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ON NATURAL PHOSPHATES.

By J. Lainson Wills, F.C.S.

(*Delivered 12th March, 1892.*)

When your President and Treasurer did me the honour to request me to read a paper on "Phosphates" before the Ottawa Field-Naturalists' Club, I hesitated in complying.

"Phosphates" in a general way, as we employ the word in this locality, implies the crystallized Mineral Apatite, so abundant in certain parts of our Laurentian formation. The good work done by the Geological Survey, has from time to time, through its officers, kept us well informed of the localities and peculiarities of the occurence of the Canadian Apatite, by valuable contributions form the pens of Sir Wm. Logan, Sterry Hunt, Vennor, Dr. Geo. Dawson, Torrance, Dr. Robert Bell and others. At the present time, I understand that Mr. Ingall also, who has been in charge of a special study of onr Canadian Apatite fields, is about to terminate and publish his preliminary report, so with deference to his opportunities and approaching publication, I could not presume to undertake a paper purely on Canadian Phosphates or Apatites as was proposed, but thought it might be acceptable to our members here, to give their attention to a more extended and general consideration of natural mineral Phosphates, and hence the title of my paper this evening, instead of being "Canadian Apatite" is "Natural Phosphates" in a general way. My present occupation prevents me from giving much time and study to the preparation of this work, but if by some generalization of facts, we can awaken a healthy discussion and exchange of ideas, my humble attempt will not have been useless.

Natural phosphates owe their commercial value to the proportion of phosphoric element contained in them, and are employed as raw material for the manufacture of phosphatic fertilizers, being also sometimes applied in the natural and raw state direct to the soil by the farmer. They are also in demand for the manufacture of phosphorus, baking powders and some other chemical products. By far the greatest demand for them, however, is made by the manure manufacturers for agricultural requirements, and this demand is yearly increasing at a very rapid rate. The occurence of natural phosphates presents the most varied and interesting modes of formation, as may be surmised by finding their deposits, not only in nearly every geological system, but in many different series of the same system.

Now in beds which may-be, have a fresh water or marine origin, now appearing as hardened conglomerate or rocks, and sometimes as sand and loose gravel: then again in vein formation or pockets, sometimes amorphous, at other time crystallized.

In the matter of texture, colour and other physical characters, we find the same endless variation.

The origin of the demand for these phoshatized products is comparatively of recent date. It was only in the commencement of the present century that crushed bones were employed as a fertilizer in agriculture, and strange to say, only then on occount of the gelatine or organic matter they might contain.

The following curious statement which appeared in a scientific journai in the year 1830, *a propos* of the employment of crushed bones in England, exposed the ignorance on the subject at that day and reads as follows:—"As to earthy matter or phosphate of lime contained in the bones, we may disregard it. It is insoluble and indestructible, and *cannot serve as a manure*, even in damp soil, and in immediate contact with the rootlets of the plant."

The suggestion of Liebig, to treat the bones with sulphuric acid, opened a new era, to the utilisation of phosphatic materials in agriculture and the manufacture of artificial manure was soon established.

The illustrious Elie de Beaumont thus expressed himself with regard to the commencement of the mining of mineral phosphates. *"Colbert has said that France would be lost for want of forests, and everyone perceives that without coal his prediction would soon be accomplished. In his day, one would have failed to comprehend how a great country might disappear."

NATURAL PHOSPHATIC DEPOSITS.

These valuable provisions of nature are the result of various causes and agencies familiar to the geological observer and their contained

*Jean Baptiste Colbert, born 1619, Minister of Finance to Louis XIV.

phosphoric acid is mostly due to animal life; and when we say "due" to animal life we wish to imply that animal life is the assimilating and concentrative medium of pre-existing phosphoric acid: whether as sea and fresh-water shells, as fish and animal bones, as excreta of birds and saurians, etc., animal organisms have been from the beginning of life and still are, the silent but mighty laboratory of nature, never resting to collect and store up the dispersed molecules of phosphoric acid. Among such are the guano beds of recent epochs, coprolite deposits, bone beds, shell beds, etc.

Nature's operations of bringing these materials or their debris together to form whole geological areas are equally varied, but the estuaries and depressions of the sea-bottoms of the different and respective geological periods, are recognized to have been the receptacles or storehouses of these wonderful supplies. A curious disposition to concretionary action, displayed by nuclei of certain organisms to absorb and accumulate phosphatic matter, with which the ancient seas abounded, is more easily seen in its effects than explained.

Such is the origin of many odd species of nodules, some varieties of which exist in immense quantities.

The abrupt or imperceptible, but never ceasing operations of geological rearrangement, follow the afore mentioned accumulations, and we then have new forms of mineralized phosphatic matter, giving rise to conglomerates, breccias, phosphatic limestone, shells and marls, sandy and ablation deposits, etc., and most of the known natural deposits of mineralized phosphate display examples of two or more of these products. For instance, the perplexities experienced just now with some of the exploratory workings of the lately discovered Florida deposits, are chiefly occasioned by the character of these beds containing boulders, and nodules from pea size to masses of several hundred pounds in weight, fish bones, sharks' teeth and fossil bones, in fact *debris* from several geological epochs, each of these materials naturally varying in purity, and therefore also in commercial value, so that the more successful enterprises may be looked for where regular and homogenous deposits occur, or some cheap and efficient mechanical means are applied for the separation of the marketable products from the less valuable or worthless intermixtures.

The classification of natural phosphates of lime is, as remarked by Dr. Penrose in Bulletin No. 46 of the U. S. Geological Survey, "a matter attended with many difficulties, not only on account of the great variety of forms in which phosphate of lime occurs, but also because many varieties blend into one another, thus often rendering it uncertain to which class a special deposit should be referred," and he adopts the following classification, based mainly on the chemical composition of the deposits, and grouped under the headings thus :—

Mineral Phosphates	Apatites	Fluor-Apatites
	Phosphorites	Chlor-Apatites
Rock Phosphates	Amorphous nodules	Loose nodules.
		Cemented (conglomerates)
	Phosphoric limestone beds	
	Guanos	Soluble guanos
		Leached guanos
	Bone beds.	

We shall recognise as we proceed with the study of the various phosphatic deposits, formed during the different geologic periods, that by far the greater part owe their origin to animal or organic remains, and we shall see that as soon as the organic compounds of a guano, for example, are dissipated and resolved into their elements, we may consider that the residual products, to all intents and purposes, revert to the mineral state, in accordance with the familiar expression " earth to earth."

We pass over, for the present, the guano of various localities, which however will be observed to lie mostly within 10 to 20 degrees of the equator.

We should remember, however, that this product has attained its zenith, both as to quality and quantity, and must cede its commercial importance ultimately to the mineral resources of phosphoric acid, which are before us for our more particular consideration.

We shall find the diagram on the wall which shows the approximate geological position or age of the different phosphate deposits, very useful to our present purpose, and we will commence with the more recently formed or mineralized products.

OCCURENCE OF NATURAL PHOSPHATES IN THE GEOLOGICAL EPOCHS.

Post-tertiary or Quarternary System.

True guanos.
Crust or "leached" guanos.
West Indian and Pacific Phosphates.

Tertiary System.

West Indian Rock Phosphates.
Nassau or Lahn nodular concretions.
Suffolk Coprolites in the Red Crag and Coralline Crag. (Reposing on the Lower Eocene)
S. Carolina beds, resting upon Eocene.
Deposition of Florida phosphate debris and organic remains.
N. Carolina overlying Eocene marl.
Fundamental rock of Florida Phosphate deposits.
Clays and *debris* of Bordeaux Phosphates.

Cretaceous System.

Belgian (Liege) Hesbaye nodules.
American Alabama amorphous nodules.
New Jersey marls
Belgian (Mons) Ciply nodules (Maestricht beds).
Somme deposits, arenaceous and nodules.
Russian "Samorod" nodules Desna-Don.
Cambridgeshire and Bedfordshire Coprolites.
French nodules of Ardennes, Meuse.
" " Montpellier and Bellegrade.

Oolitic or Jurassic System.

Bordeaux Phosphorites and nodules overlain by Tertiary (Eocene) clays and *debris.*
Algerian Phosphates.

Triassic System.

Highly phosphatic beds (between Trias and below Lias) containing exuviæ of huge reptiles as well as remains of fish and crustaceans.

Permian System.

(Appearance of reptilia.)

Carboniferous System.

(Appearance of Amphibia.)

Devonian or Old Red Sandstone.

Hignly phosphatic beds in conjunction with Lower Carboniferous.
Highly phosphatised beds in Shropshire, containing oldest known remains of vertebrate life associated with crustaceans.

Silurian System.

(Appearance of vertebrata)
Welsh Bala beds. Berwyn Phosphate mine.
Lingula flags (Quebec) 40% tribasic.
Angers slates (France).
Phosphate limestone of Kentucky.
Logrosan (Spain) Phosphorities (Apatites ?)
Caceres (Spain) "
Portugal "

Cambrian System.

(Appearance of Protozoa, Mollusca, Annuloida, and Crustacea.)

Laurentian System.

Canadian Apatite.
Norwegian Apatite.

Thus at the present time, we have Mineral phosphates of lime in process of formation, and principally known in commerce as "Crust guano".

Looking at the chemical composition of average Bird guano, we find it to be composed of the following constituents:—

Moisture	15.8
Organic matter and Ammoniacal Salts	52.5
Phosphates of lime	19.5
Phosphates of Iron and Alumina	3.1
Alkaline Salts	7.6
Silica and Sand	1.5

This typical analysis is from the average of 15 samples, made by Nesbit on the Chinchas Inland Guano.

An elementary knowledge of chemistry will assist us to perceive hat a large proportion of the above constituents will be leached out by water, or dissipated by prolonged exposure to ordinary atmospheric influences, especially when we remember that the organic matter above mentioned comprises uric, oxalic and phosphoric salts of alkalies and ammonia, and even about one third of the phosphates of lime is found to be soluble in water. Given a deposit of guano on a limestone soil or rock, and it is readily perceived that every shower will contribute to the steady but continual process of the transmutation of the carbonate of lime into phosphate of lime, in consequence of the discharge of the weaker carbonic a . by the stronger phosphoric acid.

The exhausted guano then becomes phosphatic in distinction to being nitrogenous and ammoniacal ("leached"), and the subjacent limestone undergoes a metamorphosis by a double decomposition, into phosphate of lime. If the absorbing limestone is pure, the phosphate of lime formed thereby will be correspondingly pure; and on the other hand, if the calcareous base is intermixed with clay or sand or ferruginous material, the newly formed product will contain alumina, silica, oxide of iron, etc., in like proportions.

Such has been the undoubted origin of the deposits of Aruba Rock phosphate, samples of which are on the table, and which are typical of this kind of metamorphosis and will serve to illustrate many similarly formed deposits, notably those of Curaçao, Sombrera, Navassa and Redondo (in which latter case the subsoil must have been aluminous, since the mineral is a phosphate of alumina).

In some cases the phosphatic principle may have been derived from animal *debris*, such as bones.

The composition of animal bones varies somewhat, according to the animal furnishing them, and even with the particular part of the same animal, but the following analysis, expressed in 100 parts, may be taken as an average :—

	Green Bones.	Bone Ash.
Moisture Organic matter	33· (gelatine)	
Phosphate of lime	56	70·75%
Phosphate of Magnesia	3	
Carbonate of Calcium	3	
Alkaline Salts	4	
Silica		

The bones of birds are even richer in phosphoric acid than those of animals, but bones of amphibia and fish contain less than those of birds and animals.

Amongst other animal organisms rich in phosphoric acid or phosphate of lime may be mentioned certain shell fish, or rather their shell remains, notably the shells of *Lingula* and *Orbicula*, which consist for the greater part of phosphate of lime, and are found in accumulated beds in the Lower Silurian rocks, being thus described by Sir Wm. Logan (Geology of Canada, 1863):

Those coming from the Chazy formation at Alumette Island, left after calcination 61 % of fixed residue, consisting of:

Phosphate of lime	85 7
Carbonate of lime	11 7
Magnesia	2 6
	100 0

and analysis of the original material gave as follows:—

	Alumette.	Hawkesbury.	R. Ouelle.
Phosphate of lime	36.38	44.70	40.34
Carbonate of lime and some fluorine	5.00	6.60	5.14
Carbonate of Magnesia		4.76	9.70
Oxide of Iron and Alumina	7.02	8.60	12.62
Magnesia			
Insoluble	49.90	27.90	25 .4
Volatile by heat	1.70	5.00	2.13
	100.00	97.56	95.37

We here observe an average of 40% of phosphate of lime. It would appear that our knowledge of the proportion of phosphatic element in similiar animal remains is very imperfect, so that upon further investigations, we may expect to meet with many other similar accumulated supplies of phosphoric acid.

Some authorities attribute a large portion of the phosphate of lime in the Charleston fields to such molluscs and principally *Lingula pyramidata*, which are found abundantly on the present coast.

CLASSIFICATION OF NATURAL PHOSPHATES.

I prefer for all practical purposes and from rational observation to modify the classification proposed by Dr. Penrose, thus:—

Apatites	Fluor-Apatites. Chlor-Apatites.
Mineral and Rock Phosphates	Phosphorites. Nodules, Coprolites. Concretions. Conglomerates. Phosphatic Limestone. Phosphatic Marls. Crust Guanos.

Guanos	Nitrogenous. Phosphatic, or "leached." Bat Guano.
Animal remains	Bone beds. Shell beds. Animal exuviæ.

We will now proceed to trace in a cursory way the commercially known deposits, commencing with the most recent, and passing stratigraphically in descending order to the more ancient formations.

GUANOS.

Guanos are of two kinds—Nitrogenous or those containing their original manurial qualities, and phosphatic or "leached," the latter being in a more or less mineralized condition by exposure to weathering.

Among the Nitrogenous guanos, we have the Peruvian, Ichaboe, Patagonian and Falkland Islands.

The phosphatic or weathered guanos include those of the Pacific or Polynesian Islands, Sidney, Phœnix, Starbruck, Baker, Howland, Jarvis, Enderbury, Malden, Lacepede and Arbrohlos Islands.

Some of these deposits are more or less exhausted, and new Islands furnishing similar products are from time to time worked.

The West Indian guanos are from Aves, Mona, Tortola.

Other South American are Patos Islands, Mejillones, Rata.

From Africa, Saldanta Bay and Kuria Muria Islands.

Bat Guano, the product from the floors of caverns inhabited by bats, have sometimes been sent to market as a rich fertilizer. It is found notably in Cuba (W. I.) and in N. Borneo. It possesses a characteristic dark brown colour and exhibits the undigested parts of beetles wings and insect *debris*.

BONE BEDS.

These are found in nearly all sedimentary strata, from the Devonian up to the present time, but with the appearance of those remarkable reptilia in the Permian age, we find that these kinds of phosphatic provisions of nature took enormous developments, augmenting the resources previously furnished by the amphibia of the Carboniferous epoch.

Bone beds, however, in their original state have furnished little to commercial supplies of phosphatic products, except those found in the Tertiary and Quarternary ages, such as Bordeaux, Carolina, Florida and Sombrero (breccia).

SHELL BEDS.

Since these must have existed from a time well into the Paleozoic periods, or that is to say, from the Cambrian age, we may expect and do find these mollusca remains, through a wide range of systems and strata and up to recent times.

The Silurian Lingula beds are remarkable, and have been already particularized as a probable abundant source of phosphoric acid.

The Welsh Silurian beds, and the French Bellegarde and Ardennes deposits in the lower Green-sand (Cretaceous), exhibit evidence of this origin, while the Tertiary and Quaternary phosphates contain very frequently these marine and fluvatile remains as a contribution to their value in phosphate of lime.

Some very interesting specimens are on the table from the Dutch West Indies, containing from 75 to 80% of tribasic phosphate of lime, and exhibiting in some cases, one mass of shells belonging to recent times.

COPROLITES.

Owe their name to Professor Henslow, and should be applied only to the fossil exuviæ of animals. The appelation has extended itself to many rolled or gravelly products, chiefly found in the Cretaceous formation. In England they have been worked to a large extent in Bedfordshire and Cambridgeshire, where they appear in the (Neocomian) strata, between the chalk and the subjacent Jurassic system, in nodules and pebbles of size from a pea to a hen's egg, and sometimes cemented by ferruginous sand into a hard conglomerate; organic remains are present, and casts and fragments of fossils with abundance of ammonites, vegetable remains and other debris of the Jurassic epoch, (*Iguanodon* and *Megalosaurus*, etc.).

The commercial products contain from 45 to 55% phosphate of lime.

The Coprolites of Suffolk occur in the Tertiary, being in the older Pliocene (the Red Crag and Coralline Crag). They are poorer in phosphate of lime, more ferruginous and harder in texture.

France also possesses some deposits of this character at Bellegarde, near the Swiss frontier, and also at Montpellier and Avignon, yielding 54% tribasic phosphate of lime.

NODULAR, CONCRETIONARY AND ARENACEOUS PHOSPHATES.

These by far the most important of nature's phosphatic reserves, comprising as they do, the South Carolina deposits, the French deposits of the Somme, Ardennes and Meuse, the Belgian fields of Mons and those more lately opened up at Liege (Hesbaye). The so-called "Bordeaux Phosphates," because being formerly shipped from that port, but having their real origin in the region of Quercy, comprising portions of the departments of the Lot, Tarn and Garonne and Aveyron, also furnish a considerable quantity of nodular or phosphatic concretions of kidney shape of great purity (88%), and curious geological interest. These are well represented by specimens on the table, and coming from the crevices in the Oolitic limestones, accompanied by *debris* of Tertiary age (Eocene), the walls of the crevices or fissures being at the same time incrusted with phosphorite of a high degree of purity attaining 80% of tribasic phosphate of lime.

We must not omit here the Florida nodular beds of land and river formation, which are now enjoying such a glorious boom.

As a peculiarity of this Bordeaux phosphorite, we may mention that it contains a very appreciable proportion of iodine.

The Russian deposits, situated between the Rivers Desna and Don, occur in the Cretaceous system, at about the same horizon as the Cambridgeshire coprolites and may be described as nodular.

The Nassau or Lahn concretions in clay are of Tertiary age, and although not exhibiting signs of organic remains are generally believed to be of animal origin, they attain 60 to 75% phosphate of lime, but too ferruginous to be much in request for superphosphate manufacture.

The Belgian (Ciply) deposits, which have furnished over 150,000 tons per annum of a 40 to 50% product, are of a nodular character, although the grains are often so fine as to be considered more correctly arenaceous.

The same may be said of the very remarkable French deposits, discovered near Amiens in 1886, and known as the Somme phosphates.

These are granular or arenaceous, and to this feature as well as to their richness (65-80%) may be attributed the enormous development which they have enjoyed in such a short period, attaining the annual productien of 200,000 tons.

CONGLOMERATES AND BRECCIAS.

Phosphatic beds may also assume these characters, sometimes with the cementing material as the phosphatic element, and at others with the enclosed pebbles or angular fragments as the valuable portion for commercial supplies.

Thus the Cambridgeshire coprolite fields furnish a conglomerate of phosphatic pebbles, cemented by ferruginous sand, while in the Ardennes district (France), is found a peculiar agglomeration of granules of chlorite in a phosphatic cement, the whole yielding 40 to 45% phosphate of lime.

The Belgian (Cipley) deposits yield abundant supplies of a mass of phosphatic nodules, shells casts and fossils, cemented in a calcareous matrix, to utilize which, has puzzled the ingenuity of many an "*exploitant.*"

PHOSPHATIC LIMESTONE AND MARLS.

Are found in most strata from the Silurian epoch down to more recent time.

The metamorphosis or transmutation of earthy carbonates into phosphates, is a very simple and comparatively rapid process, and the evidence of Dr. R. Ledoux in the following description is instructive. He says in a recent article on Phosphates:—"Some clients of mine sent a ship to a coral island in the Southern Pacific to bring away a cargo of bird guano. The birds were still in countless thousands. The captain had been there for a load 20 years before, and since that time no guano had been removed. At his first visit the crew had cleaned off a space and made a house of coral rock, covering it with a sail and had used it for a shelter and storehouse while at work. On leaving, the sail was taken away and the walls and board floor left. On the return, 20 years after, there was an average depth of 20 inches over the floor—an inch a year. The underlying limestone was altered into Phosphate for a depth of several feet, but the conversion of carbonate into phosphate gradually became less perfect as depth from surface was attained."

I have observed the same effect myself taking place in the West Indies, where the surface of the coral rock is speedily converted into phosphate of lime, wherever the seabirds are in the habit of congregating.

Such indeed is the simple origin of some of the most important deposits of phosphate in that portion of the world : i. e., Curacao, Sombrero and Aruba, etc.

The prospecting and first development of the latter named island having fallen to my own care and experience, I am able to produce some interesting specimens here, illustrating very clearly the history of their formation, by examination of their fossil organisms, originally carbonate of lime (coral rock), and now seen to be, by analysis, phosphate of lime of over 80%.

The deposits of Florida and South Carolina would appear to owe much of their phosphatic wealth to *debris* of phosphatized limestones and marls.

One of nature's operations, which is a factor in enriching already-formed phosphate beds, may be here alluded to, namely, the property of spring waters (which often contain considerable proportions of bicarbonates and free carbonic acid) to disolve neutral carbonate of lime, even when presented to them in apparently as the most compact and impervious material. Such has been the origin of the many remarkable caves existing in the limestone rock formations (Cheddar, Derby, Kentucky, etc.)

This property applied to a calcareous phosphated material will, in course of time, ablate, as it were, more carbonate than phosphate, and to this action is attributed the value of many thousand tons of material, in such extensive beds as those of the Somme, Ciply, Liege, and probably of Florida.

While speaking of these beds of the Cretaceous period, I may mention the recent opening up of another similar field in France. I refer to that in the department of the Pas de Calais, which would appear to be of the same nature as that of the Somme.

APATITES.

Although crystallized phosphate of lime is found as a component of rock masses in more recent strata, yet we do not yet know of any workable deposits of this mineral before passing to the oldest of fossil iferous systems, the Laurentian.

The rocks of this formation are among the most ancient on the North American continent and probably correspond to the oldest gneiss of Scandanavia. The modes of occurence are so varied in the Canadian Apatite field, that the subject would require to be treated by itself in order to do it justice here.

We are all here familiar with how it is found, both in Ontario and Quebec provinces.

Dr. Hunt thus describes in 1884, the main features of its mode of occurence: "The deposits of Apatite are in part bedded or interstratified in the pyroxenic rock of the region, and in part are true veins of posterior origin. The gneissic rock with their interstratified quartoze and pyroxenic layers, and an included band of crystalline limestone, have a general northeast and southwest strike, and are much folded, exhibiting pretty symmetrical anticlinals and synclinals, in which the strata are seen to dip at various angles, sometimes as low as 25 degrees or 30 degrees, but more often approaching the vertical. The bedded deposits of apatite, which are found running and dipping with these, I am disposed to look upon as true beds, deposited at the same time with the enclosing rocks. The veins, on the contrary, cut across all these strata, and in some noticeable instances, include broken angular masses of the enclosing rocks. They are for the most part, nearly at right angles to the strike of the strata, and generally vertical, though to both of these conditions there are exceptions. One vein, which had yielded many hundred tons of apatite, I found to intersect, in a nearly horizontal attitude, vertical strata of gneiss, and in rare cases what appear, from their structure and composition to be veins, are found coinciding in dip and in strike with the enclosing strata."

The apatites of Norway are known since 1854, and occur on the southern coast in similar rocks to our own (Canadian), and many of the associated minerals are similar to those observed in the Laurentian rocks, the vein matter differing chiefly in freedom from carbonate of lime.

Rutile may be mentioned as an exception, which in some mines is so abundant as to form a considerable revenue to a working mine, since it is worth 1/6d. per lb., say $800 per ton. These are fluor-apatites, although they contain also some chlorine.

Continental geologists (Brogger and Rensch) who have studied these formations, have supposed them to be of eruptive origin, in consequence of the absence of phosphoric acid in the surrounding rocks, but the question seems to be most doubtful, as well here as in the case of the same opinion held on the Canadian Apatite deposits.

THE SITUATION OF CANADIAN PHOSPHATE TRADE.

Although this Canadian industry has not progressed on the same scale as many other phosphate fields, Somme, Cipley, Liege, Carolina and Florida, yet there are some facts offering an explanation for this. The peculiarity of the occurence of the mineral in vein-like formation in hard rock, calls for a scientific and economic system of mining, which has been little applied to the development of our deposits, and the cost of production is thereby more considerable than that attained in other fields of supply.

Certain centres of manure manufacture still require our high testing products to complete their standard types of concentrated supers, and the rapidly increasing demand for fertilizers by all the civilized world, both the new and the old, will tend to maintain a fair value for natural phosphates. We are getting into the era in which steam does not work fast enough, and on every hand we are seeking to accomplish our ends by electricity with lightning speed. Someone has said that the man who could made two blades of grass grow where one grew before, was a benefactor to his race, but the rush a d the struggle for existence imposes that every cultivator shall be a benefactor in this regard, and carry on agricultural science at the highest possible tension for his very existence.

With increasing populations, with better means of transport, and lastly but not least, advanced scientific education, fertilizers and all other artificial means of stimulating our exhausted soils will continue to be in increasing demand.

We see no reason therefore to suppose that the mineral-phosphate Industry or phosphate mining has attained its zenith, and so far as we can see at present, the future demands of the world for phosphoric acid are destined to increase with time and agricultural progress.

RÉSUMÉ.

We may shortly generalize the foregoing facts and observations.

Of the sixty four elementary substances at present known to compose the material of our original globe, phosphorus is found to be among the twenty more abundant elements, and is recognized to have been widely disseminated in all the original and ancient rock masses. With the exception of the segregations of crystallized Apatite in the Laurentian rocks, we do not find any marked local accumulation of phosphatic bases in any of the azoic formations, or intrusive rocks.

The existence of the Eozoon Canadense is still debatable, and it is problematical whether the apatite of these older metamorphosed strata is not the mineralized product of organic remains, but passing from the Laurentian epoch to the succeeding and less altered rocks we are immediately in presence of abundant evidence of organized life, and cannot fail to remark how much more frequent are the accumulations of phosphatic beds.

The function of organized life to assimilate and concentrate the disseminated phosphoric element is strikingly apparent. The natural forces which are ever restless and continual in building up the varied geological strata of succeeding epochs (attrition, deposition, cementation, ablation, etc.) may alter and vary the manner of presentation of the phosphatic deposits which we have been considering, but the silently working power of assimilation by the organized cell, would appear to triumph over the mighty disruptive and more violent operations of nature, for the latter forces fail to re-disseminate the work accomplished by the former, but rather complete the task required to secure to man the providential supplies of phosphatic deposits with which we may satisfy our present demands, and therefore these economic supplies are seen to be chiefly in the more recent geological formations.

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ANNUAL REPORT OF THE COUNCIL FOR 1891-1892.

To the Members of the Ottawa Field-Naturalists' Club:

LADIES AND GENTLEMEN,—In presenting the customary annual report your Council has pleasure in stating that the progress of the work during the fourteenth year (which by the unscientific and superstitious might be considered an unlucky period) has been satisfactory, and that the present condition of the Club is very encouraging.

The membership continues in the vicinity of three hundred, which may be considered a verv large membership for a purely scientific society

Unforeseen difficulties prevented the Excursion Committee from completing the arrangements for some of the proposed excursions, so that these popular outings were not so numerous as in former years. Two very successful ones were, however, held; the first to King's Mountain on 30th May, and the second to Montebello on 26th June, both being well attended and profitable.

Sub-excursions, or small outing parties, visited many of the neighbouring localities, and not a few more distant places. Of these may be mentioned Wakefield, High Falls, Cassleman, Moose Creek, Chats Falls, Buckingham, Mer Bleue, Aylmer, Kettle Island, Hog's Back, Templeton, Donaldson's Lake, etc. By the Botanical Report it will be observed that some of these localities yielded new plants; in entomology and ornithology many good species were also taken and observed, while the geologists discovered very interesting exposures of different formations.

The winter course of meetings consisted of six soirees; the Council having decided to omit for one year the former elementary, or afternoon lectures. The soirees were held on Thursdays in the lecture room of the Normal School, and the following papers and reports were read:—

1891.

Dec. 17.—The Work of the Geological Survey (President's Address)..................Dr. Ells.

1892.

Jan. 14.—Notes on Travel in Japan..............Mr. Harrington.

Jan. 28. Report of the Ornithological Branch.

Report of the Botanical Section.

A Botanical Excursion to "The Chats"..Mr. R. B. Whyte.

Feb. 18.—A Microscopic Soiree with papers as follows:—

The Microscope in Entomology........Mr. Harrington.

Petrography ....Mr. Ferrier.

Forms of Animal and Plant Life in Swamp Water ....Mr. Shutt.

Feb. 25.—The Natural History of the vicinity of Lansdowne...... ....Rev. C. J. Young.

Report of the Entomological Branch.

Parasitic Fungi.... ....Mr. Lehmann.

Mch. 10.—Water; its properties and functions.....Mr. Lehmann.

The Librarian's Report will show that a number of valuable volumes have been bound, and that many publications have been received.

The OTTAWA NATURALIST, which has been issued regularly, and forms for the year a volume of 214 pages, contains many valuable papers and affords both to our members and to the outside scientific world a useful and appropriate record of the work of the Club.

It is particularly gratifying to state that, notwithstanding the large amount required for the publication of this monthly, the Treasurer's Report will show that there is a satisfactory balance.

In conclusion the Council desires to express its gratitude for the continued enjoyment of lecture and library rooms in the Normal School, and to tender its thanks to Dr. MacCabe, through whose courtesy this accommodation is granted.

Respectfully submitted on behalf of the Council.

W. HAGUE HARRINGTON,

Secretary.

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SUMMARY

OF

Canadian Mining Regulations.

NOTICE.

THE following is a summary of the Regulations with respect to the manner of recording claims for *Mineral Lands*, other than Coal Lands, and the conditions governing the purchase of the same.

Any person may explore vacant Dominion Lands not appropriated or reserved by Government for other purposes, and may search therein, either by surface or subterranean prospecting, for mineral deposits, with a view to obtaining a mining location for the same, but no mining location shall be granted until actual discovery has been made of the vein, lode or deposit of mineral or metal within the limits of the location of claim.

A location for mining, except for *Iron* or *Petroleum*, shall not be more than 1500 feet in length, nor more than 600 feet in breadth. A location for mining *Iron* or *Petroleum* shall not exceed 160 acres in area.

On discovering a mineral deposit any person may obtain a mining location, upon marking out his location on the ground, in accordance with the regulations in that behalf, and filing with the Agent of Dominion Lands for the district, within sixty days from discovery, an affidavit in form prescribed by Mining Regulations, and paying at the same time an office fee of five dollars, which will entitle the person so recording his claim to enter into possession of the location applied for.

At any time before the expiration of five years from the date of recording his claim, the claimant may, upon filing proof with the Local Agent that he has expended $500.00 in actual mining operations on the claim, by paying to the Local Agent therefor $5 per acre cash and a further sum of $50 to cover the cost of survey, obtain a patent for said claim as provided in the said Mining Regulations.

Copies of the Regulations may be obtained upon application to the Department of the Interior.

A. M. BURGESS,
Deputy of the Minister of the Interior.

DEPARTMENT OF THE INTERIOR,
Ottawa, Canada, December 19th, 1887.