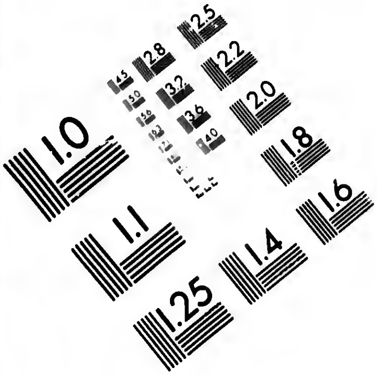

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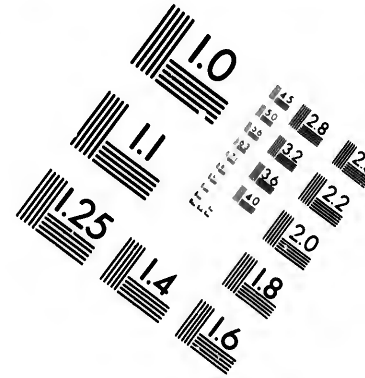

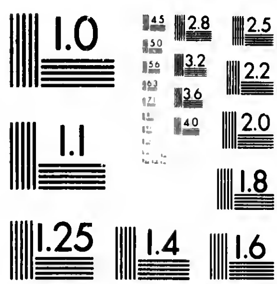

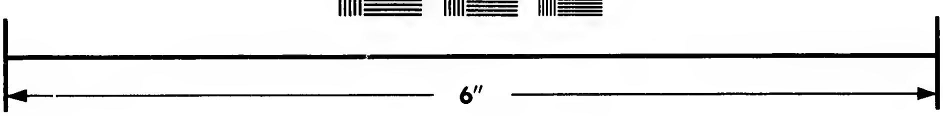

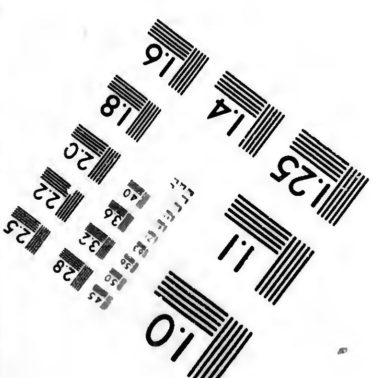

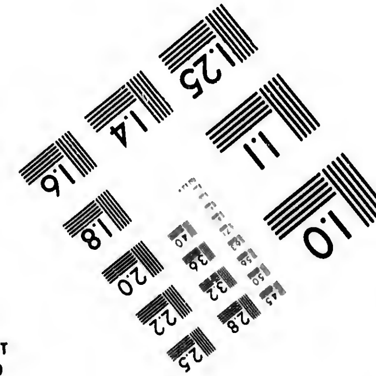

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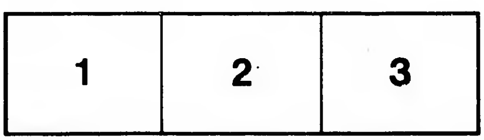

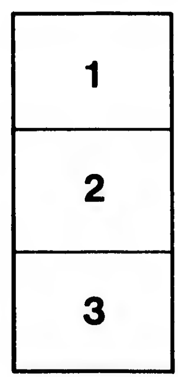

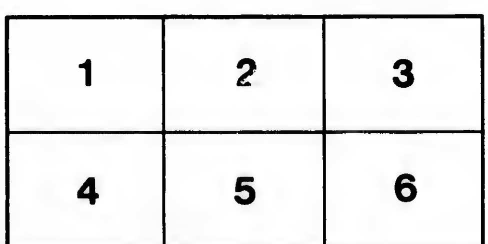

with kind regards from B.J.H.

GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, F.R.S., F.G.S., Director.

REPORT

ON THE

MINERALS OF SOME OF THE APATITE-BEARING VEINS

OF

OTTAWA COUNTY, Q.,

WITH

NOTES ON MISCELLANEOUS ROCKS AND MINERALS

1878

BY

B. J. HARRINGTON, B.A., Ph. D.

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LIST OF ILLUSTRATIONS.

GEOLOGICAL SURVEY OFFICE,
MONTREAL, June 6th, 1879.

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,
Director of the Geological Survey.

SIR,—Herewith I beg to hand you my report on the minerals of some of the apatite-bearing veins of Ottawa County, Quebec, and on miscellaneous rocks and minerals from other regions.

I have the honour to be,

Sir,

Your obedient servant,

BERNARD J. HARRINGTON.

REPORT

ON THE

MINERALS OF SOME OF THE APATITE-BEARING VEINS

OF

OTTAWA COUNTY, QUEBEC,

WITH

NOTES ON MISCELLANEOUS ROCKS AND MINERALS.

BY

B. J. HARRINGTON, B.A., PH.D.

North Ottawa Phosphate Region.

The numerous openings which have been made in search of apatite since the spring of 1876 in Buckingham, Templeton and other townships of Ottawa County, comprising what is sometimes known as the North Ottawa Phosphate Region, have afforded excellent opportunities for the study of many of our Laurentian minerals and their mode of occurrence. With the object of making such a study, two visits were paid to the region during the past season, one in June and the other in September; and although they were both of short duration, many minerals were collected for examination, and numerous facts obtained bearing upon the character of the deposits from which they were taken. Most of the time was spent in the township of Templeton, as the apatite veins of that township were known to afford a great variety of minerals; but a number of mines in Buckingham and Portland were also visited.

Acknowledgment of assistance.

My grateful acknowledgments are due to Mr. J. G. Miller, of East Templeton, Mr. Gerald C. Brown, of Buckingham, and other gentlemen, for much information, and also for most substantial assistance. Mr. Miller, who takes a lively interest in mineralogy, has been a most industrious collector, and generously placed at my disposal quantities of interesting material from his own collections.

Some of the observations which follow concerning the apatite region of the Ottawa are new only as regards that region, similar statements relating to the North Burgess district having long ago been published by Dr. T. Sterry Hunt; but, at the same time, many entirely new facts worthy of being recorded are given here, and the general similarity of the two regions is established. The interesting paper of Messrs. Brögger and Reusch on the occurrence of apatite in Norway, published in the journal of the Geological Society of Germany,* has also enabled me to institute occasional comparisons between the deposits of that country and our own, and to add to the many analogies already pointed out by Hunt, Macfarlane and other writers.

Facts published by Dr. Hunt.

Occurrence of apatite in Norway.

In Norway the more important deposits of apatite are stated by Brögger and Reusch to occur either in or in the immediate vicinity of a rock which they term "spotted gabbro," (*gefleckten gabbro*), and which they regard as eruptive. The term gabbro, however; is not used by them in its ordinary sense, but applied to a rock consisting of brown, lustrous hornblende and white to greyish-white labradorite—an aggregate commonly called diorite. Except in the colour of the hornblende, it would appear to resemble what has been termed by Mr. Vennor "blotched diorite,"† and which consists of dark green to black hornblende, with labradorite or oligoclase, and sometimes a little mica. Veins containing apatite have also been observed in these diorites, but, so far as I am aware, are not of any economic importance. Judging from the localities visited by me last summer in Ottawa County, however, there is evidently there, as in the Burgess region, an intimate connection between the apatite veins and certain pyroxenic rocks which, on account of this connection, may be looked upon as representing, in one sense at least, the so-called spotted gabbro of Norway. These pyroxenic rocks, which have been called by Hunt pyroxenites,‡ vary considerably in their characters. Sometimes they consist almost exclusively of pyroxene, though more commonly quartz and orthoclase are present. Mica, too, is of frequent occurrence, while minute garnets may occasionally be seen. The frequent presence of disseminated grains of apatite is also an important fact. When pyroxene is the principal mineral the rock commonly shows little or no trace of bedding, but is often a good deal jointed. Its aspect when the pyroxene is of a dark colour is often that of a massive eruptive rock.

Gabbro.

Diorite.

Pyroxenite.

Frequently the fresh fracture of some of the "pyroxenites" would not lead one to suspect the presence of more than very small quantities of quartz, in cases where the weathered surface shows that it is present in considerable abundance and marks the lines of stratification. Large

* Vorkommen des Apatit in Norwegen. *Zeitsch d. deutsch geol. Ges.* Heft III., pp. 646-702.

† Report of Progress, 1874-75.

‡ Geology of Canada, 1866, p. 185.

lenticular patches and veins of a coarsely crystalline aggregate of orthoclase and quartz, with more or less pyroxene, or sometimes hornblende, may often be observed, and appear to have been separated out from the mass of the rock by some process of segregation.

Of other rocks met with in the Ottawa phosphate region the most important are the gneisses, quartzites, and crystalline limestones. Gneiss. The gneisses vary much in character, but the predominating variety consists of more or less reddish orthoclase and greyish or white quartz, with little or no mica, and sometimes with garnets.* It is usually coarse or granitoid in texture, and the bedding often obscure, though in other cases it contains numerous beds or layers of quartzite from half an inch to a foot or more in thickness, which render the strike of the rock plainly visible. Gneiss with these quartzite layers may be seen on the twelfth lot of the twelfth range of Templeton, where it forms the peak overlooking McGregor Lake at the "Fidelity Mines." In other cases mica is abundant, and the gneiss assumes a marked foliated texture. It is then sometimes grey, and at others reddish. Many of the gneisses, however, which appear reddish, are only so from weathering, and on fresh fracture the feldspar is seen to be white or pale grey. The micaceous gneisses are sometimes garnetiferous, and occasionally exhibit the texture of the so-called *augen-gneiss* or eye-gneiss. Grey hornblendic gneisses also occur, and in some instances contain epidote.

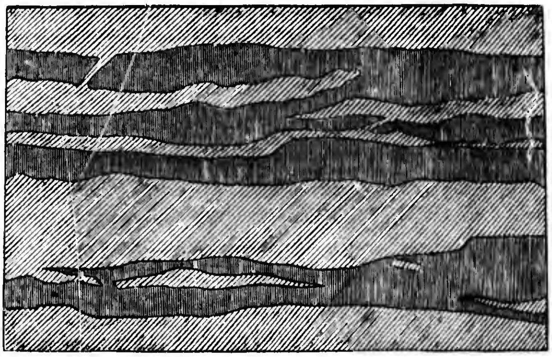
Quartzite has already been referred to as forming thin beds interstratified in some of the gneissic strata; but independent beds of considerable thickness also occur. Quartzite and dolerite. A good example of one of these may be seen in the hill behind the little village of Perkins' Mills, in Templeton. It is white and glassy, and in places contains a little orthoclase. The quartzite and adjoining orthoclase rock and hornblendic gneiss are here traversed by a dolerite† dyke more than a hundred feet thick, the course of which is N. 75° W. and S. 75° E., while the strike of the quartzite is about north-east and south-west. At the time of the intrusion of the dyke the quartzite has been curiously split up into numbers of sheets or layers in a direction approximately parallel to the course of the dyke, and the dolerite has filled the spaces between the layers, thus producing a series of small dykes parallel to the main mass, but of much finer texture, owing, no doubt, to more rapid cooling. The accompanying

* By some writers many of these rocks would be termed granulite, but we prefer to class them here under the general name of gneiss, with the more typical forms of which they are often intimately associated, and into which they pass by insensible gradations.

† By many lithologists the rocks spoken of here as dolerite would be called diabase on account of their freedom from "glass" and their antiquity. It is, however, deemed advisable to retain here the name dolerite, by which they have hitherto been designated in the Reports of the Survey.

sketch shows the appearance presented on the surface by the alternating layers of quarzite and dolerite. The portion with diagonal shading is the quartzite, with the strike of which the diagonal lines coincide, while the dolerite is indicated by the vertical shading. The dolerite, it will be seen, occasionally includes angular fragments of the quartzite. The area represented in the sketch is twelve feet long and nearly eight feet wide.

FIG. 1.



DOLERITE DYKES CUTTING QUARTZITE.

Series of dolerite dykes.

The dyke just described is but one of a series which are known to traverse the Laurentian strata in the counties of Ottawa and Argenteuil. By some they have been supposed to have influenced the character of the apatite deposits, and it has even been suggested that rich apatite veins were most likely to be found in proximity to the dykes. This, however, does not seem to be the case. The dykes cut all the Laurentian strata of the region indiscriminately, and considering the abundance of the apatite deposits, and also that they were probably formed before the dykes, it would be strange if the latter did not occasionally pass either through or close to some of them. Dykes apparently of similar character occur in the apatite region of Norway, but have not, so far as I am aware, been supposed to be in any way connected with the apatite deposits.

Microscopic character of dolerite.

Analyses of specimens of some of the Grenville dolerites were made many years ago by Hunt,* and descriptions of their microscopic characters subsequently published by me in the *Canadian Naturalist*.† Quite recently, also, microscopic sections of dykes from Templeton and Wakefield have been studied, but have not been found to offer any

* Geology of Canada, 1863, p. 653.

† New Series, Volume VIII., Number 6, p. 315.

essential differences from those of the oldest set of dykes in Grenville. With the microscope the rock shows, in thin sections, a perfectly crystalline texture, being made up of a network of striated blades of triclinic feldspar, brownish augite, black opaque grains of magnetite, and commonly small quantities of a green chloritic mineral. The relative proportions of these constituents vary a good deal, and in the case of the dyke near Perkins' Mills, described above, the proportion of augite appeared to be much larger in the main dyke than in the fine-grained portions between the layers of quartzite. In the latter a green serpentinous mineral was observed, which is probably pseudomorphous after olivine.

Limestones.

Messrs. Brögger and Reusch state that limestones rarely occur in the regions where they studied the Norwegian apatite deposits; but with us the case is different, and a number of bands of crystalline limestone are known to exist in the apatite regions of both Ontario and Quebec. Those seen by me in Templeton were highly crystalline, and often serpentinous. In a few localities they were noticed to contain concretionary balls of serpentine several inches in diameter, sometimes enveloped by a single layer, or containing several more or less concentric layers, of white fibrous calcite. Large masses of serpentine also occur in the limestone, consisting of the ordinary yellowish-green variety, traversed by numerous veins of beautiful chrysotile. Small quantities of this have been mined as asbestus on the eleventh lot of the seventh range of Templeton.

Chrysotile.

Beds or veins of apatite.

In the Geology of Canada the apatite deposits of the Burgess region were described as beds. Subsequently, however, it was stated by Dr. Hunt that although the apatite did occasionally occur in beds the workable deposits were, "with few if any exceptions, confined to the veinstones."* Limestone beds were described by him as containing disseminated grains or crystals of apatite, the proportion of which amounted in some cases to two or three per cent., or even much more, and the pyroxenites were stated to contain disseminated grains or small masses of apatite marking the stratification. (Loc. cit., p. 204.) Dr. Hunt's reasons for regarding most of the deposits as concretionary veinstones are fully given in the report just referred to, and also in his *Chemical and Geological Essays*. They depend upon such facts as banded structure, the presence of drusy cavities, the manner in which various minerals surround or encrust each other, and the rounded forms of certain crystals—indicating "a process of partial solution succeeding that of deposition."

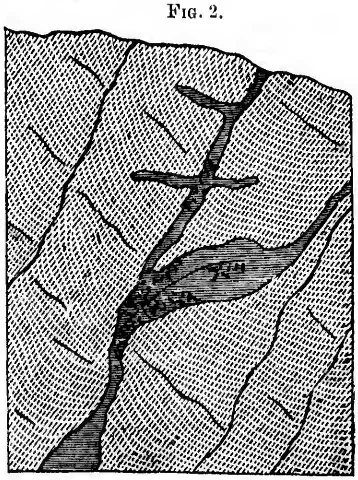
As many of the facts obtained last summer in Templeton and

* Report of Progress, 1863-66, p. 188.

adjoining townships bear upon these points, some of them may now be stated. That many of the apatite deposits of this region are not beds is plainly shown by the manner in which they cut across the strike of the rocks containing them. As examples of this, may be mentioned an important vein on the seventh lot of the first range of Portland, the course of which is N. 15° W., while the strike of the country rocks is N. 45° E. On the nineteenth lot of the ninth range of Templeton the rocks strike N. 40° E., and are traversed nearly at right angles to their strike by a vein of apatite.* Again, on lot fifteen of the eighth range of Templeton, there are three veins whose courses are, respectively, N. 40° W., N. 60° W., and N. 67° W., while that of the country rocks is N. 20° W. In some instances deposits which look like interstratified beds in places, are here and there seen to give off lateral branches, which cut directly across the strike of these rocks. An example of this was noticed at Mud Bay, on the twelfth lot of the eleventh range of Templeton, in the case of an apatite vein occurring in garnetiferous gneiss.

Examples of veins.

Fig. 2.



Branching Apatite Vein in Pyroxenite.

Branching apatite vein.

Figure No. 2 is a vertical section across a branched vein occurring on the same lot in massive pyroxene rock. The latter shows what are probably joints, though possibly planes of bedding. In either case, however, the only possible conclusion, as regards the apatite, is that it forms a vein. The pyroxene rock is indicated by broken diagonal lines, the apatite by horizontal. Plates of mica are seen to be numerous in places, especially at the points where the vein forks. The thickest portion of the vein represented is about two feet.

Figure No. 3 shows a number of small irregular veins of apatite cutting a light greenish-grey "pyroxenite," on the surface of which

* Owing to the great irregularity of the apatite veins and the limited extent to which they have been worked, it is often difficult to obtain their courses very accurately. The following twenty, however, were ascertained as carefully as possible under the circumstances. The first fifteen are the bearings (mag.) of veins in Templeton, the succeeding four in Portland, and the last in Buckingham:—

E. & W.	N. 78° E.	N. 35° E.	N. 60° W.	N. 30° W.
E. & W.	N. 45° E.	N. 17° E.	N. 40° W.	N. 15° W.
E. & W.	N. 45° E.	N. 67° W.	N. 40° W.	N. 5° W.
N. 85° E.	N. 35° E.	N. 60° W.	N. 55° W.	N. 45° E.

FIG. 3.

APATITE VEINS IN PYROXENITE.

quartz and feldspar weather out and mark the stratification of the rock. The apatite looks as if it had been drawn out or squeezed into the curious forms which it now presents, during the folding or crumpling of the enclosing rocks.

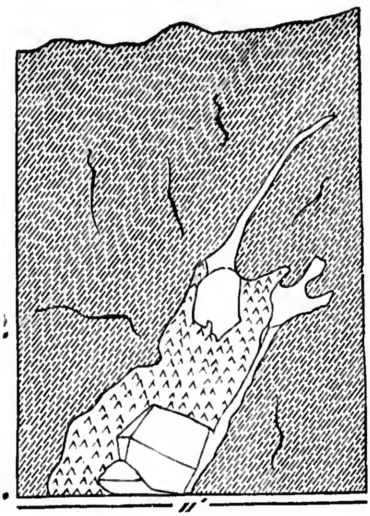
Drusy cavities.

Drusy cavities do not seem to be so abundant in the veins of this region as in those of Burgess, but are now and then met with, lined with crystals of quartz, calcite, apatite or pyroxene. Among other localities, they were observed at the Grant Mine in Buckingham and on lot seventeen in the ninth range of Templeton. In a vein at the latter locality, a cavity lined with pyroxene crystals is said to have occurred, in the centre of which there stood, like a statue in a niche, a crystal of apatite several feet in height. This was no longer visible at the date of my visit, but numerous smaller cavities were observed, mostly lined with different varieties of quartz. The *vein* at this locality is a most interesting one. It occurs in the so-called pyroxenite, and has a course of N. 78° E. and S. 78° W., with an underlie of about 70° to the south. Last summer it had been exposed for a distance of about 125 feet on its strike. Some mining had been done, but what quantity of apatite had been removed was not ascertained. Parts of it are made up almost entirely of a confused aggregation of gigantic apatite crystals, which have grown from the walls of the crevice, and many of which are several feet in length and a foot or more in diameter. The top of one, which had been broken off and was lying on the ground, had the pyramidal planes entire, and was eighteen inches long and eighteen and a-half inches in greatest diameter. Towards its eastern end, a section of the vein, in a cutting, showed it to be largely composed of calcite holding a few large crystals of apatite, and having a thin layer of the latter mineral adjoining the foot-wall. One rude crystal of apatite, which projected from this layer of apatite into the calcite, was two feet nine inches long, and also in diameter. It is shown in the accompanying cut (Fig. 4), in which the diagonal shading represents the country rock, the arrow-head markings calcite, and the white, apatite. In another opening west of the first, the vein

Interesting vein.

Large apatite crystal.

FIG. 4.



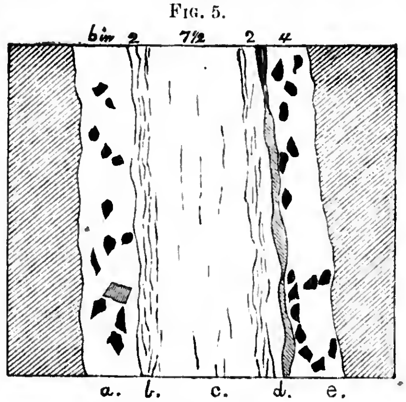
VEIN SHOWING LARGE APATITE CRYSTAL.

showed much less calcite and a good deal of dark green hornblende, pyroxene and mica—the last sometimes in plates a foot across, and most abundant along the foot-wall, while the hornblende occurred in greatest quantity along the hanging-wall. At the surface the vein showed nearly six feet of solid apatite, partly consisting of large crystals; but at a depth of eighteen feet the total width of the vein was only four feet, and of this only one foot consisted of apatite. This vein has afforded interesting examples of mineral envelopment and of broken and re-cemented crystals, some of which will be noticed further on.

As a rule, the apatite-bearing veins of the Ottawa region are characterised rather by a want of regularity or order in the arrangement of their constituents than by any degree of symmetry. Occasionally, however, instances are met with where the veins show a distinct banded structure. An excellent example of this was observed at Mud Bay, on the twelfth lot of the eleventh range of Templeton. The vein was twenty-one and a half inches thick, and occupied a well-defined fissure. A section of it is shown in the accompanying figure (Fig. 5).

Banded structure of veins.

FIG. 5.

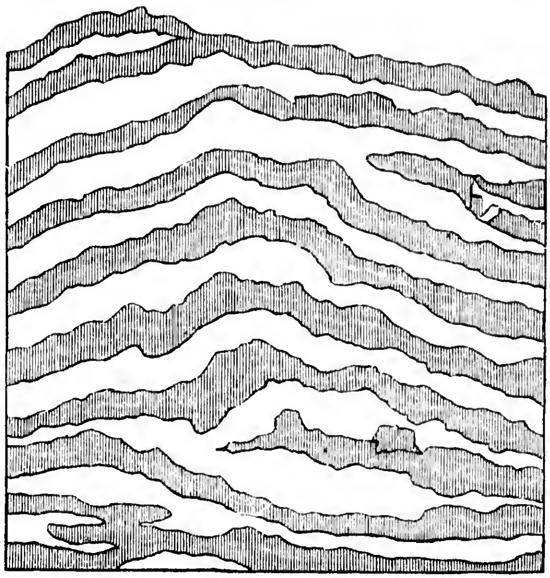


a. Calcite and mica.
b. Fine-grained mica in wavy lines, with pyroxene and a little apatite.
c. Pyroxene, granular apatite, and a little mica, in fine scales, arranged in wavy lines in the direction of the vein.
d. Mica, pyroxene and thin layers of apatite.
Calcite and mica.

The Grant Mine, on the eighteenth lot of the twelfth range of Buckingham, has also afforded an interesting illustration of the alternate deposition of minerals in a vein. The minerals are pyroxene and apatite, and they occur in layers averaging about a quarter of an inch in thickness, alternating one with the other with wonderful regularity for very considerable thicknesses, like the laminæ of Eozoon. In

Fig. 6, which is a tracing froman actual specimen the shaded portion represents the pyroxene and the white apatite. In the original the lines are scarcely as sharp as indicated by the drawing. In some cases the apatite has been dissolved away, leaving the layers of pyroxene.

FIG. 6.



VEINSTONE SHOWING ALTERNATE LAYERS OF APATITE AND PYROXENE.

Sharply-defined walls not common.

Veins with sharply-defined walls, such as are common in the case of metalliferous lodes, are rarely seen, the constituents of the vein and country rock rather merging into one another. According to Dana, "such a blending of a vein with the walls is a natural result, when its formation in a fissure takes place at a high temperature during the metamorphism or crystallization of the containing rock." *

Irregular character of apatite deposits.

Figure 7 is an illustration of the irregular manner in which the various minerals occur in some of the apatite deposits. It is a vertical section on a scale of approximately one foot to an inch, sketched in an opening from which considerable quantities of apatite had been extracted. The uncertainties of mining deposits of this character are evident.

Such examples as those which have been given prove incontestably that there are true apatite veins in the region in question; and as to their mode of formation, we concur with Hunt in regarding many of them as

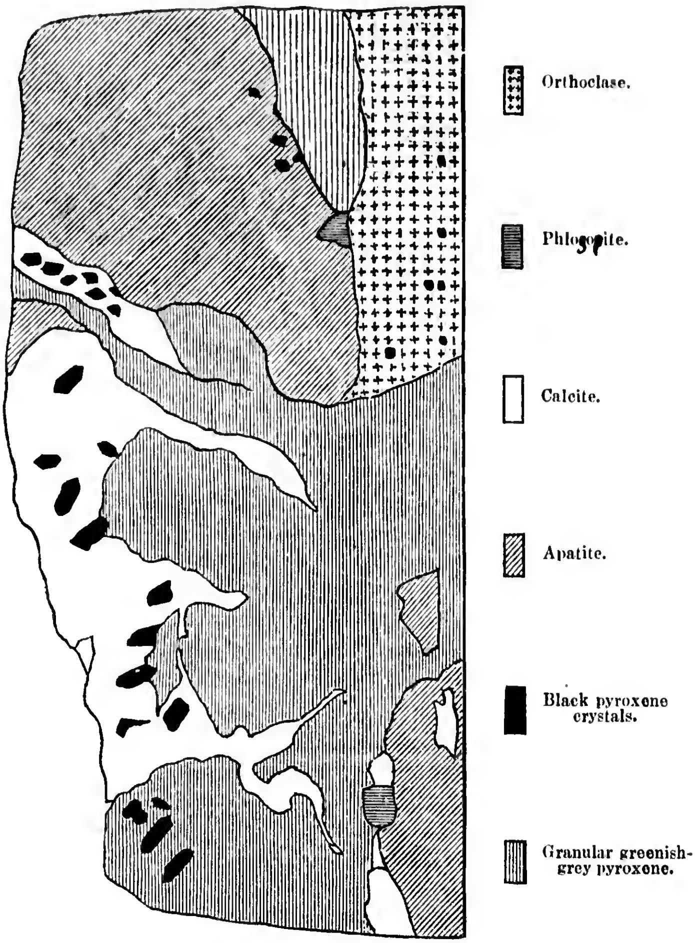
* Manual of Geology, 1875, p. 733.

fissures or cavities which have been filled by the deposition of materials derived from the adjacent strata. At the same time, however, we believe that in many cases there has been a segregation of apatite and other minerals which accompany it from the surrounding rock into

Segregated masses.

irregular or lenticular masses, without any true cavity or crevice

FIG. 7.



having ever existed. This, it is true, implies that the particles have possessed a degree of mobility which it may be hard to understand: but, nevertheless, there are many of the apatite deposits whose formation it does not seem possible to explain in any other way. The tendency which phosphate of lime exhibits to accumulate in concretionary masses, as well as in veins, in rocks of later age is well known.*

The conclusions arrived at by Messrs. Brögger and Reusch concerning the apatite veins studied by them in Norway, are that they are of eruptive origin, and that there is "no definite relation between the minerals of the veins and those of the country rock." The veins are stated to traverse indifferently both eruptive and sedimentary strata—gabbro, granite, hornblende slate, hornblende gneiss, mica-schist and quartzite; but neither apatite nor any other mineral containing phosphoric acid is known to occur in the country rock. The banded arrangement which they have observed in some of the Norwegian veins, they assume to be due to the conditions under which the "magma" has cooled. Often, too, the veins are said to be fine-grained near the walls and coarse in the centre, a phenomenon regarded as analogous to what is observable in many trap dykes. The crumpled and broken crystals of mica and other minerals are considered as best explained by assuming the eruptive nature of the veins. After the formation of the crystals a portion of the vein-matter still remained in a plastic state, and by its movements the crystals were bent and broken. The rounded crystals are supposed to have been rounded not by solution but by partial fusion. Still another ground of the eruptive origin of the veins is that in several cases they have been found to contain angular fragments of rock, which in one instance were different in character from the country rock, and supposed to have been brought up from beneath by the liquid vein-matter. Lastly, the fact that apatite is known to crystallise out from certain materials rendered liquid by fusion, and its occurrence in certain igneous rocks, is appealed to. Eruptive origin of apatite veins

This idea of an igneous origin cannot be adopted for our veins. With us, as we have seen, they occur chiefly in the pyroxenic strata, but they also traverse or occur near to other rocks which seem, to a greater or less extent, to influence their mineral character. Veins, for example, which occur near to beds of limestone are liable to be calcareous, and to hold the apatite in the form of crystals imbedded in the calcite. We have also seen that the pyroxenites often contain disseminated grains of apatite, and no doubt they are the strata from which the apatite of the veins has been chiefly derived. If, as has been suggested, the apatite of these ancient strata represents material accumulated by organic agencies,† then the connection of the pyroxene and apatite may be that the material of the former constituted an Veins of this country not eruptive.

* In connection with this subject see an interesting paper by M. Daubrée on the occurrence of phosphate of lime in France. *Comptes Rendus*, 1871, LXIII. p, 1020.

† See in connection with this subject, a paper by Dr Dawson in the *Canadian Naturalist* (N. S. Vol. VIII., p. 162,) entitled, "Notes on the Phosphates of the Laurentian and Cambrian Rocks of Canada."

oceanic bottom particularly suitable for the life of the creatures which secreted the phosphatic matter.

The fine-grained character of the veins near the walls, regarded by Brögger and Reusch as an evidence of eruptive origin, is observable in some of our apatite veins, but quite as frequently they are coarser in texture near the walls than in the centre. The phenomena of bent, crumpled and cracked or broken crystals are apparently quite as common here as in Norway, and certainly remind one of the similar phenomena in eruptive rocks, but are nevertheless explicable upon other grounds than those stated by Brögger and Reusch. The same is true of the numerous instances of mineral envelopment, for some of which, no doubt, striking parallels may be found if eruptive rocks are studied microscopically, but for many of which no analogy can be given. The very different character of the apatite of igneous rocks from that of such deposits as we are now considering, is certainly a strong argument against the eruptive origin of the latter. In the igneous rocks the apatite, which has usually been the first mineral to solidify and penetrates all the other constituents of the rock, is characterised by the sharp outlines of its crystals, though they are, for the most part, exceedingly minute,* while in the apatite veins crystals with sharp angles are comparatively rare. How, we may ask, have the enormous crystals of apatite in the veins suffered so from fusion, while the acicular prisms of the igneous rocks preserve their form intact?

Character of apatite in igneous rocks.

Depth of apatite deposits

The statement is commonly made that our apatite deposits are very limited as regards depth; but such a statement certainly seems premature when we remember that no mining operations have as yet been carried on to a depth of more than 150 feet. It, however, is evident that the depth to which the true fissure veins will be found workable will often depend largely upon the thickness and attitude of the pyroxenic strata in which they occur, and upon the course and inclination of the veins themselves as compared with the strike and dip of the enclosing rocks. A vertical or nearly vertical vein, for example, traversing a highly inclined bed of pyroxenite, is likely to be workable to a greater depth than a similar vein cutting a pyroxenite bed of slighter inclination and underlaid by other rocks, such as gneiss and limestone, in which the veins are less likely to be remunerative. As regards the irregular or lenticular masses referred to on page 10, their working must, of necessity, be to a greater or less extent of uncertain character, but it does not follow that when one of these masses is worked out another may not occur near it.

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* Zirkel, *Mikroskopiche Beschaffenheit der Mineralien und Gesteine*, s. 223.
Rosenbusch, *Mikroskopische Physiographie der petrographisch wichtigen Mineralien*, s. 216.

THE MINERALS OF THE APATITE DEPOSITS.

Mineral associates of apatite.

Leaving now such questions as the origin of our apatite deposits, we pass to the consideration of the minerals which they have been found to contain in the region visited last summer. Their names are given in column I., while, for the sake of comparison, those enumerated by Brögger and Reusch, as occurring in the apatite-bearing veins studied by them in Norway, are given under II.

I.	II.
Apatite.	Apatite.
Calcite.	Calcite.
Fluor-spar.	—
Quartz (several vars.).	Quartz.
Pyroxene.	Pyroxene.
Hornblende.	Hornblende.
Phlogopite.	Phlogopite.
Garnet.	—
Epidote.	—
Idocrase.	—
Tourmaline.	Tourmaline.
Titanite.	Titanite.
Zircon.	—
Orthoclase,	Orthoclase.
Albite.	Albite.
Scapolite.	Scapolite.
Wilsonite.	—
Talc (Steatite)?	Talc?
Chlorite.	Chlorite.
Prehnite.	—
Chabazite.	—
Hematite.	Hematite.
Rutile?	Rutile.
Pyrite.	Pyrite.
Pyrrhotite.	Pyrrhotite.
Chalcopyrite.	Chalcopyrite.
Galena.	—
Sphalerite.	—
Molybdenite.	—
Graphite.	—
—	Kjerulfin.
—	Tschermakite (oligoclase).
—	Esmarkite (anorthite?)
—	Enstatite.
—	Aspasiolite.
—	Titanic Iron Ore.
—	Magnetite.

It will thus be seen that of the thirty species given in our list, no less than eighteen, or nearly two-thirds of the entire number, are identical with those in the Norwegian deposits. The Norway list, however, contains several minerals not represented in ours; but one of these, magnetite, occurs in apatite-bearing veins in Ontario. Enstatite, though carefully looked for, has not yet been found here, although a mineral supposed to be an altered enstatite* is one of the most frequent accompaniments of the Norwegian apatite.

Enstatite.

APATITE.

The varieties of this mineral ocurring in the Ottawa region are so numerous that no attempt will be made to describe them all in detail, but simply to give a few general statements with regard to some of their more important characteristics.† Crystals of the mineral are of common occurrence, and sometimes attain to large dimensions, measuring a foot or more in diameter and several feet in length, and weighing hundreds of pounds. The form, like that of the so-called moroxite from Arendal in Norway, is a hexagonal prism terminated (often at both ends) by a hexagonal pyramid (∞ P.P.); and in no case, so far as I am aware, has the basal plane oP., so common in crystals from many regions, been observed. The edges of the crystals are sometimes sharp, but more frequently rounded. The specific gravity varies slightly in different varieties; but that of a dark green, glassy crystal from the Grant Mine in Buckingham was found to be 3.2115. The colour of the mineral varies greatly, including green of various shades (sea-green, olive-green, grass-green, asparagus-green, greyish-green, &c.), sky-blue, red and brown of different shades, yellow and white. The lustre varies from vitreous to resinous or fatty, and while the mineral in its more glassy forms is subtransparent, it is more frequently subtranslucent and often opaque.

Large apatite crystals.

Though at some localities the apatite occurs chiefly in crystals, at others it is wholly or almost altogether massive, varying from compact or crypto-crystalline to coarse granular. Frequently, also, it

* It is green or greenish-grey in colour, and sometimes occurs in very large crystals. The hardness is only 2-3, and the specific gravity 2.7-2.8. In fine splinters the mineral fuses to a black glass. The following are two analyses cited by Brögger and Reusch:—

	Oedegarden.	Snarum.
Silica	57.63	59.51
Alumina	1.02	0.97
Magnesia	30.37	30.89
Ferrous oxide	4.99	2.95
Lime	....	0.37
Water	7.21	6.01
	101.22	100.70

After examining a large number of crystals, the conclusion of these gentlemen is that the mineral is rhombic, although the crystals are very near to pyroxene in form, and had previously been described as pseudomorphs of steatite after augite.

† For fuller particulars, as well as for detailed analyses of a number of Canadian apatites, see Mr. Christian Hoffmann's Report.

exhibits a distinct lamellar texture. A friable, saccharoidal variety is very common, and often termed "sugar phosphate." When white, it is sometimes difficult to distinguish by the eye from some forms of quartz sandstone. On account of its friability it is, no doubt, much easier to grind than some of the more compact forms, but, at the same time, it is more apt to undergo loss in the operations of mining and transportation. Crystals are sometimes imbedded in this granular apatite, and frequently also rounded masses of apatite of all sizes up to many inches in diameter. Similar masses of pyroxene, as well as crystals, are also sometimes imbedded in the apatite. Good examples of the fine granular or saccharoidal apatite occur at several of the openings on the twelfth lot of the twelfth range of Templeton. On this lot also, at Mr. Miller's "Doctor Pit," a curious translucent variety occurs, somewhat resembling serpentine in appearance.

"Sugar phosphate."

At the Ritchie Mine, on the seventh lot of the seventh range of Portland, a beautiful example of the vitreous sea-green variety was seen. The mass, *as exposed*, measured nearly twenty feet across, and in the whole of this thickness was apparently free from other minerals, with the exception of a few crystals of pyroxene and mica.

As already stated, apatite crystals are sometimes found imbedded in the granular form of the same mineral; the best crystals, however, usually occur in calcite—as at Mr. Miller's "Crystal Pit." Other minerals in which they have been found are pyroxene, hornblende, phlogopite, orthoclase, scapolite, steatite and pyrite. Like the crystals from other regions, they frequently enclose other minerals, among which are calcite, pyroxene, phlogopite, zircon, sphene, fluor-spar and pyrite. So far as known the apatite of this region, like that of Burgess, is always fluor-apatite.

Fluor-apatite.

Calcite.

In addition to its occurrence in the form of beds of limestone, calcite frequently forms veins which may or may not contain other minerals, and is also one of the most common constituents of the apatite-bearing veins. In the veins it is, as a rule, much more coarsely crystalline than in the beds, but this is not invariably the case. Sometimes it is white, blue or green, but more frequently pink, flesh-colour or salmon-colour. Occasionally, also, it is colourless and transparent. Though usually massive, crystals of dog-tooth spar, nail-head spar, and other more complicated forms, are now and then found in cavities.

Calcareous veins.

Calcite is frequently enclosed in other minerals, as apatite, pyroxene, phlogopite, zircon, &c.; and still more frequently contains other minerals, as apatite, pyroxene, phlogopite, hornblende, tourmaline, sphene, zircon, quartz, chalcopyrite.

Fluor-spar.

Fluor-spar.

Specimens of this mineral have been found at several of the apatite openings, as, for example, at the "Trusty Pit," on the twelfth lot of the twelfth range of Templeton, the fifteenth lot of the third range in the same township, and the tenth lot of the fourteenth range of Hull. Usually, however, the quantity found at any one locality is small. The colour of the fluor is sometimes bright green, at others purple, violet or occasionally blue. A specimen from the township of Hull shows minute octahedra of purple fluor-spar associated with scalenohedral crystals of calcite.

Interesting vein-stone.

Specimens of a vein-stone from the augmentation of Grenville, further down the Ottawa, consist of an aggregate of dark green pyroxene, grass-green apatite, purple and wine-coloured fluor-spar, white orthoclase, calcite, black tourmaline, sphene and small prisms of zircon. Sometimes the fluor is imbedded in apatite, while at others the apatite occurs in the fluor.

In some cases fluor-spar has been observed in drusy cavities with quartz.

Quartz.

Varieties of quartz.

Quartz is a common mineral in the apatite deposits, sometimes being imbedded in the apatite, calcite or other constituents of the deposit, or lining drusy cavities. The quartz in these cavities is sometimes colourless, at others smoky or amethystine, and occasionally red or brown, and more or less opaque from included oxide of iron. The amethystine quartz is commonly pale, but fairly coloured crystals have been found on the seventeenth lot of the ninth range of Templeton. At this locality chalcedonic quartz has been deposited in crevices in the vein, producing agate when there has been an alternation of different colours. In some specimens, layers of vitreous quartz alternate with the chalcedony. The surfaces of the agate are often covered with little scalenohedral crystals, which are apparently pseudomorphs of quartz after dog-tooth spar. Most of them are under an eighth of an inch in length, and frequently they are hollow. Occasional grains of copper pyrites are imbedded in the chalcedony, while zinc blende occurs in vitreous quartz at the same locality.

Mountain leather.

In a specimen said to have come from the Grant Mine in Buckingham, glassy quartz was imbedded in a mass of mountain leather. In one or two instances also, veins of pale blue subtranslucent quartz were observed cutting a mixture of granular apatite and pyroxene.

The occurrence of quartz in some of the stratified rocks of the region is elsewhere referred to.

Pyroxene and Uralite.

Of all the mineral associates of apatite in the Ottawa region, pyroxene is the most constant and the most abundant. In one form or another it is probably present in all the apatite deposits, excepting, perhaps, some of the calcareous veins with imbedded apatite crystals. The most common variety appears to be an aluminous sahlite or lime-magnesia-iron pyroxene, but a light-coloured variety, probably diopside or malacolite, is also common. Less frequently a beautiful black kind may be observed, excellent examples of which have been obtained from the thirteenth lot of the eleventh range of Templeton. It is here associated with green apatite, white orthoclase, scapolite, graphite and small grains of titanite. The pyroxene crystals often contain little round or irregular masses of the orthoclase as well as scales of graphite, and their surfaces are sometimes coated by broad plates of the last-named mineral. The crystals differ from those of the more ordinarily occurring sahlite not only in colour, but also, to a certain extent, in chemical composition and form, having the faces of the inclined rhombic prism usually much more fully developed than the clinopinacoid, and presenting rather different pyramidal terminations. The observed planes are those of the inclined rhombic and rectangular prisms ∞ P. ∞ P∞. [∞ P∞], combined with the pyramidal faces P. 2 P.–P. and the clinodome [2 P ∞]. The faces of the rhombic prism are often developed almost to the exclusion of the ortho- and clinopinacoid. In some crystals the pyramidal planes are pretty equally developed, but in others much distorted. In the specimens examined the basal plane oP. is absent, but there is a very distinct basal cleavage. The fracture varies from uneven to conchoidal. The colour is mostly black, but in some specimens blackish-green. On the edges or in thin splinters the mineral is translucent, and by transmitted light appears deep bottle-green. The lustre is vitreous, and sometimes almost splendent. The hardness is about six, and a crystal, of which the following is an analysis, was found to have a specific gravity of 3·385:

Varieties of pyroxene.

Analysis of black pyroxene

Silica	51·275
Alumina	2·821
Ferric oxide	1·317
Ferrous oxide	9·164
Manganous oxide	0·329
Lime	23·344
Magnesia	11·612
Loss on ignition	0·174
	100·026

The analysis shows that this is an aluminous lime-magnesia-iron pyroxene, and its composition and other characters seem to connect it with the variety sometimes called fassaite.

Lilac pyroxene in yellow scapolite.

Examples of other varieties of pyroxene may be met with at almost any of the apatite mines. They vary much in colour, usually being of some shade of green or grey, but sometimes white or brown. Lower down the Ottawa, in the augmentation of Grenville, a beautiful lilac pyroxene occurs, the crystals of which are sometimes imbedded in a pale lemon-yellow scapolite.

Large crystals.

Now and then crystals of large dimensions are obtained. One, for example, from the township of Templeton is eleven and a half inches in circumference, nine inches long, and weighs eight and one-third pounds. Large crystals have also been found on the sixth lot of the first range of Portland township, and a portion of one now in the museum of the Geological Survey weighs about twelve pounds. Some of them, though dull outwardly, are glassy within, and of a pale bottle-green colour.

Forms of crystals.

The simplest forms observed are crystals of sahlite showing the following combination: $\infty P\infty$. ∞P. [$\infty P\infty$]. $P\infty$. P. Other planes are, however, frequently present, and among them $2P$. $3P$.–P. and oP. Sometimes the crystals of sahlite are striated longitudinally, and they are often much flattened in the direction of the orthodiagonal. One, for example, having a width of an inch and eight-tenths, measured only seven-tenths of an inch in thickness; another, an inch and a half wide, was five-eighths of an inch thick, while a third measured two and a quarter inches by eight-tenths of an inch—giving an average width of over two and a half times that of the thickness.

Flat crystals.

In the township of Templeton well crystallised pyroxene is often found in veins unaccompanied by apatite, for which mineral, however, it has frequently been mistaken. As affording a good example of this, a vein occurring on the twenty-fourth lot of the ninth range may be mentioned. Good crystals of more or less glassy, subtranslucent green pyroxene are here imbedded in a pale flesh-coloured calcite. They vary in length from a couple of inches downwards, and are often well terminated at both ends. They are almost invariably flattened in the direction of the clinodiagonal, and show the following planes: ∞P. [$\infty P\infty$]. $\infty P\infty$. $P\infty$. P. $2P$.–P. oP., and sometimes [$2P\infty$]. The specific gravity of a crystal was found to be 3·232. Scales of mica sometimes coat the crystals, or are enclosed in them.

On lot thirteen in the eighth range of Templeton a white to greyish-white or greenish-white pyroxene occurs, small quantities of which were at one time mined under the supposition that the mineral was apatite. The crystals exhibit the same planes as those just described, but are less frequently flattened in the direction of the clinopinacoid.

The enclosure of mica in pyroxene crystals, which has already been alluded to, may frequently be observed, and in some instances the scales or crystals of mica may be seen to be more or less symmetrically arranged with reference to the planes of the pyroxene. On the seventeenth lot of the ninth range of Templeton large crystals were observed, showing a central portion of dark green pyroxene surrounded by a zone of minute scales of mica, while the outer portion of the crystal was pale green pyroxene. Other inclusions also are common, and among them calcite, apatite and orthoclase. Not infrequently also pyroxene crystals are rounded as if by the action of some solvent, but this is much less common than in the case of apatite. Sometimes they have been cracked or broken in two; and the spaces between the pieces filled up with calcite, apatite, or some other mineral. In one case, a crystal four inches in diameter was observed which had been fractured and re-cemented with apatite. Mica in pyroxene.

The most interesting peculiarity observed, however, is the tendency which the pyroxene in some localities exhibits to become altered into a kind of uralite. This name was long ago given by Gustav Rose to crystals possessing the form of pyroxene but cleavage and other characters of hornblende, and first observed by him in certain rocks from the Urals, which he termed uralite porphyries. The larger crystals were found to freqently contain a kernel of pyroxene, which in the smaller ones had entirely disappeared. In the case of pyroxene from Arendal in Norway also, Rose observed a perfect transition from lustrous crystals showing no apparent trace of hornblende within to others with drusy surfaces, in which no trace of augite could be detected.* Uralite.

Crystals of pyroxene from Traversella afford another example of a change of this kind. The unaltered crystals are described as transparent and glassy, but on being altered become opaque, and often assume a silky lustre. In this opaque portion fine fibres running parallel to the principal axis begin to be developed, and, as the change advances, distinctly recognizable individuals of hornblende are formed, also parallel to the principal axis and looking like actinolite.†

Of late years, by the aid of the microscope, it has been demonstrated that the development of uralite has taken place in many crystalline rocks, not only in Europe but on this side of the Atlantic. In the case of diabase, the change of this kind has been described by Rosenbusch as follows: ‡—"The alteration processes to which the augite of

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* Bischof, *Lehrbuch der Geologie*, 1864, pp. 623, 624.

† *Lehrbuch der Geologie*, Bischoff, 1851, p. 539.

‡ *Mikroskop. Physiogr. d. massigen Gesteine*, 1877, p. 330.

Uralite in diabase.

diabase is subject is one of most varied character. Ordinarily, they begin with the formation of a vertical fibrous structure. At the same time the fibres often take the form of well-defined uralite, and in this case the process commonly begins from the entire periphery of the augite, and proceeds thence towards the centre, in general more rapidly in the direction of the vertical axis than at right angles to it. So long, then, as the process is not wholly completed, there remain in the interior portions of augite with irregular outline. Less frequently, or rather only in exceptional cases, the formation of uralite does not begin along the whole circumference, but attacks only single narrow strips in a vertical direction, so that thin columns of augite and uralite, parallel to the vertical axis, alternate with one another. The uralite itself passes on still further alterations of the rock into chlorite, and this finally into a mixture of brown iron ore, quartz and carbonates.*

Uralite of Templeton.

The above facts have been cited because of interest in connection with what now follows concerning the alteration of certain pyroxenes in the apatite region of Quebec. The best examples were observed at the mines of Mr. Breckon, on the twenty-third lot of the thirteenth range of Templeton, where crystals have been obtained showing perfectly the transition from pyroxene to what may be called uralite. The crystals are mostly flattened in the direction of the orthodiagonal, and while some of them are apparently quite unaltered, others have been converted into hornblende for a greater or less depth from the surface; others, again, are entirely changed to hornblende, and show no trace of pyroxene even when sliced and examined microscopically. In the first stage of alteration the pyroxene, which in its original condition is glassy and of a grey colour, becomes more or less dull and greenish or greyish-white, still, however, retaining the cleavage of pyroxene. In this pale portion acicular prisms of green hornblende begin to be developed, gradually increasing until, in some cases, all trace of pyroxene is obliterated. The change appears to have always begun at the surface of the crystals, extending inwards more rapidly in some parts of the crystals than in others, but although the hornblende prisms at the surface appear to be mostly parallel with the principal axis, within they are seen to run in every direction, or in some cases to be arranged in radiating groups. Intermingled with the hornblende prisms a little calcite occurs in places.

Even when the crystals have been entirely changed to hornblende the pyroxene angles remain perfectly distinct, and one crystal with

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* For other interesting details concerning uralite see Zirkel, *Mik. Beschaff. d. Min. u. Gest.* p. 178. Also Rosenbusch, *Mik. Physiog. d. Min.*, p. 316.

In the case of an "augite syenite," from Jackson, N.H., Mr. G. W. Hawes has observed an alteration of augite into compact brown hornblende instead of into the usual fibrous green uralitic mass.—*Geology of New Hampshire*, Part IV., 1878; p. 205.

terminal planes shows the following combination: $\infty P \infty$. ∞P. $[\infty P \infty]$. $P\infty$.$-P$. $2P$. The crystal is an inch and seven-eighths wide and a little over half an inch thick. The remaining portion of another crystal, which has lost its terminal planes, is three inches wide and an inch thick, and apparently wholly uralite. The crystal which supplied the material for the following analyses was about an inch and three-quarters wide and an inch thick. The centre consisted of glassy grey pyroxene, surrounded, however, by the dull and pale material described above, and this was surrounded in turn by an aggregation of hornblende prisms. These three portions may be called respectively A., B. and C. A. resembled in appearance much of the ordinary pyroxene of the region, from which also it probably does not differ much in composition. The specific gravity was found to be 3·181, and it gave on analysis the following results:— Analyses of pyroxene and uralite.

A.

Silica	50·868
Alumina	4·568
Ferric oxide	0·970
Ferrous oxide	1·963
Manganous oxide	0·148
Lime	24·438
Magnesia	15·372
Potash	0·497
Soda	0·218
Loss on ignition	1·439
	100·481

This is the composition of an aluminous diopside or malacolite, and, except in the larger proportion of iron, resembles that of pyroxene from Grenville and Bathurst.* The following analysis of B., the white portion of the crystal, shows that, chemically, no great amount of change had taken place. The specific gravity (3·205) was also about the same as that of A:—

B.

Silica	50·898
Alumina	4·825
Ferric oxide	1·711
Ferrous oxide	1·358
Manganous oxide	0·152
Lime	24·392
Magnesia	15·268
Potash	0·150
Soda	0·076
Loss on ignition	1·200
	100·060

* See analysis, Report of Progress, 1874-75, p. 302, and Geology of Canada, 1863, p. 467.

It will be observed that although the total amount of iron in A. and B. is almost identical, more of it exists as ferric oxide in B. than in A. The quantity of alkalies is also only about one-third of the amount found in A.

If now we pass to C., the uralitic portion of the crystal, the changes are much more striking, as will be seen from the following analysis:

C.

Silica	52·823
Alumina	3·215
Ferric oxide	2·067
Ferrous oxide	2·709
Manganous oxide	0·276
Lime	15·389
Magnesia	19·042
Potash	0·686
Soda	0·898
Loss on ignition	2·403
	99·508

The specific gravity in this case was only 3·003. Comparing C. with A. and B. we find that the lime is diminished by about nine per cent., while there is a gain of about four and a half per cent. of magnesia. The ratio of loss and gain, however, is not that of the molecular weights of lime and magnesia; that is to say, for a molecule of lime lost a molecule of magnesia has not been gained. A portion of lime has been lost without its place being taken by magnesia. At the same time there is a slight increase of silica relatively to the other constituents, and, as would be expected, a decrease in density.

Differences in composition of pyroxene and hornblende.

It is well known that pyroxene commonly contains more lime and less magnesia than hornblende, and in the present case loss of lime and gain of magnesia would appear to be the principal cause determining the change to hornblende. The larger proportion of alkalies in the uralitic or hornblendic proportion of the crystal is also worthy of note, because hornblende is commonly richer in alkalies than pyroxene. On the other hand, it is interesting to observe that there is less alumina in the hornblendic product than in the original pyroxene, for, as a rule, hornblende is apt to contain more alumina than pyroxene. This subject has recently been discussed by Mr. G. W. Hawes in his valuable report on the mineralogy and lithology of New Hampshire. He there gives some interesting analyses to illustrate the differences in the composition of pyroxene and hornblende, and seems to regard preponderance of alumina as the principal cause determining the formation of the latter species. At the same time, however, he does not loose sight of the fact that pyroxene usually contains more lime and less alkalies than hornblende.

Analyses of pyroxene &c.

In the following table the analyses of A., B. and C. are included together with analyses of pyroxene from Grenville (D.) and Bathurst (E.), and also of hornblende from the High Falls of the Madawaska, in Ontario (F.), and from Edenville in New York State (G). E. and F. are by Hunt, and G. by Rammelsberg. D. is from the Report of Progress for 1874-75, p. 302 :—

	A.	B.	C.	D.	E.	F.	G.
Silica	50·868	50·898	52·823	51·27	51·50	55·05	51·67
Alumina	4·568	4·825	3·215	4·00	6·15	4·50	5·75
Ferric oxide	0·970	1·711	2·067	0·10	0·35	..	2·86
Ferrous oxide	1·963	1·358	2·709	..	..	5·85	..
Manganous oxide	0·148	0·152	0·276	..	..	..	..
Lime	24·138	24·392	15·389	25·27	23·80	13·44	12·42
Magnesia	15·372	15·268	19·042	17·46	17·69	20·95	23·37
Potash	0·197	0·150	0·686	0·14	..	..	0·84
Soda	0·218	0·076	0·898	0·62	..	..	0·75
Ignition	1·439	1·200	2·403	1·63	1·10	0·35	0·46
	100,481	100·060	9[illegible]·08	100·49	100·59	100·14	98·12

The uralitic portion of the crystal, it will be seen, does not differ greatly in composition from the hornblende (pargasite) of the High Falls of the Madawaska, nor from the so-called edenite of Edenville. The pyroxene, too, somewhat resembles the aluminous diopsides (D. E.) of Grenville and Bathurst.

Paramorphism.

The formation of uralite is spoken of by some writers as though it were an example of paramorphism, but I have been unable to find analyses proving that this has anywhere been shown to be the case. That in the above instance, at least, we have an example of true pseudomorphism, cannot reasonably be doubted. For, in some cases, we have not so much as a nucleus of pyroxene whose "crystallogenic force" might be supposed to induce the hornblende prisms to arrange themselves in the form of a pyroxene crystal, and without such a predisposing cause it is hard to understand why hornblende prisms should adopt such an arrangement.

Other examples of supposed alteration of pyroxene to hornblende were observed on the seventeenth lot of the ninth range and the twenty-first lot of the twelfth range of Templeton, and also on the sixth lot of the first range of Portland. One crystal, from the first of these localities, was no less than a foot in circumference. It exhibited the prismatic angles of pyroxene, and on being broken in two was seen to consist almost entirely of a greyish-green fibrous mineral, which is evidently hornblende. Rude crystals from the Grant Mine in Buckingham appear to be pseudomorphs of asbestus after pyroxene.

Asbestus.

Hornblende.

Hornblende, as an original constituent of the apatite-bearing veins, is of far more common occurrence than the pseudomorphous minerals described above, and is occasionally one of the principal constituents of the veins, often occurring near to the walls. It does not, however, appear to be nearly as abundant as in the Norwegian apatite districts, where some of the veins are characterised by Brögger and Reusch as "apatite-bearing hornblende veins." With us pyroxene usually takes the place of the hornblende. The latter varies in colour from pale green to deep olive-green. As yet none of it has been analysed, but while it may in some cases have the composition of actinolite, most of it is probably the aluminous variety known as pargasite. Much of it resembles in appearance the uralite, of which an analysis has been given on page 22. Crystals with terminations were not seen, but beautiful blades with the characteristic angle of hornblende are common, penetrating calcite, or more rarely apatite, quartz, &c. Among the minerals imbedded in hornblende, mica and apatite are, perhaps, the most common, but calcite, titanite and others also occur.

Actinolite and pargasite.

An interesting specimen from the Grant lot in Buckingham apparently consists of the so-called mountain-leather, which is usually regarded as a variety of hornblende. At the same locality asbestus occurs, but in some cases at least, as stated above, appears to be an alteration product of pyroxene.

Mountain leather.

Phlogopite.

According to Brögger and Reusch, phlogopite is an exceedingly abundant mineral in the veins of Oedegarden, in the Bamle district, Norway, and, judging from their description, its mode of occurrence is in many respects very similar to that of the mica found in the apatite regions of this country. They state that "a brown magnesia-mica is in many veins almost the only mineral, but frequently accompanied by green enstatite, together with small masses of apatite. As the quantity of mica decreases and that of the apatite increases, the character of the veins changes. The richer veins are distinguished by the fact that mica almost exclusively occupies the sides of the veins and apatite the centre." Adjoining the wall-rock the mica is said to occur mostly in small scales, while in the middle of the veins it is in large plates. The veins in which mica is the predominant constituent are termed by Brögger and Reusch "apatite-bearing mica veins." Few, if any, of the veins which I have seen in the Ottawa district could properly have this designation applied to them, notwithstanding that phlogopite is one of the most common of the minerals accompanying

Abundance of phlogopite in Norway.

Phlogopite of Ottawa district.

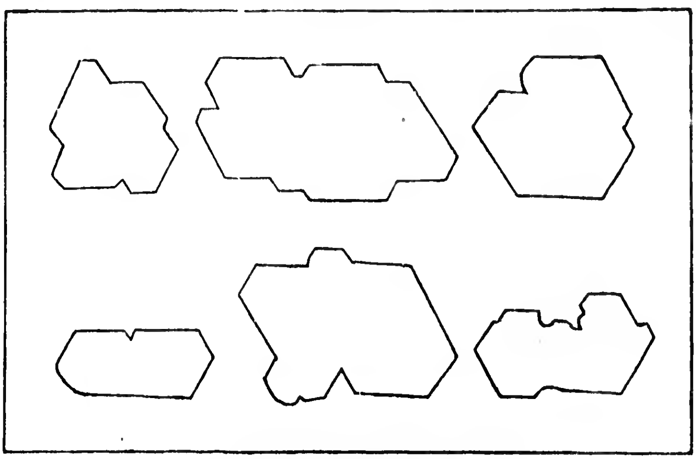
the apatite; but as an example of one which is very largely composed of mica, may be mentioned a vein in the first range of Portland township. It is about twenty-four feet thick, and contains numerous lenticular masses of apatite, sometimes several feet in diameter, imbedded in phlogopite and pyroxene. The mica is partly in fine scales, but sometimes in plates more than fifteen inches wide. From an opening at this locality, about thirty-five feet deep, several hundred tons of very fine apatite have been extracted.

In some instances mica lines the walls of veins, while the centre is filled with apatite. As in Norway also, mica in fine scales is sometimes found adjoining the walls, while large crystals occur in the central portions of the vein. Large crystals are, however, quite as often found near the walls, and in some cases are scattered indiscriminately through all parts of the vein.

Minerals accompanying phlogopite.

Among the minerals in which phlogopite is found imbedded are apatite, calcite, pyroxene, hornblende, scapolite, and zircon. On the other hand, the phlogopite often contains calcite and apatite, these minerals occuping cavities whose forms frequently have some relation to the prismatic faces of the mica crystals. Or the calcite, and more rarely the apatite, may form thin films between the layers of mica. In a few instances, small prisms of apatite were observed penetrating phlogopite crystals.

Fig. 8.



OUTLINES OF PHLOGOPITE CRYSTALS.

The phlogopite crystals* from many localities in Templeton and the adjoining townships are, as in the Burgess region, often of great beauty.

* According to the latest observations on the subject, phlogopite is monoclinic in crystallisation.

They vary in lustre from pearly to almost metallic, and in colour from yellowish or reddish-brown to almost black. The prisms are usually tapering, and the lateral planes often perfectly smooth or polished. Compound crystals are common, and often have curious outlines, such as are shown in the accompanying figure. (Fig. 8. Outlines traced from the crystals themselves and reduced to one-fourth natural size.)

Bent and corrugated crystals.

Remarkable examples of bent and corrugated or wrinkled crystals are very common, and crystals have been found with beautiful markings parallel to the prismatic faces.

Though large plates of mica occur in many of the apatite veins, they are rarely of economic value owing to unevenness, the presence of calcite or other impurities, and too dark colour. In some cases, also, they are said to exfoliate on heating. Muscovite is not known to occur in any of the apatite deposits of the region in question.

Muscovite.

GARNET.

Several varieties of garnet have been met with in the apatite-bearing veins of Ottawa County, although, so far as known, they are by no means common. A dark red specimen from lot twelve in the twelfth range of Templeton is probably almandine or common garnet. It was imbedded in orthoclase. In the townships of Wakefield and Portland specimens of essonite or cinnamon-stone have been found, and in some cases mistaken for apatite. This variety is found both massive and crystallised in rhombic dodecahedrons. Among the minerals immediately associated with it, besides apatite there are quartz, feldspar, calcite, and idocrase—prisms of the last being imbedded in the garnet. A more or less smoky amber-yellow garnet has been found in the township of Hull, but whether associated with apatite or not I am unaware. The crystals are highly lustrous, and show planes of the dodecahedron and trapezohedron.

Almandine and essonite.

Chrome-garnet?

A beautiful emerald-green chromiferous mineral occurs in the township of Wakefield, associated with apatite, pyroxene and tourmaline. In colour and lustre it closely resembles ouvarovite or chrome-garnet. Although one specimen seems to exhibit prismatic structure, another shows faces apparently of a rhombic dodecahedron—three planes meeting at 120°. As the presence of chromium does not seem to have been hitherto recognised with certainty in any of our Laurentian minerals, this one must be regarded as of particular interest, and a quantitative analysis of it will shortly be made.

As we have already seen, garnets are common in some of the gneisses of the region, and have also been observed, though rarely, in the pyroxenites.

Epidote.

Epidote.

In addition to its occurrence in some of the stratified rocks of the region, epidote has, in a few cases, been met with as a constituent of the apatite deposits. One locality is on lot nine of the tenth, another on lot twenty-three of the thirteenth range of Templeton. At the former it is associated with dark green pyroxene, pyrite and calcite; at the latter with hornblende, pyroxene, orthoclase, scapolite, pyrite and calcite. In both cases the mineral is yellowish-green, and fuses with much intumescence to a black slag. In the closed tube it gives, as is usually the case with epidote, a little water.

Idocrase or Vesuvianite.

Idocrase

Beautiful crystals of brownish-red idocrase, nearly an inch in diameter, have been found in the township of Templeton, but whether from one of the apatite veins I have been unable to ascertain. Small prisms of green idocrase imbedded in cinnamon-stone have also been obtained from the township of Wakefield, being in this case associated with apatite.

Tourmaline.

Black tourmaline.

The only variety of this mineral noticed in any of the apatite-bearing veins is the ordinary black tourmaline, but this is of quite common occurrence. The best crystals are usually imbedded in calcite, but they are brittle and not often obtained with terminations. In one case a triangular prism, about an inch and a half long and nearly half an inch across the faces of the prism, had been broken in two, and the space between the parts filled with calcite. Other minerals besides the calcite in which tourmaline occurs are apatite, pyroxene, quartz, scapolite and orthoclase, and in one instance small prisms were observed imbedded in fluor-spar. The tourmaline prisms are sometimes aggregated into radiating groups, and this is the case not only in some of the apatite veins but also with tourmaline which sometimes occurs in joints in the quartzites.

Radiating prisms.

Titanite or Sphene.

As in the Burgess region, so here this is one of the most common of the mineral associates of apatite, and occurs both in the veins and in some of the stratified rocks of the region. In the veins the crystals of sphene are imbedded in various minerals, among which are apatite, pyroxene, hornblende, orthoclase, calcite and scapolite. The crystals are of various shades of brown, and commonly subtranslucent. They vary in size from merely microscopic ones to others measuring several inches across. As a rule, however, they are very brittle, and difficult to obtain in a perfect condition. Many of them contain rounded grains of calcite like those found in crystals of apatite and pyroxene. In composition they probably resemble the sphene of Grenville, an analysis of which—made many years ago, but never published—gave me the following results:—

Analysis of sphene.

Silica	32·09
Titanic acid	37·06
Ferrous oxide	1·16
Lime	28·50
Loss on ignition	0·66
	99·47

Specimens of sphene may be found at almost any of the apatite mines, but the largest which I have seen occur at Breckon's Mine on lot twenty-three of the thirteenth range of Templeton. They were here, however, very brittle, and no good specimens were obtained. In the museum there are fairly good crystals collected by Mr. Frank Adams on the south-east half of lot eight in the fourteenth range of Hull.

Zircon.

This interesting mineral is one of frequent occurrence in the apatite veins of Templeton and the adjoining townships, and is sometimes found in crystals of great beauty. The crystals almost always consist of a square prism terminated by planes of two square pyramids and a zirconoid or octagonal pyramid (∞P. P. 3P. 3P3.), and, so far as observed, the faces of the secondary prism, ∞P∞, are always wanting. Crystals which have been found on lot twenty-one of the twelfth range of Templeton present a simpler combination than the above, consisting only of the square prism ∞P. combined with the unit octahedron P.* They differ, too, not only in form but in colour, and in having a lower specific gravity.

Forms of zircon crystals.

Through unequal development, especially of the terminal planes, the zircon crystals are often much distorted. Occasionally, also, they are aggregated in groups parallel to the vertical axis. In size the crystals vary greatly, but one from the twenty-third lot of the thirteenth range of Templeton (belonging to Mr. Miller, of Templeton,) is four and a

Large zircon crystals.

* This is the form of all the crystals which I have seen from Grenville. Small crystals from the sixth range of North Burgess, Ontario, said to come from a granitic vein, show the combination ∞P. 3P. P. 3P3., and occasionally have faces of the secondary prism ∞P∞. Many of them have 3P. developed to a much greater extent than P., and therefore have a curious pointed or tapering appearance.

half inches in length and an inch across each of the faces of the prism. This is, however, only part of the crystal, and how much longer it was originally is not known. A crystal fifteen inches long is also reported to have been found at the same locality by a miner, who was unfortunately unaware of its value and broke it in pieces with his hammer. A crytal presented to the museum of the Geological Survey by Mr. F. W. Henshaw is over an inch long and about half an inch square, and shows the ordinary combination ∞ P. P. 3P. 3P3. Another, presented to the museum of McGill College by Mr. Miller, is an inch and three-quarters long. It is flattened prismatically, so that while it measures half an inch one way, it is only a quarter of an inch thick.

The best zircons are hyacinth-red to cherry-red in colour, but others are reddish-brown and more rarely greyish. A crystal from the "Bishop Pit," on the twenty-first lot of the thirteenth range of Templeton, resembles somewhat in colour the greyish crystals from Buncombe County in North Carolina, but has a pinkish tinge at the extremity. Its specific gravity is only 4·482, while that of one of the dark red crystals from lot twelve in the twelfth range was found to be 4·614.* Many of the crystals are subtransparent, but they range from this to almost opaque. Though they commonly have a high lustre, few, if any, could be used as gems, for they are usually brittle and full of flaws. They are also apt to contain inclusions of other minerals, among which are apatite, calcite and mica, the last being probably the most common. The calcite occurs in little rounded masses analogous to those which are so common in the apatite and pyroxene crystals. The minerals in which the zircons have been found imbedded are apatite, calcite, orthoclase, pyroxene, phlogopite, black tourmaline, and prehnite. The apatite containing the zircons is usually a fine-granular variety, but in one instance a small prism of zircon was found imbedded in a large crystal of green apatite.

Specific gravity of zircon.

Zircon is now known to be a far more widely diffused mineral than was formerly supposed, its presence having been detected in many crystalline rocks both in Europe and America.† The crystals are sometimes macroscopic, as in the so-called zircon syenite of Norway, but more frequently can only be seen with the microscope. Among

Frequent occurrence of zircon in crystalline rocks.

* This is almost exactly the density of the Grenville zircon, which, according to Hunt, is 4·625-4·602.

† See Rosenbusch, *Mik. Physiog. d. Min.*, p. 189. Also the magnificent reports on the Geological Exploration of the Fortieth Parallel, published under the direction of Mr. Clarence King, Volumes I., II. and VI. In Volume I. (p. 397) of this series, Mr. R. W. Woodward, Chemist of the Exploration, describes a new method for the detection of small quantities of zirconia due to the presence of zircon in rocks. It is based upon the fact that zircon is but slightly acted upon by hydrofluoric acid.

The occurrence of zircon in some of the granites and gneisses of New Hampshire is described by Mr. G. Hawes in his report on the Geology and Lithology of that State.

the rocks in which it has been observed are granite, syenite, gneiss, mica-schist, felsite, eklogite, basalt, hypersthenite, &c.

ORTHOCLASE.

Orthoclase.

We have already referred to orthoclase as a constituent of the gneisses and pyroxenites; but in addition to its occurrence in these stratified rocks it is also common in veins cutting them, including many of the apatite-bearing veins. The orthoclase of these veins is very often white, but at other times flesh-coloured, grey, lavender, green and other colours. The green has been found in both Templeton and Hull; in the latter township in masses of considerable size. Orthoclase crystals are sometimes found in cavities, but more frequently the mineral is massive and often coarse-crystalline in texture. Masses with broad cleavage surfaces are often imbedded in a ground-mass of paler colour and finer texture, also consisting of orthoclase or orthoclase and quartz. Rude crystals and masses presenting broad cleavage surfaces have been found by Mr. Miller on lot thirteen of the eleventh range of Templeton, which appear to have been acted upon by some solvent which has eaten the feldspar into curious corrugated channels or cavities, while the black pyroxene accompanying the feldspar has been but little affected. Among the minerals imbedded in the orthoclase of many of the veins, besides quartz, there are apatite, pyroxene, hornblende, sphene (very common, and sometimes in large crystals), zircon, mica, tourmaline, and calcite.

In a few cases granitic veins, or possibly true dykes, were observed cutting sharply across the apatite veins, and therefore of more recent origin. One of them, occurring on lot twelve in the twelfth range of Templeton, is eighteen inches thick, and bears S. 18° E. Another, on lot eight in the tenth range of the same township, is two feet thick, and bears north and south.*

ALBITE.

Occurrence of albite.

This species of feldspar has been found in a few localities in the township of Templeton, associated with apatite, sphene, pyroxene, &c. Cavities or crevices in the last-named minerals have drusy linings of albite crystals, which, on analysis, have been found to contain—

Potash	2·75
Soda	8·96
	11·71 p.c.

*For analyses of orthoclase from Buckingham township,—associated with graphite, but similar in appearance to much of what occurs with the apatite—see Mr. Christian Hoffmann's Report published last year.—*Report of Progress*, 1876-77, p. 511.

Scapolite.

Scapolite group of minerals.

This name is now made by many mineralogists to include a group of closely related minerals, all of which are tetragonal in crystallisation, and consist of silicates of alumina and lime, with, or in some cases without, soda. The most important member of the group is wernerite, and to this species much of our scapolite probably belongs, but until more analyses have been made the general term scapolite must be used.

Scapolite localities.

Scapolite is a common mineral in the Laurentian, and has hitherto been observed at a number of localities, including Hunterstown, Grenville, Calumet Island, Golden Lake (Renfrew County), &c.* In the region more particularly referred to at present, it has been found as a constituent of the apatite-bearing veins in many localities, among which the following may be mentioned:

Templeton—Lot	13, Range	XI.	Templeton—Lot	21, Range	XII.
" — "	12, "	XII.	" — "	23, "	XIII.
" — "	14, "	XII.	Portland — "	6, "	I.

Hull—Lot 8, Range XIV.

The best crystals which I have seen are from lot fourteen in the twelfth range of Templeton. Very large ones (sometimes more than a foot in length), but of rude form, have been found on the twenty-third lot of the thirteenth range, where an enormous vein of massive scapolite occurs.

Form of scapolite crystals.

The crystals from the different localities are, on the whole, very similar, but occasionally present points of difference. Usually they are short and thick, but sometimes slender. The simplest forms observed consist of a combination of the two square prisms—the faces of the secondary greatly predominating—with the unit octahedron or square pyramid ($\infty P\infty \,.\, \infty P.\ P.$). Good examples of these were seen at a small opening on the twenty-third lot of the thirteenth range of Templeton, the crystals being unusually long for their thickness. The more commonly occurring crystals, however, exhibit a much larger number of planes. Some of those, for example, from the fourteenth lot of the twelfth range of Templeton show the following:

Prismatic	$\infty P\infty$ $\infty P.$ $\infty P2.$	Pyramidal.......	3P. $P\infty$. 3P3.

Basal, oP.

All these are sometimes found in single crystals, but ∞ P2 and 3P3, as is frequently the case with crystals from other regions, are hemihe-

* See Geology of Canada, 1863, p. 473. Also Chapman, Minerals and Geology of Central Canada, Toronto, 1871, p. 113.

dral in arrangement. Occasionally the faces ∞ P. are more fully developed than ∞ P∞, but the reverse is usually true. The colour of the scapolite varies mostly from white to grey or greenish-grey, but sometimes there is a pinkish tinge. A massive variety from further down the Ottawa, in the augmentation of Grenville, is of a pale lemon-yellow colour, and holds imbedded crystals of lilac pyroxene. The surfaces of the scapolite crystals are often dull, owing, no doubt, to partial decomposition, and sometimes much stained with oxide of iron. The decomposed portion, however, usually forms only a thin crust, beneath which the mineral appears white and exhibits its characteristic fibrous texture and cleavage. Not infrequently the crystals look as if they had been submitted to pressure while in a soft or plastic state, and have had their faces curved, or have been bulged out at the base where attached to the rock. In other cases they have been too hard to yield readily to the pressure, and have been cracked or broken, the spaces being sometimes filled with other minerals.

Many of the best scapolite crystals are imbedded in calcite, and they are very often accompanied by pyroxene. Apatite, titanite, tourmaline and other minerals are frequently imbedded in the scapolite.

Analysis by Mr. Frank Adams.

During the past summer Mr. Frank D. Adams, while engaged on one of the survey parties in tracing out some of the trap dykes north of the Ottawa, found specimens of scapolite on lot thirteen of the eighth range of Ripon, one of which he subsequently analysed at the Sheffield Scientific School, New Haven, with the following results :*

Silica	54·859
Alumina	22·448
Ferric oxide	0·486
Lime	9·092
Magnesia	trace
Potash	1·127
Soda	8·365
Chlorine	2·411
Sulphuric acid (SO_3)	0·796
Water (combined)	0·722
Water (hygroscopic)	0·141
	100·447
Deduction for O replaced by chlorine	.59
	99·857

Chlorine in scapolites.

The presence of chlorine in scapolites seems to have been previously almost entirely overlooked, and its detection, as well as that of sul-

* On the Presence of Chlorine in Scapolites ; by Frank D. Adams. Contributions from the Laboratory of the Sheffield Scientific School.—*American Journal of Science*, April, 1879, p. 315.

phuric acid, in the present instance, is a fact of much interest. In order to ascertain whether this was an exceptional case, fourteen other specimens of scapolite were examined by Mr. Adams, and chlorine found in them all, although in some cases the amount was small. The above analysis shows the scapolite from Ripon to be more highly acidic than most of the members of the scapolite family.

Wilsonite.

This name was many years ago given by Dr. Hunt to a mineral occurring in the township of Bathurst, where it was first observed by Dr. Wilson, formerly of Perth. By some mineralogists it is regarded as an altered scapolite, with which mineral Chapman has shown it to agree in cleavage. Hunt, on the other hand, regards it as a variety of gieseckite, and discards the idea of its being an alteration product of scapolite. (Geology of Canada, 1863, p. 483.) **Wilsonite an altered scapolite.**

In the townships of Templeton and Hull, a mineral with the rose-red colour and other characters of wilsonite occurs at many of the apatite mines, and certainly appears to be an alteration product of scapolite. In all the specimens seen the two minerals occurred together, and appeared to merge one into the other, the cleavage of the two minerals being continuous. Among the localities in which the wilsonite has been found are Templeton, lots twelve and twenty-three in the thirteenth, and twenty-one in the twelfth range, and Hull, lot four, range ten.

Steatite.

A soft ($H = 2 - 2\frac{1}{2}$) steatitic mineral of grey or greenish-grey colour occurs in some of the apatite veins, and is, perhaps, in some cases of the nature of pyrallolite. Specimens from Mr. Miller's "Old Red Pit," at the Fidelity Mines in Templeton, are subtranslucent, very compact, soapy in feel, and have a distinct conchoidal fracture. The mass is here and there penetrated by a prismatic mineral, which looks as if it had originally been hornblende, but which is now quite as soft as the material in which it is imbedded. In some cases bright green prisms of apatite are imbedded in a grey steatitic mineral, which in one instance looks as if it were pseudomorphous after mica. **Pyrallolite.**

Chlorite.

Under this general name mineralogists include a number of foliated minerals, which, though differing considerably in the relative proportions of their constituents, are, for the most part, hydrous silicates of magnesia, ferrous oxide, and alumina. At several of the apatite mines of Templeton a green chlorite-like mineral has been observed, and a specimen from the north-west half of lot eighteen in the ninth range of that township has been examined. The chloritic mineral in this case was associated with apatite, quartz, iron pyrites and calcite, and occurred in uneven folia, mostly of an olive-green colour, and with a pearly lustre. The hardness was $2\frac{1}{2}$, and specific gravity 2·61. Folia flexible, but scarcely elastic. An analysis gave the following results:

Analysis of chlorite.

Silica	35·80
Alumina	13·18
Ferric oxide	4·28
Ferrous oxide	10·18
Magnesia	22·80
Water	12·64
	98·88

This, it will be seen, is approximately the composition of ripidolite, with part of the alumina replaced by ferric oxide and part of the magnesia by ferrous oxide. The silica is higher than in ripidolite, but this is probably due to the presence of a little quartz, which was difficult to separate perfectly. The quantivalent ratio for $R : R_2 : Si : H$, deduced from the above figures, is 5 : 3 : 8 : $4\frac{1}{2}$, while for ripidolite it is 5 : 3 : 6 : 4.

PREHNITE.

This mineral, which is of frequent occurrence in connection with the copper-bearing rocks of Lake Superior, has not heretofore been found in the Laurentian of Canada. I am indebted to Mr. J. G. Miller for a specimen from lot sixteen in the twelfth range of Templeton.

The mineral is translucent and of a yellowish-white colour, with a greenish tinge in places. It seems to have occurred in a cavity, and shows rounded surfaces made up of an aggregation of crystals. The hardness is a little above 6, and specific gravity 2·891. Analysis gave the following results:

Analysis of prehnite.

Silica	42·82
Alumina	23·86
Ferric oxide	1·42
Manganous oxide	0·10
Lime	27·64
Magnesia	0·09
Water	4·82
	100·75

Before the blow-pipe the mineral fuses easily and with much intumescence.

The hardness of prehnite serves to distinguish it readily from members of the zeolite family, with some of which it might be confounded.

Chabazite.

"Zeolitic" minerals are said to have been observed in some of the apatite-bearing veins of North Burgess, but no particular species seems to have been identified. Among minerals collected last summer at the "Bishop Pit," on the twenty-first lot of the twelfth range of Templeton, chabazite has been detected. It occurs in small colourless or white, glassy crystals, in irregular cavities in scapolite and pyroxene. The crystals, which are mostly under an eighth of an inch in diameter, are obtuse rhombohedrons, and many of them penetration twins. Chabazite identified.

The chabazite, like the last mineral described, is evidently of secondary origin, and possibly derived from the scapolite.*

Hematite.

Peroxide of iron occasionally occurs enclosed in quartz in some of the apatite veins, and is also the colouring matter of the ordinary red apatite. In a crystalline condition it has not been met with in the Ottawa phosphate region, though sometimes associated with apatite in Ontario. Hematite.

Rutile.

This mineral is reported to occur in some of the apatite-bearing veins, but I was not successful in finding any. Specimens of supposed rutile from Templeton prove to be only peroxide of iron enclosed in glassy quartz. In Norway rutile is said to be one of the most characteristic minerals of the apatite veins, and Brögger and Reusch state that if it were of any economic value it could be obtained in large quantity. One crystal found by them weighed no less than 1140 grammes.† Rutile in Norway.

Pyrite.

Though not usually a very abundant constituent of the apatite veins, pyrite is nevertheless of frequent occurrence. It is commonly massive,

* Since the above notes were in type, Mr. Miller has kindly forwarded me a number of interesting specimens. Among them is one of prehnite from lot twenty-three in the thirteenth range of Templeton, occurring in a cavity in apatite, a crystal of the latter mineral being imbedded in the prehnite. Also a specimen of chabazite from a new locality (Portland West, lot twenty-one, range twelve), and other zeolitic minerals, one of which is evidently natrolite.

† Small crystals of rutile have been found, since the above was written, in an apatite vein on the tenth lot of the tenth range of Templeton.

Crystals of pyrite.

but sometimes occurs in well-defined crystals (cubes, octahedrons, or combinations of those forms). In some cases pyrite is imbedded ' apatite, but, on the other hand, rounded crystals of green apatite c imbedded in pyrite. At the Grant Mine, in Buckingham, very liant iron pyrites was observed, imbedded in fine granular calcite, both the pyrites and calcite being penetrated by small rounded prisms of pale yellowish-green apatite.

PYRRHOTITE.

In some of the apatite-bearing veins of Norway pyrrhotite or magnetic pyrites is a very abundant mineral, and is sometimes accompanied by ordinary pyrites. Examples are given by Brögger and Reusch of veins in which pyrrhotite is the predominant mineral. The apatite is imbedded in the pyrrhotite, and usually in the form of much rounded crystals.

In the Ottawa district pyrrhotite is sometimes met with in the apatite veins, but, so far as yet observed, never forms such an abundant constituent as in Norway. It is also found associated with apatite in Ontario.

CHALCOPYRITE.

Occurrence of chalcopyrite.

This mineral was met with at several of the apatite mines in Templeton, last summer. It commonly occurs in the form of little irregular grains, or imperfect crystals, in white subtransparent calcite, the grains often being arranged more or less parallel to one of the directions of cleavage of the calcite. In one instance it was observed in similar grains imbedded in chalcedonic quartz.

SPHALERITE OR ZINC BLENDE.

Blende.

This appears to be a rare mineral in the apatite-bearing veins. A small specimen was found last summer on the seventeenth lot of the ninth range of Templeton. It was yellowish-brown in colour and associated with quartz and green apatite.

GALENA.

Galena.

Minute quantities of galena have been found by Mr. Miller at his "Trusty Pit," on the twelfth lot of the twelfth range of Templeton. It occurs with smoky quartz in cavities in pink calcite.

MOLYBDENITE.

Molybdenite.

Molybdenite has been found at the same locality as the last. In the only specimen which I have seen it was imbedded in iron pyrites, but it is stated to have been found also in apatite and pyroxene.

GRAPHITE.

This mineral is said to occur in many of the apatite veins, although seen in but few of those examined last summer. In one instance it was observed in broad folia wrapping round crystals of black pyroxene, which themselves contained scales of graphite. In another case it occurred in the form of highly lustrous plates penetrating coarse crystalline calcite in various directions. In the graphite veins of Buckingham, crystals of apatite are often found imbedded in the graphite, Graphite.

Many other minerals, no doubt, occur in the apatite-bearing veins of the region in question; but, excepting a few doubtful species, the foregoing are all that have as yet come under my notice. One would naturally expect that loganite, which is so frequently mentioned by Hunt as occurring in North Burgess, would also be found here. According to Hunt also, wollastonite is sometimes a constituent of the apatite veins of Burgess, and, associated with quartz, forms interrupted beds interstratified with pyroxenite. Somewhat similar beds, in which the wollastonite is accompanied by both quartz and calcite, occur in Templeton, but as yet the wollastonite has not been observed in any of the veins of the region. Loganite and wollastonite.

Barite, again, though not anywhere found associated with apatite, occasionally forms veins near to those of apatite. Barite.

MISCELLANEOUS ROCKS AND MINERALS.

MANGANIFEROUS CALCITE.

Isomorphous minerals.

The members of the calcite group of minerals afford us some of the best known examples of what is called *isomorphous replacement*, or the replacement of an element by one or more other chemically equivalent elements without a marked change of crystalline form. As a result of this isomorphous replacement, not only do we obtain a number of minerals which are regarded as specifically distinct (dolomite, ankerite, mesitite, &c.), but also many varieties of the species themselves. The so-called ferro-calcite, for example, is a variety of calcite with part of the calcium replaced by iron, plumbo-calcite another variety with lead, replacing calcium. Spartaite, again, is a manganiferous calcite; neotype a variety containing barium, and strontiano-calcite a variety containing strontium. In the case of dolomite also, other metals besides the calcium and magnesium are often present. As an example of this, may be mentioned the dolomite from Sutton, in the Eastern Townships, which afforded Dr. Hunt carbonate of lime 40·10, carbonate of magnesia 20·20, carbonate of iron 10·65, carbonate of manganese 7·65, insoluble 21·40=100·00.*

Analysis by Dr. Hunt.

Manganiferous calcite.

I am indebted to Mr. A. J. Hill, C.E., of Amherst, N.S., for a specimen of calcite which proves, on analysis, to be a manganiferous variety. It was found in fissures near a "trouble" in the bituminous coal of the Cumberland seam at the Joggins. The calcite had been deposited on both walls, either entirely filling the fissure or leaving cavities in the centre, and fragments of the coal were enclosed in the vein. The calcite is white and translucent, and apparently made up of an aggregation of imperfectly formed nail-head crystals. An analysis gave the following results:—

Analysis of calcite.

Calcium carbonate	96·639
Magnesium carbonate	traces.
Ferrous carbonate	1·095
Manganese carbonate	1·949
	99·683

Heated before the blow-pipe, the mineral turns black owing to the oxidation of the manganese. A very little iron pyrites is associated with the calcite.

* *Geology of Canada*, 1863, p. 613.

On the Occurrence of Olivine in Canada.

The occurrence of olivine in the eruptive rocks of Rougemont, Montarville and Mount Royal, as well as in a doleritic dyke cutting the Hudson River formation at St. Hyacinth, and in the dolomitic conglomerate or breccia of St. Helen's Island, near Montreal, was described by Dr. Hunt many years ago, and an analysis of that from Montarville given. Recently it has been found in a number of other localities, and a few facts concerning its occurrence at some of these are of sufficient interest to be given here. Occurrence of olivine.

Owing to the difficulty of navigating the Ottawa River below the railway bridge at Ste. Anne's during the time of low water, communication with a deeper channel than the one ordinarily followed was deemed necessary, and was finally effected by cutting across a ridge of rock in the bed of the river. Coffer-dams were built enclosing the required area, and when the water was pumped out an excellent opportunity was afforded of seeing the bottom of the river. The rocks exposed were sandstones and conglomerates of the Potsdam formation, striking nearly east and west and dipping to the south $< 3\frac{1}{2}°–4°$. Traversing these beds with a course of N. 20° W., a vertical dyke about three feet thick was found. It consisted of a rather fine-grained ground-mass holding large plates of mica sometimes an inch or more across, irregular masses and occasionally large crystals of black augite, and angular masses of olivine occasionally more than an inch in diameter. The last-named mineral gives the rock a very striking appearance, as much of it is of a bright red colour. An analysis of this red olivine gives the following results:— Olivine from Ste. Anne's.

Silica	38·560
Magnesia	44·369
Ferric oxide	1·361
Ferrous oxide	12·649
Manganous oxide*	0·112
Water (ign.)	2·914
	99·965

It is, therefore, a variety with much less iron than that from Montarville, which, according to Dr. Hunt's analysis, contains—Silica 37·17, ferrous oxide 22·54, magnesia 39·68 = 99·39.

When thin sections of the olivine from Ste. Anne's are examined with the microscope, the usual fissured or cracked appearance is seen. Along some of the cracks an alteration to serpentine has taken place, while along others a little red oxide of iron is visible. Although the

* With a little oxide of cobalt.

amount of this peroxide is small as shown both by the microscope and by analysis, it is, nevertheless, evidently the cause of the general red colour which the mineral has assumed.

Olivine from near Mount Albert.

Another locality in which olivine has recently been found is a short distance to the south-east of Mount Albert, just south of the south second fork of the Ste. Anne River, Quebec. The explorations of Mr. Richardson during the past season have shown that it there forms important rock-masses close to the serpentines of Mount Albert, which have evidently been produced by the alteration of the olivine. A specimen of the rock collected by Mr. Richardson is fine-granular, slightly friable, and pale yellowish to greyish-green in colour. It shows a few minute black grains, probably of chromite, and rarely a little of a fibrous mineral which resembles enstatite. Altogether, the rock looks remarkably like one variety of that from North Carolina, which was many years ago described by Genth, and regarded by him as the source of the serpentine and talc of the same region.* An aggregate of olivine and chromite occurs at Dun Mountain in New Zealand, and hence the name *dunite*, by which the rock is now commonly known. There, also, it is accompanied by serpentine. Rocks of somewhat similar character also occur at a number of localities in Europe. The dunite of New Zealand is stated to be an eruptive rock, while the olivine rock of North Carolina, according to Dana, is "metamorphic." Concerning the relations of the olivine rock from near Mount Albert little is known, but it is probably not eruptive.

Dunite.

Origin of olivine rocks.

The origin of such olivine rocks as those of Carolina and Mount Albert is a difficult and disputed question, but one which still remains, whether we believe that the serpentines which accompany them were derived from them or not. In opposition to the view that they owe their origin to chemical precipitation, Clarence King suggests that they may represent accumulations of olivine sands like those now occurring on the shores of the Hawaiian Islands.† Whether such accumulations did take place in the earlier geological formations we do not know, but there is certainly nothing unreasonable or unlikely in the view that magnesian precipitates may then, as in later times, have been formed and subsequently altered to olivine.

Microscopic characters of dunite.

A thin section of the olivine rock or dunite from near Mount Albert, when examined with the microscope, presents the appearance shown in Fig. 9 *a*. It is seen to consist almost entirely of granular olivine, with occasional black grains of chromic iron. Owing to an alternation of layers with finer and coarser texture, it shows a more

* *American Journal of Science*, Vol. XXXIII.; 1862, p. 199.

† *United States Geological Exploration of the Fortieth Parallel.* Vol. I., p. 117.

or less banded structure. As observed above, an enstatite-like mineral may occasionally be seen in the hand specimen, but none of it happened to occur in the portion sliced.

Fig. 9.

a b

Serpentine derived from dunite.

Fig. 9 *b* is drawn from a section of one of the so-called serpentines occurring near the dunite. Its relation to the latter is evident, for it still contains numerous grains of unaltered olivine. In some specimens the change has not advanced so far as here, but in other cases the olivine has almost, if not entirely, disappeared. The chromite, however, always remains.

Olivine in Nova Scotia.

Another example of the occurrence of olivine is to be found in the case of a dark-grey dolerite occurring near South Lake, in Antigonish County, Nova Scotia. When a section of the rock is examined with the microscope, it is seen to consist of a beautifully banded triclinic feldspar, brownish augite, magnetite, and very numerous irregular grains, or occasionally rude crystals, of olivine. The olivine resembles that sometimes seen in gabbro. It is traversed by the usual cracks or rifts, which in this case appear very broad and black, and also contains great quantities of black and opaque microlites, which are probably magnetite, and which are sometimes so abundant as to render the mineral almost opaque. Some of them are arranged in parallel rod-like forms, while others are occasionally grouped in star-like or other more or less symmetrical shapes.

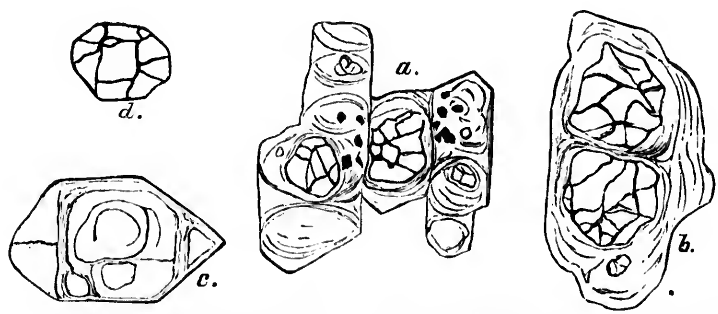
Olivine in British Columbia.

Olivine has also been detected in several of the eruptive rocks of British Columbia. One of these, of Tertiary age, from Kamloops, affords most beautiful examples of the alteration of olivine to serpentine. It is massive, rather fine-grained, and of a very dark olive-green colour. The examination of a slide with the microscope shows that originally the rock must have consisted of crystals and grains of olivine, augite (mostly in crystals) and a small proportion of plagioclase feldspar and magnetite. But while the augite mostly remains fresh, a

Alteration of olivine to serpentine.

large part of the olivine, which appears to be the most abundant constituent of the rock, has been altered to serpentine. Most of the olivine crystals and grains retain a nucleus of the unaltered mineral, showing the characteristic rifts, and the outlines of many crystals which are partly or entirely converted into serpentine are still perfectly sharp. In the accompanying figure (Fig. 10) *a* represents a group of crystals which are mainly composed of serpentine, but show nuclei of olivine and a few opaque grains probably of magnetite; *b* is an irregular mass also partly changed to serpentine; *c* represents a crystal which has been entirely converted into serpentine; while *d* is an almost perfectly fresh crystal of olivine.

FIG. 10.



On further alteration such a rock might be almost entirely converted into serpentine. Such a change has been observed elsewhere, as, for example, in the case of many of the Würtemberg basalts, which are said to be "little more than serpentine rocks containing some magnetite, since the olivine and augite which composed the basalt are changed into serpentine." *

Serpentines of the Eastern Townships.

In this country we have other examples than those already given of the production of serpentines by the alteration of other rocks. That such is the origin of many of the serpentines of the Eastern Townships there can be little doubt. The fact of their being commonly chromiferous suggests that they may have been derived from such peridotic rocks as lherzolite, dunite, olivine-gabbro, &c. †

ON SOME OF THE DIORITES OF MONTREAL.

There are probably few regions of such limited extent that furnish

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* Rutley, on authority of Dr. M. G. R. Fritzgärtner. *The Study of Rocks*, 1879, p. 117.

† Concerning these rocks and the changes which they have undergone, see Rosenbusch, *Massige Gesteine*, pp. 525–538.
Also, Bonney, On the Serpentine and Associated Rocks of the Lizard District.—*Quarterly Journal of the Geological Society*, Vol. XXXIII., p. 884.

a greater variety of interesting eruptive rocks than Montreal and its vicinity. This fact, long ago, attracted the attention of Dr. Hunt, and though many of the rocks were ably described by him, there still remains a wide field for investigation, both as regards the character of the rocks and their relative ages. Numerous facts bearing upon these points have recently been accumulated, but many additional details are required before the subject can be fully discussed.

In the *Geology of Canada* the intrusive rocks of Montreal are described as dolerites, trachytes and phonolites, the first of these constituting the main mass of Mount Royal as well as numerous dykes, while the others occur only in dykes, which are stated in some instances to cut the dolerites. No mention is, however, made of the numerous dykes of diorite which occur, and which, in some cases, have also been observed to cut the dolerite of the mountain. These diorites vary considerably in their characters, ranging in colour from light to dark grey, and in specific gravity from 2·75 to over 3.* They are usually medium to fine-grained in texture, and often porphyritic with crystals of hornblende. Sometimes, too, they are amygdaloidal, the cavities containing calcite, zeolitic minerals, and rarely epidote. They all appear to contain carbonates, the quantity of which, however, varies in different cases. Their principal constituents are hornblende, a triclinic feldspar, and titanic iron; but they commonly contain other minerals, the most important of which is, perhaps, mica. Augite is also sometimes present. The mica is occasionally so abundant that the rock becomes the mica-diorite of some lithologists. **Diorite dykes.**

A dyke occurring in the reservoir extension consists of what may probably be regarded as a typical variety of the diorites referred to above. It is dark grey in colour, rather fine-grained, but still showing, without the lens, quantities of acicular prisms of a black mineral which proves to be hornblende. The dyke was about two feet thick and very homogeneous, showing neither porphyritic nor amygdaloidal texture. Specimens sliced and examined with the microscope are seen to consist essentially of hornblende, a triclinic feldspar, and numerous opaque grains of titanic iron. Mica, apatite, calcite, and a little of a green chloritic mineral, are also commonly present. The hornblende appears mostly fresh, though in places slightly altered to the chloritic mineral just mentioned. It is of a rich brown colour and strongly dichroic. In cross sections the cleavage of the prisms is often beautifully displayed. The feldspar is in part

* The following are the specific gravities of a number of specimens:—

2·749	2·94	2·923	3·005
2·889	2·97	4·947	....
2·805	3·07	2·927	....

altered, but in places fresh. It is triclinic, and, judging from the unusually basic character of the diorite, must be a feldspar low in silica. The black mineral occurs mostly in irregular grains, but here and there in curious fantastic forms after the manner of titanic iron ore. That it consists mainly of this mineral, and not of magnetite, is evident from the considerable proportion of titanium dioxide shown by the analysis, and also from the fact that when the rock is pulverised the magnet removes almost nothing. The specific gravity of different fragments of the rock varied from 2·927 to 3·005. An analysis was made some time ago, and, as the composition appeared unusual, search was made for descriptions of similar rocks from other localities, but none could be found. Since then, however, Mr. G. W. Hawes has described rocks of wonderful similarity from Campton, in the State of New Hampshire.* An analysis, by Mr. Hawes, of one of these diorites is given under II. for comparison with I., which is an analysis of the diorite from Montreal just described:—

Analyses of diorite.

	I.	II.
Silica	40·95	41·94
Alumina	16·45	15·36
Ferric oxide†	13·47	3·27
Ferrous oxide	...	9·89
Manganous oxide	0·33‡	0·25
Titanium dioxide	3·39	4·15
Lime	10·53	9·47
Magnesia	6·10	5·01
Potash	1·28	0·19
Soda	4·00	5·15
Phosphoric acid	0·29	..
Carbon dioxide	..	2.47
Loss on ignition	3·84	3·29§
	100·63	100·44

On boiling I. with hydrochloric acid for several hours, and filtering, the insoluble residue after ignition amounted to only 51·80 per cent. Although the amount of carbon dioxide was not determined, it must constitute a large proportion of the loss which the rock sustains on ignition; for acetic acid dissolves 4·02 per cent. of lime and 0·67 of ferrous oxide, and these bases, if calculated as carbonates, would require 3·57 per cent. of carbon dioxide. The basic character of the rock, and the extent to which it is dissolved by hydrochloric acid,

* *Geology of New Hampshire*, Part IV., p. 160.
American Journal of Science, 1879, p. 148.

† All the iron is calculated as ferric oxide, the ferrous oxide not having been determined.

‡ With a little cobalt. § Water.

seem to indicate a feldspar of the nature of anorthite. In that case a considerable proportion of the alkalies must belong to the hornblende; but this is not improbable, as some varieties of hornblende are known to contain several per cent. of alkalies.

Another dyke, occurring within a few yards of that just described, is also of much interest. It is dark grey in colour, and, like the last, shows numerous acicular prisms of hornblende penetrating the mass in all directions. Here and there macroscopic scales of dark brown mica are seen, and the rock is dotted with numerous spots—occasionally as much as a quarter of an inch across—of a glassy, colourless to white mineral, which, on analysis, proves to be analcite. The specific gravity of the analcite is 2·255, and its composition as follows:— Interesting dyke. Analysis of analcite.

Silica	53·29
Alumina	23·33
Ferric oxide	trace.
Lime	0·64
Magnesia	trace.
Soda	14·54
Water	8·47
	100·27

The mineral was examined for potash, but none found. Before the blow-pipe it fuses easily to a colourless glass. When thin sections of the rock are examined with the microscope the analcite appears very transparent and shows but few inclusions. It is traversed by numerous reticulating cracks, but displays no characteristic cleavage. The feldspar is mostly dull, but here and there is sufficiently transparent to show its triclinic character with polarized light. The hornblende and titanic iron appear exactly similar to what occurs in the ordinary diorites of the locality. No augite has been observed, but one slide shows numerous green crystals, which are evidently pseudomorphs of serpentine after olivine.

In so far as its constituents are concerned, this rock appears to be somewhat similar to that which Tschermak, many years ago, called *teschenite*, after Teschen in Austria. Tschermak regarded the analcite as one of the normal constituents of the rock, and this it may possibly be in the present instance. On the other hand, the general similarity of the other constituents of the rock to those of the ordinary diorites of the vicinity would lead one to infer that the analcite is a secondary mineral, and that the rock is simply an altered diorite. Teschenite.

The diorites described above traverse not only the Lower Silurian limestones, but also the dolerite of Mount Royal. Rounded masses of the diorite of precisely similar character occur in the Lower Helderberg conglomerate or breccia of St. Helen's Island. Those, therefore, Age of eruptive rocks.

who would classify eruptive rocks according to age, would say that Mount Royal is a diabase and not a dolerite. Admitting such to be the case, how is it, the question may be asked, that dykes of *phonolite* are abruptly cut off by the diabase, when phonolite, according to the chronological theory, ought to be of Tertiary or more recent age? It may be that future investigations will solve the difficulty, but, in the meantime, the eruptive rocks of Montreal do not seem to fall into their proper place in a classification based upon age.

Magnetic Iron Ore.

According to Dr. G. M. Dawson, deposits of magnetic iron ore occur near the west end of Cherry Bluff, on Kamloops Lake, British Columbia. The ore forms irregular veins varying from the thickness of a sheet of paper up to three feet or more in a sort of diorite, and is often associated with epidote. A specimen which has been analysed was bluish-black in colour, and showed in places a curious sub-columnar structure. The only gangue visible was a little quartz and calcite. The results of the analysis are as follows:

Analysis of magnetite.

Ferric oxide	64·85
Ferrous oxide	27·57
Manganous oxide	0·09
Lime	1·26
Magnesia	0·78
Phosphoric acid	0·23
Sulphuric acid	0.07
Carbonic acid	0·33
Water	0·37
Insoluble matter	4·07
	99·62
Metallic iron	66·84
Phosphorus	0·100
Sulphur	0·028

The proportions of ferric and ferrous oxide are nearly those required by theory for magnetite, the ratio of ferrous to ferric oxide being 1: 2·35 instead of 1: 2·22. Calculation would give 28·64 and 63·65 per cent., respectively, of ferrous and ferric oxide, instead of the proportions given in the analysis. The insoluble residue consisted chiefly of silica, but also contained a little alumina, iron, lime and magnesia.

Spathic Iron Ore.

In the summer of 1877, beds of spathic iron ore were discovered by Dr. Robert Bell at Flint Island and elsewhere near Hudson Bay, in rocks supposed to belong to the Nipigon group. Some of the specimens show a distinctly crystalline texture, while others are very compact. Owing to their containing manganese they were dark brown to black.

A specimen of the compact variety from Flint Island gave on analysis: Analysis of spathic iron ore.

Ferrous carbonate	52·70
Manganous carbonate	24·64
Calcium carbonate	traces.
Magnesium carbonate	11·81
Insoluble residue	10·94
	100·09
Metallic iron	25·44

It was brownish-grey in colour, and had a specific gravity of 3·49. The insoluble matter was white and mainly silica. The ore is interesting on account of the rather unusually large proportion of manganese which it contains, and which would make it valuable for the manufacture of spiegeleisen. Ores of the kind have long been mined at a number of localities in Europe, but there the most important deposits are of Devonian and Permian age.

Another specimen from Flint Island was little more than a fine-grained quartzite charged with carbonates of iron and manganese. It contained 13·62 per cent. of iron. On the same island coarsely crystalline siderite occurs in veins, associated with quartz, though not in sufficient quantity to be considered economically important.

Davieau's Island, on the east coast of Hudson Bay, is another locality in which Dr. Bell has found spathic iron ore. A specimen collected by him is distinctly crystalline in texture, and contains 27·83 per cent. of iron. The proportion of manganese has not been determined, but is probably high. Fuller details concerning the localities of these spathic ores are given by Dr. Bell in his report.

Lignite, or Brown Coal.

Hat Creek, British Columbia.—In his report on the southern part of the interior of British Columbia (page 121), Dr. G. M. Dawson has described the occurrence of an enormous bed of lignite in rocks of Tertiary age. The bottom of the seam could not be seen, as it was concealed beneath the waters of the stream, but the thickness of lignite above the water-line was found to be forty-two feet.

A specimen received for examination was a dull brown to black lignite, cracking on drying, and then presenting black conchoidal

Analyses of lignites.

surfaces, with more or less pitchy lustre. Analyses by slow and fast coking gave the following results :

	Slow coking.	Fast coking.
Water (at 100°–115°C.)	8·60	8·60
Volatile combustible matter......	35·51	41·42
Fixed carbon....................	46·84	40·93
Ash (white)	9·05	9·05
	100·00	100·00

The powder showed no disposition to coke. When heated with a solution of caustic potash, it coloured the solution intensely brown.

Junction of Nicola and Coldwater Rivers, British Columbia.—Proximate analyses of coals from this region were given in last year's report, but since then another specimen has been examined which came from the uppermost seam (fifteen feet four inches) of the section given in Dr. Dawson's report (p. 125). It was black, somewhat pitchy in lustre, and showed distinct planes of bedding. The powder was brownish-black, and coloured a solution of caustic potash brown, though not very intensely. Slow and fast coking gave the following results:

	Slow coking.	Fast coking.
Water (at 100°–115°C.)..........	5·78	5·78
Volatile combustible matter......	27·65	33·72
Fixed carbon....................	52·69	46·62
Ash (reddish-white).............	13·88	13·88
	100·00	100·00

The powder was not fritted even by rapid heating.

Kohasganko Stream, British Columbia.—This specimen was brought by Dr. G. M. Dawson from a seam of lignite occurring on the above named stream.* It was dull brown to black, and on drying fell into small fragments, often with highly lustrous surfaces. It showed distinct lamination and a good deal of mineral charcoal between the layers. The powder was blackish-brown and coloured the potash solution very strongly. By slow and rapid heating the following results were obtained:

	Slow coking.	Rapid coking.
Water (at 100°–115° C)..........	9·90	9·90
Volatile combustible matter......	37.71	42·61
Fixed carbon....................	38·85	33·95
Ash (pale grey).................	13·54	13·54
	100·00	100·00

Good coal from Belly River.

Belly River, North-West Territory.—A specimen of coal from near Belly River, recently received for examination from the Surveyor-

* See Report of Progress, 1876-77, p. 76.

General, Mr. L. A. Russell, proved to be of excellent quality. In appearance it resembled a true bituminous coal from the Carboniferous, though really of Cretaceous or possibly Tertiary age. It contained a little mineral charcoal and occasional thin films of calcite in joints. Colour black and fracture uneven to sub-conchoidal. Analyses by slow and fast coking gave the following:

	Slow coking.	Fast coking.
Hygroscopic water	5·79	5·79
Volatile combustible matter	41·25	35·20
Fixed carbon	47·91	53·96
Ash (reddish-grey)	5·05	5·05
	100·00	100·00
Ratio of volatile combustible matter to fixed carbon	1 : 1.16	1 : 1.53

The powder was slightly sintered by rapid heating. It also coloured a potash solution brown, but not so deeply as the lignites just described.

GOLD AND SILVER ASSAYS.

Cariboo District, British Columbia.

In the Report of Progress for 1876-77 a series of assays was published of samples taken from a number of quartz veins in the Cariboo district, British Columbia; but in almost every instance the proportions of gold and silver found were very trifling. Subsequently, other samples were sent for examination by the Deputy Minister of Mines. They were assayed, and the results, which were forwarded to Victoria in June last, showed a much larger quantity of gold than in the specimens previously examined. The results may be given in tabular form, as follows:

Assays of quartz from Cariboo.

	Gold. Oz. to ton of 2,000 lbs.	Silver. Oz. to ton of 2,000 lbs.
No. 1	1·243	0·134
" 2	0·802	0·249
" 3	0·116	0·233
" 4	3·245	0·213
" 5	2·450	0.359
" 6	[illegible]·568	0·374
" 7	0·972	0.263
" 8	2·296	0.396
" 9	0·124	0·176

The first six samples were in fragments and consisted mainly of quartz and iron pyrites—the latter mineral in larger proportion than in most of the specimens previously assayed. The remaining samples were in powder, and it is probable that Nos. 7, 8, 9 were simply 2, Average amount of gold.

5 and 3, respectively, but pulverised. The average amount of gold in the first six is 1·571 ounces to the ton of 2,000 lbs., and of silver only 0·26 ounces.

MISCELLANEOUS LOCALITIES.

1.—*Cinnemousun Narrows, British Columbia.*

Miscellaneous gold and silver assays.

Rusty quartz with iron pyrites, the latter constituting about one-third the bulk of the specimens.

Gold........................	Distinct traces.
Silver........................	0·087 ounces to the ton.

2.—*From a Large Vein south-east of Cinnemousun Narrows, B.C.*

Quartz, much stained with oxide of iron. The specimen was found to contain,

Gold	Distinct traces.
Silver	1·02 ounces to the ton.

3.—*North Fork of Cherry Creek, B.C. From "Vernon's Silver Lead."*

Quartz, a good deal stained with oxide of iron, and carrying a little galena and iron pyrites. The specimens also showed an occasional green stain, possibly indicating the presence of tetrahedrite, a mineral known to occur on Cherry Creek.

Gold	0·058 ounces to the ton.
Silver	8·254 " " " "

4.—*Cherry Creek, B.C.*

Pellets of galena from Cherry Creek, above the Cañon. They were found in the sluice-boxes higher up the stream than the known silver-bearing lodes. Assay by scorification gave—

Silver.....................	220·937 ounces to the ton.

5—*Cherry Creek, B.C.*

The occurrence of rich silver ore on Cherry Creek has been described by Dr. G. M. Dawson in his report (p. 160), and several samples from the locality have been assayed. The first of these was a mass of about twenty pounds weight, which was sent to the Paris Exhibition of 1789. It consisted of an argentiferous tetrahedrite or freibergite, with some galena and zinc blende in a gangue of white quartz. Fragments were broken off so as to represent the whole as far as possible without destroying the specimen, and assays of these by scorification gave,

Argentiferous tetrahedrite.

Silver.....................	658 437 ounces to the ton.

Another specimen, collected by Mr. J. Fraser Torrance as being a fairly rich sample of the ore, and also consisting of quartz, tetrahedrite, galena and blende, gave,

Silver...................... 255,937 ounces to the ton.

A second sample received from Mr. Torrance, and stated to represent a vein eighteen inches thick, gave,

Silver..................... 53·958 ounces to the ton

It consisted of the same minerals as the other specimens, the proportion of gangue, of course, being very much larger. In all three cases the buttons contained a little gold.

6.—*Locality?*

A specimen from British Columbia, received from Mr. Camby, of the Canada Pacific Railway Survey. It consisted of milky-white quartz, holding a considerable quantity of galena, iron pyrites, and copper pyrites.

Gold......................... 0·029 ounces to the ton.
Silver....................... 1·079 " " " "

7.—*Gros Cap, Lake Superior (Brown's Silver Mine).*

A specimen received from Dr. R. Bell, and consisting of rather fine granular galena and zinc blende in a gangue of calcite and quartz.

Silver........................ 0·058 ounces to the ton.

The proportion of galena and blende was small; but even taking this into consideration, it is evident that neither of these minerals contains much silver.

8.—*Victoria Mine, Garden River.*

Coarse crystalline galena * with curved faces. It was carefully freed from gangue, and found to contain,

Silver.......................30·623 ounces to the ton.

Another sample received at the same time, but from which the gangue was not separated, gave,

Silver.........................21·146 ounces to the ton.

9.—*Lake Temiscaming, Ontario.*

Specimens of galena from a locality discovered in 1877 by Mr. Edward Wright, of Ottawa. The galena is coarse crystalline, and resembles in appearance much of that from the Victoria Argentiferous galena from Lake Temiscaming.

* For other assays of galena from this locality, see Report of Progress, 1876-77, p. 480.

Mine, near Garden River. Like the latter, too, it probably occurs in rocks of Huronian age, Lake Temiscaming being on the line of these rocks. A specimen of the galena, entirely freed from gangue, gave, by scorification,

Silver..................... 18·958 ounces to the ton.

Another specimen, received from Mr. Wright at the same time, but containing a good deal of rock matter, gave,

Silver..................... 11.66 ounces to the ton.

A third specimen of galena from a point about fifty feet from that at which the above was taken gave, after careful separation of the gangue,

Silver..................... 18·229 ounces to the ton.

10.—*Richmond Gulf, Hudson Bay.*

Coarse crystalline galena from the south side of the entrance of the gulf. Collected by Professor Bell in 1877. It was found to contain,

Silver..................... 12·03 ounces to the ton.

11.—*Hartford Mine, Capelton, P.Q.*

Tetrahedrite from Capelton, Quebec.

At this mine a steel-grey tetrahedrite occurs, associated with copper pyrites. A specimen containing only a very little of the latter mineral was assayed in order to ascertain whether it was argentiferous, and yielded,

Silver..................... 75.03 ounces to the ton.

12.—*Near Sherbrooke, P.Q.*

Copper pyrites.

Specimens of copper ore examined for silver, at the request of Mr. A. Holland, of Ottawa. The specimens consisted of copper pyrites, a little iron pyrites, and glassy quartz. They yielded,

Silver..................... 19.687 ounces to the ton.

It is well known that the copper ores of the Eastern Townships, as a rule, contain silver; but the proportion is usually less than that found in Mr. Holland's specimens.

13.—*Musquash Harbour, New Brunswick.*

Galena from New Brunswick.

Specimens of galena received through Mr. Ells from the *Lancaster Silver Mining Company* of St. John, N.B. The galena was separated as far as possible from the gangue of quartz in which it occurred, and gave,

Silver..................... 14·219 ounces to the ton.

The veins are stated to occur in rocks of Laurentian age, but the galena contains more silver than any other from the Laurentian which I have hitherto examined.

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