And analysis of the original material gave as follows:—

	Alumette.	Hawkes-bury.	River Ouelle.
Phosphate of Lime....	36.38	44.70	40.34
Carbonate of Lime, 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	25.44
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 similar 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 mollusks and principally *Lingula, pyramidata*, which are found abundantly on the present coast.

Classification of Natural Phosphates.

I prefer for all practical purposos, 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 stratagraphically in descending order to the more ancient formations.

Classification of Natural Phosphates.

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, Megillones, Rata.

From Africa, Saldanta Bay and Kuria Muria Islands.

Bat guano, the products 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 North Borneo. It possesses a characteristic dark brown color and exhibiting 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 kind 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, excepting 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 Palæozoic 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 Bellegrade and Ardennes deposits in the lower Greensand (Cretaceous), exhibit evidence of this origin, while the Tertiary and Quarternary 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 appellation 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 Bellegrade, near the Swiss frontier, and also at Montpelier and Avignon, yielding 54% tribasic 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 are 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, is 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 production 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 at 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 (Ciply) 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 mechanical ingenuity of many an "*exploitant*."

Phosphatic Limestone and Marls.

These are found in most strata from the Silurian epoch down to more recent times.

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 store-house 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 sea birds are in the habit of congregating.

Such indeed is the simple origin of some of the most important deposits of phosphate in that part 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 gas) to dissolve neutral carbonate of line, even when presented to them in apparently the most compact and impervious material. Such has been the origin of the many remarkable caves existing in the limestone rock formation (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 fossiliferous 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 Scandinavia. The modes of occurrence 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 occurrence: "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 quartzose and pyroxenic layers, and an included band of crystalline limestone, have a general northwest 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 about 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, Ciply, Liege, Carolina and Florida, yet there are some facts offering an explanation for this. The peculiarity of the occurrence 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 manufacture still require our high-testing products to complete their standard types of