, (and some of the markings seem inexplicable upon any other view,) they probably represent the burrows and the radiating trails of marine worms.

While the southern coasts owe their peculiarities largely to the general presence of Cambrian quartzites or of granite, those of Yarmouth and Digby illustrate, in an equally striking way, the results of upheaval and of marine erosion where the prevailing rocks are slates. The most remarkable exhibitions of the effects due to these two causes are to be found about Point Fourchu, (Yarmouth Harbor), in the vicinity of Chegoggin Point, thence

northward to Port Maitland, and again between Cape St. Mary and Meteghan. All along this coast the strata are thrown into a series of short folds, usually oblique to the coast line, and are broken by numerous faults. To the north of Cape St. Mary Light, the shore is especially high and bold, presenting an almost endless variety of craggy precipices, overhanging bluffs, caves and "stacks," the latter sometimes of grotesque outline. There is seldom any beach, or any safe means of ascent or descent, so that any examination of the section must be made by boat, and even this method is possible only in the calmest weather. The views afforded, however, and the instruction to be gained, are well worth some little risk.

Among other incidents of marine erosion may be mentioned here the occurrence of some noticeable "spouting horns" near the extremity of Western Head, near Lockeport.

Besides the examples of folded rocks and of erosion to be found along the coast are those afforded by the rivers and streams of the interior. Of these in Queen's County one of the best is that of the Port Medway; in Yarmouth County, the Tusket; and in Digby County, the Sissaboo or Weymouth River. The section afforded by the latter is especially interesting for its variety and completeness, and as affording a key to the structure of a large part of this county. So also are the sections afforded by the Grand Joggins, Bear River, Moore River, and Deep Creek, on the south side of Annapolis Basin, as well as by the several smaller creeks emptying into the same sheet of water. In a single railway cutting, near the mouth of Bear River, may be counted not less than fourteen small folds, and as many as six faults.

At the head of St. Mary's Bay, and adjoining the so-called "Sea Wall," is a fine example of a *monoclinal block*, the red sandstones, of probable Triassic age, here forming a series of very picturesque vertical bluffs, rising to a maximum of a hundred feet, with a regular but low inclination northward, and affording many curious instances of marine sculpture in comparatively soft beds.

V. JOINTS, CLEAVAGE, ETC.

The divisional planes referred to above are of such common occurrence in regions of metamorphic or partly metamorphic rocks, such as form so large a part of Nova Scotia, as hardly to deserve notice here. And yet their recognition and distinction from each other and from planes of bedding is one of the most serious practical difficulties to be encountered by the field geologist, especially in the study of the Cambrian rocks of the southern coast. The quartzites of this system abound in joint planes, often causing them to divide into prismatic blocks, while the slates of the same system have in general a strongly pronounced cleavage structure. Both may be, and often are, much more pronounced than the bedding planes, so that strata which are really level-lying, or in low undulations, may present the appearance of being highly inclined. Such a condition of things is especially prominent over much of the country north of Caledonia in Queen's County, where, were it not for the fact that the rocks are strongly banded or ribbanded with somewhat strongly contrasted colors, indicating the true planes of deposition, mistakes might very readily be made as to their true position. Portions of the coast south-east of Lunenburg, where similar strongly ribbanded beds occur, afford other illustrations of the same fact.

Besides the joints which characterize the massive quartzites of the Cambrian, or the granite by which the latter is invaded, it is proper to notice here the similar divisional planes found in the traps of Digby Neck, Briar Island, &c. Some of the columns thereby determined are illustrated in Plate v. (Part 1 of the present volume of the Transactions,) as seen at Israel Cove on the Petite Passage, and others much more remarkable occur along the south side of Briar Island.

VI. METAMORPHISM.

Almost every stage of the metamorphic process may be well studied along the coasts of the south-western counties. The quartzites, as might be expected, show the least evidence of

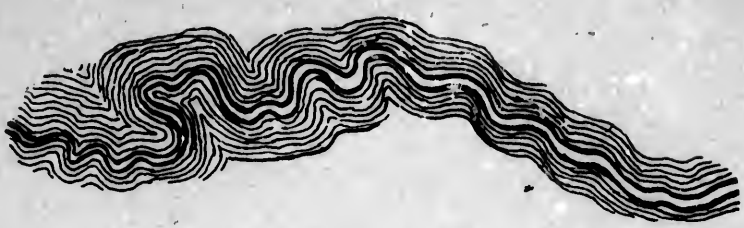
change, the effect in their case being usually confined to greatly increased hardness and compactness, or to the development in the mass of mica scales and metallic sulphurets; but among the finer beds, now mica schists, the alteration is often much more extreme, the mica being not only far more conspicuous, but accompanied, often over large areas, by multitudes of staurolites and small garnets, as well as andalusites. The staurolites are often quite perfect and readily separable from the matrix, but the andalusites are rarely well formed or differentiated, shading into the associated rock, while they are themselves indefinitely penetrated by mica, garnet, and staurolite crystals. The best localities for the collection of staurolites are the vicinity of Jordan Falls, and the west side of Shelburne Harbor, in the village of Carleton, while both these and andalusites may be found in large numbers about Baccaro, on St. Anne's Point, in Pubnico, and about Brazil Lake and Lake Annis in Yarmouth County. The garnets observed upon the coast, though numerous and usually quite clear, were all small, while those of the interior, along the borders of the granite, while considerably larger, were generally dull. A somewhat remarkable example of this latter class is to be seen in the fields half a mile east of Brazil Station on the Dominion Atlantic R. R. in Yarmouth, the schistose rock having its surface thickly covered with projecting crystals of this mineral from the size of a pea up to a diameter of an inch or more. Rocks of very similar character occur about the shores of Lake George, and again upon the coast at Chegoggin Point. Near an old quartz mill in this vicinity is an 18 foot belt of garnetiferous schist, having cross veins of pure garnets mingled with hornblende and menacoanite. Along the same belt of metamorphic strata (between Yarmouth Harbor and Lake Wentworth) the rocks frequently contain scattered sheafs of hornblende, and in places become a nearly pure hornblende rock.

Quite a different type of metamorphism is to be found along the northern side of the great central granite tract in Digby and Annapolis Counties. Here the stratified rocks which adjoin the granite are of much more recent origin than those described

above, being of Devonian age, and in places filled with the characteristic fossils of that formation. The best opportunities for their study are to be found along the line of the Nova Scotia Central R. R., between Alpina and Nictaux Stations, (this interval being almost continuously occupied by rock cuttings, usually fossiliferous,) the east branch of Bear River, (a mile and a half above the head of the tide,) and in Mistake Settlement, between North and South Range, in Digby County. The strata include iron ores in addition to slates and sandstones, and the former as well as the latter carry organic remains. Near the granite the rocks assume more or less fully the character of gneisses, while the iron ores, elsewhere hematites, have become, in part at least, converted into magnetites. The fossils often show also the distortions due to the pressure they have undergone.

VII. VEINS, CONTACT PHENOMENA, ETC.

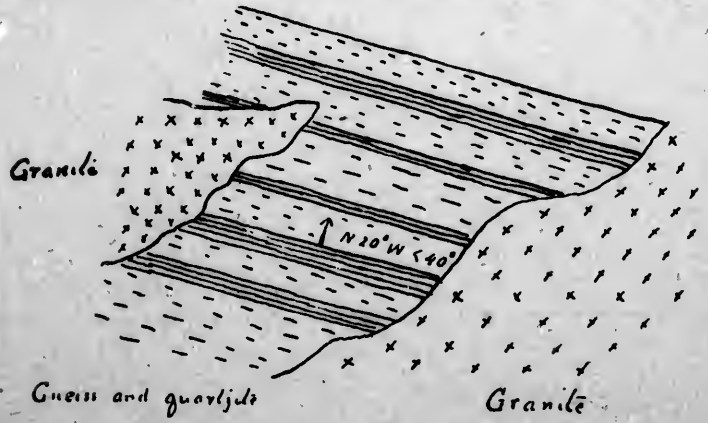
Space will not allow of any lengthy reference here to the quartz veins of the Cambrian system. Nor is this necessary, as their character and relations with the associated strata have been so fully described by earlier writers in connection with the development of the gold mines of which they form the basis. It will be sufficient, in illustration of their occasional magnitude, to refer to two instances only; the first, that of the "Jumbo Mine," in Westfield, Queen's County, with a width, though not wholly of pure quartz, of over sixty feet, while the second is that on which was located the stamp mill, referred to above, at Chegoggin Point, and which is about 26 paces across, of pure milk-white quartz. At this latter locality may also be seen an interesting example of *slickensiding*, the pure milk-white quartz of which the vein consists being divided by a vertical fissure or fault plane, of which one wall to an unknown depth has, by the friction accompanying the fault, been polished to the smoothness and brilliancy of a mirror. These large veins are, however, less auriferous than those of smaller size.



QUARTZ VEIN IN LAMINATED SLATES.

A singular instance of a very narrow but tortuous vein seen upon the shore about Eagle Head Breakwater, east of Liverpool Harbor, is here reproduced. The contortions are in exact correspondence with the corrugations of the enclosing strata.

Another type of veins of much interest is where these latter consist of granite, and, with other contact phenomena, finds abundant illustration at many different points along the borders of the principal granitic masses. A striking example of such a granite vein or dyke of large proportions may be seen on the shore opposite Coffin's Island, near the eastern head of Liverpool Harbor. The beds exposed here are chiefly gneisses, quartzites, and mica schists, of the Cambrian system, and have a very regular northward dip of 40°. Across these beds, however, and almost at right angles, run heavy masses of coarse white weathering granite, the dip and strike of the strata being apparently wholly unaffected thereby. (See Fig.) In the same



GRANITIC INTRUSION IN CAMBRIAN STRATA, BERLIN, QUEEN'S COUNTY.

vicinity a mass of granite, 20 or 30 feet wide, may be seen enclosed between tilted beds of quartzite and running for 100 yards or more in perfect conformity with the latter, then suddenly terminating. On the other hand on the Shelburne River, where crossed by the post road, may be seen a good illustration of the intricate blending of the granitic and schistose masses commonly met with along their lines of contact. Regularly stratified beds are, as before, abruptly cut off across their line of strike, long irregular tongues of granite invade the associated strata, and what look like detached blocks of the latter are sometimes completely enclosed by granite.

In the section on the Nictau River, already referred to, and just north of Alpina Station, is a good opportunity of studying the intrusion of granitic masses among Devonian strata, showing both the exotic origin of the granite and the period of its extrusion.

In connection with the granitic masses, both small and large, occur numerous veins in which the constituent minerals of granite, viz., quartz, felspar and mica, have been segregated out on a larger scale, affording fair specimens of each. A good illustration of such segregated veins may be seen at the western head of Liverpool Harbor, at the Government Breakwater, where, in addition to good specimens of felspar, may be found sheafs of pale yellowish plumose mica. In some instances these veins carry tourmaline and garnet as well as mica.

Still a third type of veins, abundantly illustrated in the region under review, is found in connection with the traps of Digby Neck. Like the veins in the Cambrian rocks, first described, these are usually silicious, but whereas the former are of pure milky quartz, with accompaniments of metallic sulphurets and gold, the latter are as generally highly colored and banded, including all varieties of agate, jasper, chalcedony, &c., as well as amethyst, while the associated minerals are calcite, zeolites of many varieties, together with oxides of iron (hematite, martite, magnetite). Simple veins of agate and jasper, from one quarter of an inch to a foot in diameter, may be seen almost anywhere

along the Bay of Fundy shore of Digby Neck, but are especially numerous and finely colored in the hills overlooking the Petite Passage, about Tiverton. Veins of iron ore occur three miles from Digby on the road to Broad Cove, at Johnston's mine, in Waterford, at Mink Cove, and elsewhere, while at Nichol's mine, in Rossway, are to be seen particularly interesting combinations or associations of all the minerals named above. A peculiar brownish white unctuous or soapy clay is another abundant and interesting accompaniment of the veins at this locality, filling the fissures of the rock in all directions and causing it to be locally known as a soap mine.

Veins of pure zeolites occur in various parts of Digby Neck, but less frequently than those of quartz or iron ore. *Thompsonite* is the one of most frequent occurrence, and is especially abundant on the Bay of Fundy shore at Broad Cove, seven miles from Digby, and again near Gulliver's Cove.

Veins of native copper may be seen on the eastern side of Digby Gut, near the entrance.

DRIFT SAND HILLS, BARRINGTON BAY, N. S

Illustrating Prof. Bailey's Paper: "*On Illustrations of Dynamical Geology.*"

INNER SLOPE OF DRIFT SAND HILLS, BARRINGTON BAY, N. S.

Illustrating Prof. Bailey's Paper: "*On Illustrations of Dynamical Geology.*"

GLACIAL TROUGH IN TILTED CAMBRIAN QUARTZITES, LOCKEPORT ISLAND, N. S.

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