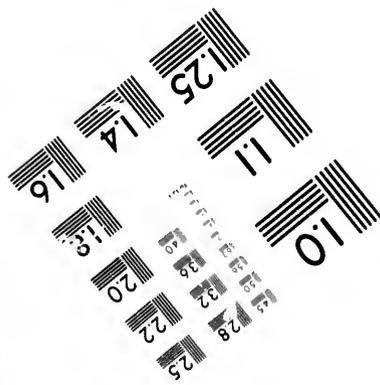
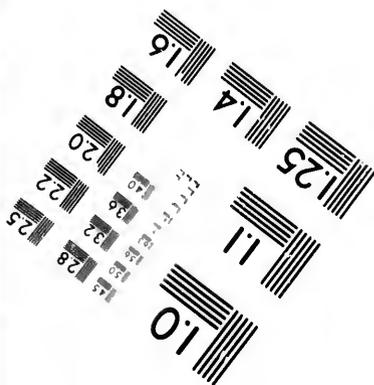
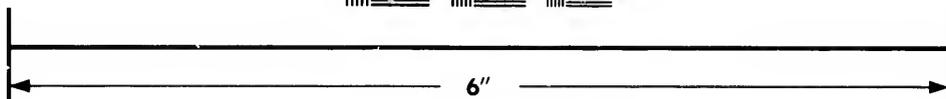
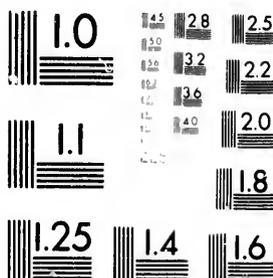


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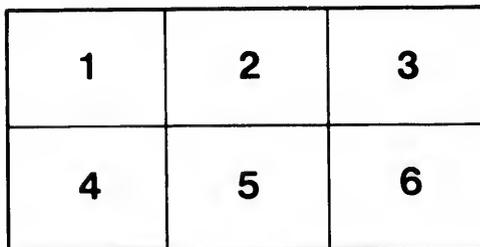
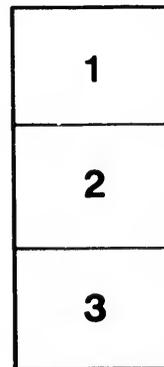
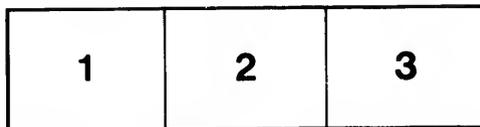
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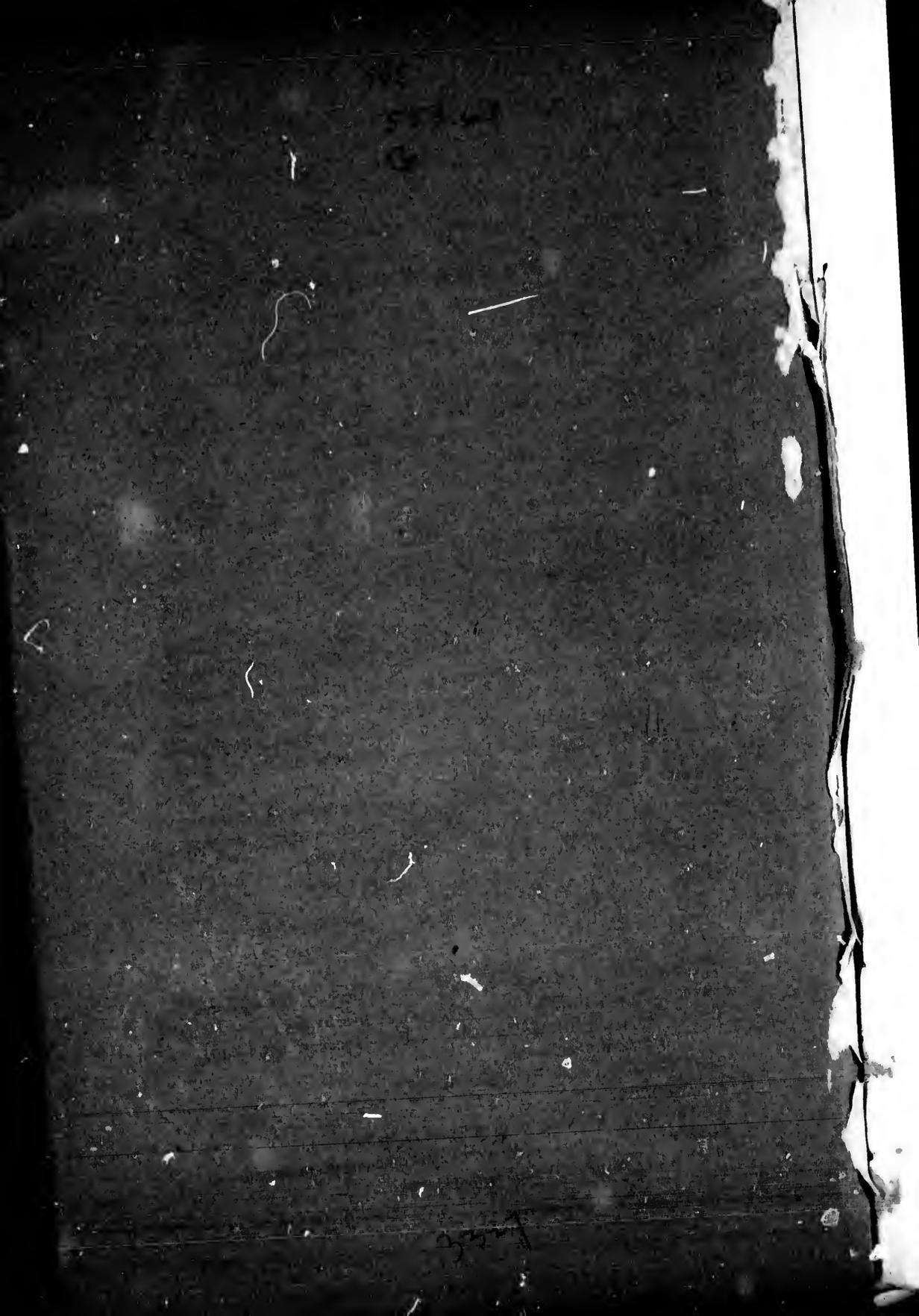
THE
GYPSUM OF NOVA SCOTIA.

By EDWIN GILPIN, A.M., F.G.S., INSPECTOR OF MINES.

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THE GYPSUM OF NOVA SCOTIA.

BY EDWIN GILPIN, A.M., F.G.S., INSPECTOR OF MINES.

THE writer ventures to lay before the Institute the following remarks on the gypsum found in the Maritime Provinces of Canada, gathered from his own notes as well as from the experience of others.

The beds of this mineral attain in these provinces, the Acadia of the early writers, dimensions which arrest the attention of the geologist and traveller. It contributes an important item to the little list of mineral exports, and with its associated limestones and marls, gives to large districts of Nova Scotia a fertility seldom surpassed in the northern part of the temperate zone.

Rising in cliffs from fifty to one hundred and fifty feet in height, it looks down on the mud-laden tides of the Bay of Fundy, and the blue waters of the Gulf of St. Lawrence, or forms a striking feature on the beautiful Bras d'Or Lake, a little inland sea, "running away into lovely bays and lagoons, leaving slender tongues of land and picturesque islands, and bringing into the recesses of the land the flavour of salt and the fishes and molluscs of the briny sea."

The traveller meets it surrounded by dense growths of spruce and hemlock shadowing some quiet pond in the woods, or standing like some ruined castle of marble on the side of a fertile river valley.

AGE OF THE GYPSUM.

So far as the writer is aware, the gypsum deposits of Nova Scotia are the largest and most extensive in the world, and the only ones occurring in measures of the Carboniferous age.

Dr. Dawson in his classical work on "Acadian Geology" has separated the Carboniferous of the Maritime Provinces into five divisions:—

- 1.—The upper, or Permo-Carboniferous Coal-Measures, not holding beds of workable coal.
- 2.—The true or productive Coal-Measures.
- 3.—The Millstone Grit.
- 4.—The marine limestone or gypsiferous formation.
- 5.—The lower, or false Coal-Measures, holding many characteristic coal fossils, but destitute of workable beds.

They follow no regular order, but it is frequently observed that the gypsum rests in the beds of marl, in other cases it rests on beds of dark limestone, alternating with beds of gypsum and anhydrite.

The limestones and shales are characterised chiefly by numerous brachiopods, especially *Productus corni*, *Athyris subtilita*, and *Terebratula sufflata*, with other marine invertebrates.*

The limestones present every shade of composition, varying from arenaceous and argillaceous to the almost chemically pure mineral, according to the varied modes and conditions of its deposition. The thickness of the beds varies from 6 inches to 50 feet; the greatest continuous section being about 300 feet. These limestones are very free from magnesia as a general rule. Out of twenty limestones from this formation in Pictou county, that the writer has analysed, but two contained notable percentages of this mineral, viz., 10 and 10.5 per cent. as carbonate of magnesia, the average percentage being 2.5. Dr. How, of King's College, Windsor, mentioned finding considerable traces of magnesia in a gypsum deposit of that locality, and in one instance a large percentage in a limestone contiguous to gypsum, but other limestones in this district are very free from magnesia. The writer finds no mention of magnesian limestones occurring in any other Nova Scotia district, except a memorandum, perhaps not altogether reliable, of a bed one foot thick met in a chisel borehole made in Antigonish county some years ago. Three limestones associated with gypsum, near Mabou, in Cape Breton, gave but traces of magnesia on qualitative examination. Two limestones, however, presented by Mr. Fletcher, of the Canadian Geological Survey, from the vicinity of the gypsum beds of Judique, Cape Breton, gave 15 and 21 per cent. of magnesia carbonate. In other parts of the island, according to Mr. Fletcher, the limestones are non-magnesian.

The marls are, so far as the writer has had opportunities of observing them, made up of a siliceous or argillaceous base with limestone, gypsum, bituminous and carbonaceous matter in various proportions. They are frequently penetrated by veins and nodules of gypsum and limestone and in some cases hold the fossils characterising the formation.

The sandstones are of the usual gray and reddish colours, generally much broken by slaty cleavage. The conglomerates are composed largely of the older rocks, and in some cases hold pebbles of the preceding beds of the same formation. In many places they show marks of metamorphism, and occasionally are united by ferruginous cements, which, through weathering, have formed deposits of bog ore.

* Dawson's "Acadian Geology."

THICKNESS OF THE LOWER CARBONIFEROUS MARINE
LIMESTONES.

The thickness of this formation varies in the different districts. In Cumberland county, Sir W. Logan estimated the thickness of the upper part at 1,658 feet; adding the lower members, there would be a total thickness of about 2,500 feet.

In Pictou county no complete sections have been measured, and the passage to the Millstone Grit is obscure; the writer is inclined, however, to consider it as somewhat greater than in Cumberland county, and ventures to approximate it at 3,000 feet.

In the Eastern parts of Cape Breton the officers of the Geological Survey, have, as the result of a careful and systematic survey, been enabled to estimate its thickness at 4,637 feet. In these dimensions they have included the great beds of conglomerate lying at the base of the formation, part of which may belong to, or be an equivalent of, Dr. Dawson's lowest or fifth division.

In Western Newfoundland, Mr. A. Murray, the chief of the Geological Survey of that Island, estimates the thickness of the Lower Carboniferous marine formation at 2,150 feet, not including 1,300 feet of coarse conglomerate, corresponding to that found at the same horizon in Eastern Cape Breton.

HORIZON OF THE GYPSUM.

The gypsum occurs in this great volume of measures, so far as is at present known, at no fixed horizon. In the vicinity of Hillsboro, in New Brunswick, Mr. G. Matthews states that the gypsum occurs with regularly stratified bituminous limestones and marls directly overlaid by the Millstone Grit. In this district, he marks the occurrence of a series of limestones lower down in the measures, which do not appear to be gypsiferous. In Cumberland county it occurs about the middle of the series. In Pictou county it is found in the lower part of the formation, and frequently only a few yards from the Silurian strata, but does not form as prominent a feature as in many other districts.

The researches of Mr. Fletcher in Cape Breton have shown that in Sydney Harbour, it occurs a few feet below the Millstone Grit, and that on Boularderie Island, the base of the Boisdale and St. Anne's Hills, it occupies the same position, being "overlaid almost immediately by the gray sandstones of the Millstone Grit, containing characteristic fossils." About the Strait of Canso and near Baddeck, it occurs low down in the Carboniferous Limestone.

On the western shore of Cape Breton, at Mabou and Broad Cove it is found quite close to the coal beds, but this is evidently caused by faulting, and affords no key to its proper position in the limestone formation. A similar association occurs in the sections of the Little River coal-field of Richmond county.

In Newfoundland, Mr. Murray (Report of Progress, 1873, p. 15), places the leading exposures of gypsum in the lower part of the limestone formation, division B, and states that they are underlaid by over 1,000 feet of conglomerates corresponding to those already mentioned as occurring at the base of the Sydney Carboniferous. The associated strata are similar to those found in Cape Breton; the limestones being in many cases crowded with characteristic fossils. At a higher horizon, a short interval below measures which represent the Millstone Grit of Cape Breton, Mr. Murray found smaller deposits of gypsum associated with magnesian limestones, marls, and calcareous or dolomitic sandstones.

VARIETIES OF THE GYPSUM.

The gypsum in this great series of deposits presents every variety of colour and state of aggregation, and a corresponding difference in its composition.

On the Tobique river, in New Brunswick, it may be characterised as an impure earthy gypsum of a red and greenish colour seamed with layers of pure white and crystalline gypsum, and holding nodules of limestone in the red coloured portions.

At Hillsboro it forms generally a pure white snowy alabaster; other portions are cream-coloured, or with a shade of blue, and are translucent. At the works of the Albert Manufacturing Company there is a quarry face composed of the last-mentioned varieties, 400 feet long and from 25 to 75 feet high. Selenite, though met in veins and small crystals, is rare. The anhydrite occurs here in beds underlying the gypsum, and is of unknown dimensions.

At Sussex, New Brunswick, selenite occurs as single and grouped crystals containing symmetrically disseminated sand, and the process of formation seems to be still going on.

In the Windsor district, three ranges of gypsum are worked, the most northerly of which runs in an almost unbroken line to Maitland, 30 miles distant. From the quarry in the town of Windsor, considerably over a million of tons have been extracted, and the deposit shows no signs of exhaustion. Here the gypsum is white and blue with large quantities of selenite; in some quarries small beds of limestone and anhydrite are found in the gypsum. At some points in the district large deposits of

The anhydrite occurs in fibrous, lamellar, granular, and impalpable masses of irregular form, and as orthorhombic crystals.

The following analyses show generally the composition of the gypsum and anhydrite found in these provinces, the state of aggregation being due rather to the forces and modes of its deposition than to any decided change in composition by mixture of foreign bodies:—

GYPSUM.	SO ₃	CaO	H ₂ O	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃
Granular white ...	44·16	33·83	21·30	...	...	...
Fibrous „ ...	45·51	32·10	20·96	3·21	...	...
Compact „ ...	45·76	31·87	19·90	2·80	}·60	
Compact red ...	46·50	31·99	21·56	...	}·45	

ANHYDRITE.	SO ₃	CaO	H ₂ O	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃
Crystalline ...	55·80	40·68	2·91	·23	}·25	
Coarse ...	56·77	41·40	·94	·26	}·03	
Fine ...	58·01	40·21	·65	·09	}...	

MINERALS ASSOCIATED WITH THE GYPSUM.

Among the more common may be mentioned Glauber salt, common salt, calcespar, magnesia carbonate, and arragonite. The writer has also observed carbonate of iron, limonite, and in one instance a few crystals of silica, and at Cheverie inspissated bitumen. Sulphur also occurs in small quantity in the gypsum of Wentworth, near Windsor, as crystals associated with the mineral ulexite to be noticed below. Mr. H. Louis, in a paper on "Additions to the Mineralogy of Nova Scotia," read before the Nova Scotia Institute of Natural Science, mentioned finding crystals of sulphur in a quantity of soft grayish gypsum, near Truro. The quantity present, being small, was not considered of economic value.

Brine springs issue from many points in the Lower Carboniferous of Nova Scotia, and from some of them salt of good quality has been manufactured to a small extent. These springs are frequently in the vicinity of the gypsum deposits, but do not appear, as a rule, to be immediately connected with them. The presence of these springs suggests the possibility of beds of salt being found intercalated in these measures. Their detection would be a very valuable discovery in a country which is so largely engaged in fishing, but no explorations have ever been made for the purpose of settling the question. When the extensive denudations of the Nova Scotia marine limestones, and the changes of level incidental to the great thickness of succeeding measures are considered, it is to be

feared that ancient systems of drainage have dissolved out these deposits, if they ever existed. But the matter can be settled only by proper boring explorations, similar to those which disclosed the valuable salt beds of Goderich, Ontario.

The late Dr. How made, some years ago, an interesting discovery of compounds of borax in the gypsum and anhydrite of Windsor.

These minerals occur in crystals and nodules up to two inches in diameter and in some cases form a considerable percentage of the rock. The nodules are sometimes pearly white, compact, and hard; in other specimens they are made up of acicular tufts of prismatic crystals, colourless and transparent.

The following table shows the composition of these interesting minerals, and also of another discovered by the same gentleman. The latter appears to have been produced by alteration of the ulexite by selenite, as it occurs partly and completely replaced by the selenite, retaining the same nodular form :—

Component Parts.	Natroboro Calcite. Ulexite (Dana).	Cryptomorphite.	Silicoboro Calcite. Howlite (Dana).	Wentworthite.
Water	34.49	19.72	11.84	18.00
Lime	14.20	15.50	28.69	31.14
Sulphuric acid ... ..	...	...	...	31.51
Silicic " ... ..	...	...	15.25	4.98
Boracic "	44.10	59.10	42.22	14.37
Soda	14.20	5.68	...	...
	<u>106.99</u>	<u>100.00</u>	<u>98.00</u>	<u>100.00</u>

The ulexite is a very pure form of the Peruvian boratetiza, which the writer believes is found only in these two countries. It has been largely exported from Peru into the United States for the manufacture of borax, and for glazing operations. Should these Nova Scotia deposits be found to occur in quantities of economic importance, they would form a valuable article of export, and materially aid the output of the associated gypsum.

ORIGIN OF THE GYPSUM.

It is a comparatively easy task to account for the origin and mode of formation of most of the sedimentary non-metamorphosed rocks. But among the short list of those whose history is not quite understood must be placed Gypsum.

Several theories have been advanced to account for its presence in the geological sequence; none of these, however, are applicable to every condition of its occurrence.

Dr. T. S. Hunt, in the report of the Geological Survey of Canada, 1857-58, gives a detailed account of some interesting experiments made with a view of throwing light on the formation of Canadian dolomites. From these experiments, which may be considered an extension and modification of the researches of Haidinger and Mitscherlich in this connexion, he deduces the following views. First, that in lakes or sea basins not having an outlet, the mutual decomposition of bicarbonate of lime and sulphate of magnesia gives rise to carbonate of magnesia and sulphate of lime, which are successively deposited on concentration; explaining the constant association of magnesian rocks with stratified gypsum. Secondly, that in sea basins the action of waters containing bicarbonate of soda causes the separation of the lime as carbonate, and the formation of a very soluble bicarbonate of magnesia, also deposited on evaporation. This mixture when heated under pressure, readily forms the double carbonate constituting dolomite.

This theory offers a means of accounting for the origin of the gypsum of Ontario, thus described by Sir W. Logan, "Geology of Canada, 1863:"—In the Onondaga, Upper Silurian, measures of Ontario, between the Niagara and Grand rivers, gypsum occurs as lenticular masses, varying in horizontal diameter, from a few yards to a quarter of a mile, and from three to seven feet in thickness. The strata above them are crushed and broken, while those beneath form a level floor. These deposits are associated with dolomites and marls, and at Goderich, Ontario, with beds of salt up to 60 feet in thickness. At various points in this formation there are springs yielding from three to four thousandths of free sulphuric acid; but Sir William Logan affirms the gypsum to have been contemporaneous with the strata, and to be unconnected with the acid springs of the present day: and also illustrates the origin of the magnesian portion of the Newfoundland Lower Carboniferous.

It does not, however, apply to the gypsiferous measures of the Lower Provinces. These deposits as already described, occur as regular beds, of enormous size, accompanied by measures abounding with the remains of a vigorous marine fauna, and essentially non-magnesian. To meet these differences of condition, Dr. Dawson, in his "Acadian Geology," has proposed to account for their formation in the following manner:—

That volcanoes in the Pre-Carboniferous rocks, surrounding the ocean

in which the marine limestones were forming, poured out rivers of sulphuric acid which, flowing into the sea, changed the limestone into gypsum: the lessened acidity of the waters, and the deposition of detritus in some cases, allowing part of the gypsum to be mixed with the limestones and marls, and at other points causing the total conversion of the limestone.

There are some objections to this view, among which may be mentioned the following:—The older rocks now present no traces of the origin or action of the acid, nor do the marls, sandstones, and shales associate with the gypsum, and it is evident that they must have occasionally also been subjected to its action. It may be questioned how long a stream of sulphuric acid would remain sufficiently undiluted to allow of an uninterrupted action producing such enormous masses of the mineral, and it is evident that over so vast an area the whole mass of water could not have been acidulated to any degree.

Dr. Dawson quotes the cases of several volcanoes of the present day giving rise to sulphuric acid and forming gypsum by acting on beds of limestone, but they appear trifling and local when compared with the extent of the effect now under consideration, and are moreover sub-aërial.

When the great extent of the Acadian gypsiferous formation is considered, it will almost appear that the two theories noticed above can have acted only in isolated cases. The anomalous character of these deposits and their associates opens a new field to the chemical geologist. The writer is not aware of any other theories that have been advanced to account for this abnormal local development of gypsum. There are, however, two agencies that may have assisted in their formation.

Springs containing carbonate of lime and sulphate of magnesia, and holding free carbonic acid would form sulphate of lime, which, when escaping at the sea bottom and partially relieved from pressure, would lose carbonic acid and deposit sulphate of lime. Similarly, springs holding sulphuretted hydrogen, passing into water holding carbonate of lime and free carbonic acid, will gradually form sulphate of lime in both fresh and salt water.

Some of the Iceland gypsum is apparently deposited in the latter manner, and the gypsums of Nova Scotia are in some instances connected with springs yielding small percentages of sulphuretted hydrogen. Such springs, when rising in comparatively undisturbed waters, would gradually form large masses of gypsum of great purity. When, however, currents prevailed, particles of the gypsum would be carried to one side and form gypseous marls, and become mixed with the limestones.

This force is perhaps justly considered unequal to the effects now seen, but it must be remembered that it was synchronous with the slow growth of the limestone beds of that period, and great masses of limestone composed entirely of shells as at Windsor, Brookfield, Shubenacadie, and other places, and that the springs issuing on lines of pre-existing fractures would become shifted by the dynamic changes of pressure of accumulating strata, and gradually traverse considerable areas.

This apparently insignificant power may thus have produced effects similar to the fall of the leaf, which has preserved to our use masses of vegetable matter now compressed into beds sometimes 30 to 40 feet in thickness.

These deposits, however formed, were gradually buried by the succeeding sediments, and under heat and pressure probably became anhydrous. In the march of time, when the strata were again exposed to the weathering of the atmosphere, water, etc., the anhydrite once more became hydrated.

This would appear from crystals of anhydrite occurring with their edges converted into gypsum, and from the lenticular masses of anhydrite embedded in the gypsum. This is also confirmed by the action of anhydrite from a deep boring at Goderich, Ontario, which, when placed in fresh or salt water at ordinary temperatures, rapidly became hydrated. Silliman found that the gypsum of the East River of Picton, like that of South Virginia, contained one atom of water to two of sulphate of lime, and gave the following analysis:—

Sulphuric acid	...	...	...	...	...	54.7
Lime	...	...	...	...	...	39.4
Water	...	...	...	...	...	5.9
						<u>100.0</u>

This compound may illustrate the transition stage. The writer believes the gypsum forming marine boiler incrustations sometimes presents a similar composition.

The veins and irregular masses of gypsum and selenite found in the associated limestones and marls, and in the triassic sandstones, and occurring as films and plates in the coal seams, are probably a later deposit from aqueous solutions.

The broken and dislocated appearance of the strata immediately surrounding the gypsum was formerly considered a proof of their intrusive origin, and is now generally considered to be due to the expansion caused by absorption of water by the gypsum. This disturbance of the

strata may perhaps be more readily explained by the action of water which has dissolved or worn away portions of the gypsum, and allowed the shales, etc., to occupy the cavities thus formed. The gypsum frequently presents deep funnel-shaped holes, which contain water, and on examination yield bones of deer and other animals.

The hydration of the gypsum a short distance below the surface would be a comparatively slow operation, even now not completed at its outcrop, and the expansion would be spent more in binding the strata than in its fracture.

APPLICATION OF THE GYPSUM.

The uses to which gypsum is put are so much the same in every country that a detailed list would merely express the information already possessed by the members. The soft blue and white varieties are largely exported, to be ground for agricultural purposes. It is considered in the Southern States to be a valuable adjunct to the growth of cotton and tobacco. It is also much used as a top dressing, in the Northern States and the Provinces of Quebec and Ontario.

In Nova Scotia itself certain districts have been well served with this enricher in a remarkable manner. In the Bay of Fundy, which separates Nova Scotia and New Brunswick, the tides rise to a height of from 40 to 60 feet, and from the rapidity of their movements exert a powerfully erosive effect on every stratum exposed to their action.

Great part of the Lower Carboniferous marine limestone formation of Nova Scotia is penetrated by it, or drained by its tributaries; thus large quantities of the limestone, gypsum, and marl have been denuded and re-arranged in large meadows covering many thousand acres. These have been protected from inundation by large dykes, and present a soil of unsurpassed fertility. Constant additions are being made to these meadows by the unceasing denudation.

In addition to this, its dissemination, together with limestone and clay through the overlying soils, have rendered large districts in Cumberland, Pictou, Hants, and Antigonish, and parts of Cape Breton, capable of producing, when efficiently worked, more than average crops of the more common grains and roots.

The compact white gypsum and selenite is used for finishing walls, for cornices, etc. No more suitable place than Nova Scotia could be selected for the manufacture of those cements into which gypsum enters, as the mineral is cheap and of every grade of quality.

There are numerous gypsum mills scattered through Canada, and a rapidly increasing amount, which cannot be readily ascertained, is annually ground for domestic use. A large mill at Hillsboro, New Brunswick, has been working for a number of years on the deposits of that locality, already mentioned as being of the greatest purity.

The principles involved in the manufacture of gypsum are so well known, that the chief interest centres in the comparison of cost. At this establishment, a forty-five horse-power engine furnishes the power necessary for driving the stones, revolving pans, making barrels, etc. Four cauldrons are used, each holding 18,000 lbs.; in the course of a day each boiler will yield three charges. At present this mill is working at only one-fifth of its capacity. From what information the writer has been able to acquire, the cost of the calcined gypsum is about 3s. per barrel of 300 lbs., barrel and paper lining included. This price would of course be materially reduced were the mill working up to its capacity.

The cost of quarrying the gypsum varies from 1s. 5d. to 2s. 6d. per ton; the selling price on board varies from 3s. 6d. to 4s. 9d., including a short haulage, interest, etc.

The mineral is all held in fee simple, and pays no royalty to the government, and is so abundant, that, as yet, operations have been confined to the outcrops of the beds nearest to the available shipping points. This, of course, materially reduces its price, and the capital charges of the quarry owners.

The vessels employed in carrying the gypsum to the neighbouring ports of the United States, are of small burden: up to 400 tons. When shipping from the Bay of Fundy ports, they sail up with the flood tide, and lie in the soft mud at the wharves when the tide falls; thus, alternately afloat and aground, they receive their cargoes.

The term "inexhaustible" is seldom applicable to the treasures of the earth, as they appear in any one district; but it may be justly enough applied to those deposits as developed in Nova Scotia. The extent of the trade, which, although considerable, falls far short of the facilities nature has offered for its prosecution, may be gathered from the following

STATISTICS.

The town of Windsor may be considered the head-quarters of the gypsum trade, as three-fifths of the total amount shipped is raised in the surrounding quarries. The total amount shipped from Windsor since 1833, is about 2,544,376 tons, of 2,240 lbs., valued at about 2,200,000 dollars.

The following table will show the average volume of the total export of the province, during the last twenty-five years:—

Year.	Tons.	Value. Dollars.
1855	95,301	80,875
1860	105,431	85,936
1865	56,155	45,088
1870	98,050	75,650
1873	120,693	120,693

In 1877, year ending June 30, Canada exported 101,376 tons, valued at 96,175 dollars; of which Nova Scotia exported 96,440 tons, valued at 89,488 dollars. In 1878, Canada exported 100,134 tons; of which Nova Scotia exported 94,607 tons, valued at 85,049 dollars. In 1879, Nova Scotia exported 95,126 tons, valued at 74,923 dollars.

The total exports from Nova Scotia since 1854, are about 2,300,000 tons, valued at about 1,900,000 dollars.

Very little ground gypsum is exported from Nova Scotia, but about 5,000 tons, or 20,000 dollars worth, is annually exported from New Brunswick to the United States. The imports of raw and manufactured gypsum into the western parts of Canada, from the United States, amount to an annual value of about 10,000 dollars.

The United States do not impose any duty on raw gypsum, but the ground or calcined article is subjected to 20 per cent. duty, which is practically prohibitive. There is no duty on foreign gypsum coming into Canada except when ground, then the duty is 20 per cent.; or when calcined, in which case it pays 15 cents per hundred pounds.

From the Provincial census of 1861 it would appear that 75,387 tons were quarried for domestic use. The Dominion census of 1871, gives only the quantity exported, viz., 96,544 tons. It may, however, be assumed that the quantity used for domestic purposes has not decreased. This would make the total quantity quarried in Nova Scotia, in 1879, about 150,000 tons. Mr. Hunt gives the quantity raised in England, in 1878, at 74,908 tons, valued at £22,472.

The writer thinks that the foregoing, necessarily imperfect, account of an important Canadian mineral may prove of interest, and that, if of no other value, it may indicate where unlimited quantities of a valuable agricultural material can be procured, should at any time the progress of invention and discovery allow its introduction into England.

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