

Note on the Phosphates of the Laurentian
and Cambrian Rocks of Canada.
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The extent and distribution of the
deposits of Apatite contained in the Laurentian
rocks of Canada, and in the succeeding
Cambrian and Silurian ~~deposits~~ ^{formations} have
not escaped the notice of our Geological
Survey, and have been ~~given~~ ^{stated} in some
detail in Reports of Mr. Henry Mr. Richardson
and others, as well as in the General
Report prepared by Mr. William L. Logan in
1863. Some attention has also been given
more especially by Dr. Perry Hunt to the
question of the probable origin of these
deposits.* The importance of these questions
with reference to the discussions respecting Edson
have induced me to embrace such oppor-
tunities as have offered to visit the localities
in which phosphates occur, and to examine their
structure and mode of occurrence. I would
now present as the result of these inquiries some
facts and conclusions which may be of interest
to geologists in connection with the life of the
Laurentian period, and also with the recent

* Geology of Canada 1863. Chemical and Geological Survey 1865.

investigations recorded in the Journal of the Society
respecting phosphatic deposits in the Cambrian and
Silurian of Wales. *

In the Lower Silurian and Cambrian
rocks of Canada, Phosphatic deposits occur in
several localities, though apparently not in
sufficient quantities to compete successfully with
for commercial purposes with the rich Lower
Devonian beds and veins of crystalline
Apatite.

In the Chazy formation at Hamette
Island, and also at Grenville, Hawkesbury and
Lockiel, dark-colored phosphatic nodules abound.
They hold fragments of Lingulæ which also
occur in the containing beds. They also contain
grains of sand, and when heated emit
an ammoniacal odour. They are regarded
by Mr W Logan and A Hunt as Coprolites and
are said to consist of "a paste of comminuted
fragments of Lingulæ evidently the food of the
animals from which the Coprolites were der-
ived". * It has also been suggested that these
animals may have been the larger species
of Trilobites. In the same formation at
some of the above places phosphatic matter is
seen to fill the moulds left by shells of
Pleuronomaria and Holopea.

In the Graptolite Shales of the Quebec
Group at Point Lewis, similar nodules occur, and
* Journal of Geological Society August, 1875
Geology of Canada P 125

and they are found at Riviere Ouelle, Ramour
Parka and elsewhere on the Lower St Lawrence,
in limestones and limestone conglomerates of
the Lower Potsdam group, which is probably
of a little above the Union of the Algonquin
or Algonquin Series. In these beds there are
also small phosphatic tubes with thick walls,
which have been compared to the tubes of
the genus Serpulites. *

The Algonquin or Algonquin group, as
developed near St John New Brunswick, contains
layers of calcareous sandstone blackened with
phosphatic matter, which can be seen under
the lens to consist entirely of shells of Lingula,
often entire and lying closely together in
the plane of the deposit, of which in some
thin layers they appear to constitute the
principal part. Mr Matthew informs me
that these layers belong to the upper part
of the series and that the layers crowded
with Lingulae are thin, none of them ex-
ceeding two inches in thickness; but he
thinks that the dark colour of some
of the associated sandstones and shales is
due to ammonitoid Lingulae.

At Ramour Parka, where I have
studied these deposits, the ordinary phosphatic

* Geology of Canada p 259. * Richardson's Report 1889.
+ Bayley & Matthews Report on geology of New Brunswick.

modules are of a black color, appearing brown
with ^{blue} spots of transmitted light when cut in
thin slices. They are of rounded forms
having a glazed and often pitted surface
and are very hard and compact, breaking
with glistering surfaces. They occur in thin
bands of compact and brecciated limestone
which are very sparingly fossiliferous, affording
only a few shells of Hypolithes, and certain
Scolithus-like cylindrical markings. In some
other beds there occur with the modules siliceous
and other pebbles, rendering it possible that the
former have been derived from the disintegration
of older beds; but their forms show that
they are not themselves pebbles, and while
they are frequent in the limestone conglomerates
they also occur in compact limestone, similar
to that of which a great part of the very
thick conglomerates of this series are
composed.

In some of these limestones the
phosphatic bodies present a very different
appearance, first noticed by Richardson
at Avire Quelle and of which I have
found numerous examples at Kamovaska.
A specimen now before me is a portion of
a gray limestone included in dark red or

purple shale. It is filled with irregular black thick-walled tubes and fragments of such tubes, of various diameters from a quarter of an inch downward. The texture and colour of these tubes are precisely similar to those of the phosphate nodules, and their composition appears to be similar.

Under the microscope the nodules and the walls of the tubes show no organic structure nor continuity, but appear to consist of a fine granular paste holding a few grains of sand and a very few small fragments of shells and some small specular bodies. The general colour by transmitted light is brown but some portions show a light blue colour due probably to the presence of phosphate of iron (vivianite). The enclosing lime-stone and the filling of the tubes usually presents a coarser texture, as if made up of angular fragments of calcite and of broken shells, with some dark-coloured fragments probably of brachiopods. Scattered through this matrix there are also small fragments visible to the naked eye of brown and blue phosphate matter.

One of the nodules from Alameda gave to D. Hunt 36.38 of Calcic phosphate; one from Hawkesbury 44.70; another from Riviere duelle 40.34, and a tube from the same place 67.53. * A specimen from ~~Hawkesbury~~ analysed by Dr. Harington gave 55.65 per cent

One of the richest pieces of the Lenglupensis sandstone from St John yielded to the same amount 30.82 of calcic phosphate and 32.44 of insoluble silicious matter, the remainder being apparently calcic carbonate.

Various opinions may be entertained as to the origin of these phosphate bodies; but the weight of evidence inclines to the view originally stated by Dr Hunt that they are of coprolite origin*. The forms both of the tubes and the nodules, and the nature of their matrix seem to exclude the idea of their being simply concretionary, though they may in some cases have been modified by concretionary action. There are in the same beds little piles of unconsolidated coprolite, but similar in some respects to the nodules. There are also scolithus-like tubes penetrating the beds and lined with a very thin coating of matter similar to that of the tubes. Neither the tubes nor the nodules present any true structure but they resemble coprolite matter both in their granular character and their included fragments.

The tubes are of unconsolidated form, when regarded as coprolite; but they may have

* Geology of Canada p. 466.

been moulded on the bodies or the sides of
the ~~tubes~~ burrows of marine worms, sub-
sisting on food largely composed of phosphates
and having the habit of depositing their
excreta either ~~either~~ as linings of their
burrows or as tubes to protect themselves.
The nodules may be masses of excre-
mentitious matter produced by ~~the~~^{the}
same animals or by others, ^{as crinoids, etc.} sub-
sisting on similar food. Where such
animals greatly abounded and for a
long time, a considerable part of the de-
posit forming on the sea bottom might
consist of their excreta, and these
might either remain as coprolitic balls
or sheltering tubes, or might be compressed
together and thus form ammonites
or bedded deposits more or less affected
by concretionary or crystalline action.

The food of animals producing
such coprolitic matter can scarcely have
been vegetable, for though ^{collect and} marine as
well as terrestrial plants, ^{certain} phos-
phates the quantity of there is very mi-
nute and is little likely to be con-
centrated or accumulated in solid
excreta. We must therefore look to the
animal kingdom for so highly phosphatic
food. Here we find that a large

proportion of the animals inhabiting the
Præcambrian seas formed highly phosphatic
skeletons. Dr Hunt has shown that the
shells of Singulæ and allied genera
were of this character, and he has
found the same in the case of certain
Pteropods as Conularia, and of the
supposed worm-tubes called Serpulites.
It has long been known that the crusts
of ordinary Crustacea contain a
notable percentage of calcic phosphate,
and Hicks and Huddleston have shown
that this is the case also with the Cambrian
Trilobites. Dr Harrington has kindly verified
this for me by analysing a piece of highly
trilobitic limestone from the Lower Potsdam
formation at St Simon, and in which the
crusts of these animals are so well preserved
that they show their minute tubulated
structure in great perfection under the micro-
scope. He finds the percentage of calcic
phosphate due to these crusts to be 1.49
percent of the whole mass. It is to be observed
however that the crusts of Trilobites must
have contained very large of chitinous matter
which in some cases still exists in them
in a carbonised state. The crust of a
modern Sinulus, measuring 5.25 inches across,
has been found by Dr Harrington to contain

of 1.845 per cent of ashes, and of
these of 1.51 per cent was Ca_2 Calcic
phosphate. The crusts of some Trilobites
may have contained as large a pro-
portion of organic matter; but they
would seem to have been more rich
in Phosphates. Next to Lingule and Tri-
lobites, the most abundant shells in
the formation containing the Phosphates
in question are the shells of the
genus Hyolithes, of which several
species have been described by Mr
Bellings*. Dr Harrington has ascertained
for me that these shells also contain
Calcic phosphate in considerable proportion.
The percentage of this substance in a shell not
quite freed from matrix was 2.09 per cent.
These shells have usually been regarded
as pteropods, but I find that the Canadian
Perrinitid species show a structure very
different from that of this group. They
are thicker than the shells of proper Pteropods
and present an outer shell perforated with
round pores sometimes arranged in vertical
rows and lined with a thin imperforated
layer. In these respects they resemble
the shells of Naupliopods and Worms rather
than of the higher Mollusks. I am there-
fore disposed to regard the claim of these

* Canadian Naturalist 1871.

Curious shells to be Peropods as they doubtless
they may have belonged to tetracolum worms
or they may possibly be an abnormal
brachipodous type, in connection with
which view it may be remarked that
the speculum much resembles a brachipod
shell, while the tube may be an
exaggeration of the canical structure
observed in the genus Calceola which
perhaps belongs to brachipods rather than
to corals. Shells of Hyalithes occur in
the same beds with the phosphate nodules
at Riviere duelle & Kamomaska, and in
one curious specimen sliced by Mr. Weston
several of these shells occur slipped one
within another, which would seem to have
been a result of their being disarranged
by some animal and pressed into each
other - posing though its intention.

It is remarkable then as some of the
most common invertebrates of the Permian
seas secreted phosphate shells, it is not
more wonderful that carnivorous animals
feeding on them should produce phosphate
coprolites than that this should occur in the
case of more modern animals feeding on
fishes and other invertebrates.

We may now turn to the question as to the source of the abundant apatite of the Laurentian rocks. Were this diffused uniformly through the ~~rocks~~^{beds} of this great system, or collected merely in fissure or segregation veins, it might be regarded as having no connection with other than mineral causes of deposit. It appears however from the careful stratigraphical ~~and~~ explorations of the Canadian Survey in the districts of Burgess and Elmsley, which are especially remarkable for deposits of apatite, that the mineral occurs largely in conformable beds interstratified with limestone, gneiss and pyroxenites, though deposits of the nature of veins likewise occur. It also appears that the principal deposits are confined to certain horizons in the upper part of the Lower Laurentian, above the limestones containing corals, though some less important beds occur in lower portions. *

The principal apatite-bearing band of the Lower Laurentian consists of gneiss, pyroxenite rock and limestone, and has a thickness of 2600 to 3600 feet. It has been traced over a great extent of country west of the Ottawa River, and has recently been recognized to the east of that river as well. The apatite ~~sometimes~~^{often} occurs in compact beds, sometimes attaining a

* See Beem's Reports for 1872-3 & 1873-4

thickness of several feet, though it has been
observed that these beds are very irregular in
thickness. Several beds sometimes lie near to
each other in the same subordinate member
of the series. Thin layers of apatite also occur
in the lines of stratification of the pyrochne rock.
In other cases disseminated crystals occur
throughout thick beds of limestone, sometimes
according to Dr Hunt amounting to two or
three per cent of the whole mass. Dis-
seminated crystals also occur in the beds of
Magnetite, and Dr Hunt refers to a similar
mode of occurrence as observed in Sweden
and in New York.

The veins of apatite fill narrow
and small irregular fissures, and the mineral
is associated in these veins with calcite and
with large crystals of mica. In one instance
at Henderson in New York the apatite instead
of its usual crystalline condition assumes the
form of radiating and botryoidal masses
constituting the Eupyschroite of Brunn.
(as in some cases
from the beds) In all the localities in which I have
been able to examine the Laurentian apatite,
it presents a perfectly crystalline ^{texture} ~~condition~~,
while the containing strata are highly meta-
morphosed, and this appears to be its
general condition wherever it has been
examined. Numerous slices of the more

Compact Apatite of the beds have been prepared by Mr Weston of the Geological Survey, but as might be expected they show no trace of organic structure. All direct evidence therefore in the organic origin of this substance is still wanting. There are however certain considerations based on its mode of occurrence which may be considered to afford some indirect testimony.

If Mr. Hunt we regard the Iron ores of the Laurentian as organic, then the Apatite which occurs in them may reasonably be supposed to be of the same origin with that which contemporates some of the prolific Iron ores of the Silurian and Devonian, and which is manifestly derived from the included shells and crusts.

If we consider the evidence of Carbon sufficient to establish the organic origin, in part at least, of the Laurentian limestones, we may suppose the disseminated crystals of Apatite to represent phosphate matter segregated from the organisms which they contained. We may also infer the possible existence in the Laurentian period of forms of life akin to some of those which formed phosphatic skeletons in the Permian ~~or~~ age.

Such Silurian beds of compact or nodular Apatite without structure as that of

the Onia Limestone described by Mr. Davis, and those of Huron Onia and elsewhere in Canada described by Richardson, may be held as affording parallels to the bedded ~~apatite~~ of the Laurentian, and agree with ~~them~~ ^{it} in the irregular horizontal distribution of the material, while the presence of graphite in association with the Phosphate mineral in the Silurian deposits of Wales and the Laurentian of Canada may not be an accidental circumstance, but may depend in both cases on the association of Calcareous organisms whether vegetable or animal.

The argillaceous Calcareous Sandstone of St. John is a material which by metamorphism might readily be converted into a Pyroxenite rock with bands of apatite.

The probability of the animal origin of the Laurentian apatite is perhaps further strengthened by the prevalence of animals with phosphate crusts and skeletons in the primordial age, giving a presumption that in the still earlier Laurentian ^{Singular} ~~part~~ preference for phosphate matter may have existed, and perhaps may have extended

to still lower forms of life, just as the
appropriation in more modern times of
phosphate of lime by the higher animals
seems to have been accompanied by a
diminution of its use in animals of lower
grade.

The Laurentian Apatite pretty constantly
contains a small percentage of Calcium Fluoride,
and this salt also occurs in bones, more
especially in certain fossil bones. This
may in both cases be a chemical
accident, but it supplies an ad-
ditional coincidence.

In the lower portions of the lower
Laurentian no organic remains have
yet been detected, and these beds are
also poor in phosphates. The horizon of
special prevalence of boron is the Pennell
band of limestone which according to
Mr William Logan's sections is 11500 feet
above the fundamental gneiss. It appears
from recent observations of Mr Connor
and of Mr W. J. Morris, that the bed
holding the Burgess horizon is probably in
the same geological horizon with that
of Pennell. The phosphates are most abundant
in the beds overlying this band. This gives
a further presumption that the collection and
deposition of the Apatite is due to some

