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SERPENTINES OF CANADA.

By N. J. Giroux, F.G.S.A., C.E., P.L.S., of the Geological Survey of Canada.

The study of serpentinous rocks and other serpentines is certainly one of much interest and has been followed with great enthusiasm by several of the most eminent geologists.

As serpentines are met with in almost every country where geological work has seriously been taken up, scientists of all schools took part in the great discussions which ensued from their geognosy and geogeny. Such being the case it may be well to enunciate the views of a few of the best known writers on the subject before describing the mode of occurrence of our Canadian serpentines. The divergence of opinion as to the mode of formation and occurrence of serpentine did not originate until the view was expressed that they were of eruptive origin, and this is not so very long ago, as the most distinguished scientists were all of the opinion, at the beginning of this century that serpentines were stratified contemporaneous deposits. In 1826, Maculloch, in his geological classification of rocks, separated the primitive rocks into two groups, stratified and unstratified, and placed the serpentines and granites together in the latter. But subsequent studies led him to announce that like gneiss or mica-schist, the serpentines are stratified rocks. The great objection then, to classing serpentines with the unstratified rocks was that unlike granite and trap, they had not been found to present dykes or ramifying veins. However, De la Beche, Brongniart, Elie de Beaumont and many others regarded them as an eruptive rock, and Professor Hitchcock, in 1835, speaking of serpentine says:

"Dr. Maculloch considers it as sometimes stratified; and accordingly enumerates it in both these classes and also as a veinous rock. It occurs in connection with granite, gneiss, micaceous, chloritic and argillaceous schists."

These characters apply to the serpentine of Massachusetts, according to Professor Hitchcock, who places it along with the limestones in the stratified class. Favre and Stapff regard the serpentines as of aqueous and sedimentary origin. Dr. T. Sterry Hunt in 1859 and 1860 speaking of these rocks said they were undoubtedly indigenous

and resulting from the alteration of silico-magnesian sediments, and in many writings since has supported this view of the subject. In the transactions of the Royal Society of Canada, Vol. I, Sec. IV., 1883, is given the geological history of serpentines, including studies of Pre-Cambrian rocks by this author. Very interesting facts and many observations from several European and American geologists are mentioned in this clearly written paper, the most of which are in support of the theory therein advanced. Some of the serpentines that were then declared to be indigenous have been studied more in detail, and facts of recent date, brought to view, tend to show that these are in certain places eruptive.

The serpentines are, as we all know, metamorphic or igneous rocks, and consequently we should not judge of their age from lithological evidence only, for with very few exceptions this criterion is of little value. Since it is generally admitted that metamorphic rocks are not of any particular geological age, so we shall have to consider our serpentines as being also of different ages, for they not only differ in their lithological association but in chemical composition as well.

If we have serpentines that are the altered remains of olivine rocks, we have them derived from some other source as well, for it is impossible to suppose that the banded and slaty serpentines of the Shickshock mountains in Gaspé, and of Long Lake in the Province of Quebec are due to the metamorphism of the same class of stratified beds, the main constituents of which are derived from the trituration of olivine rocks; for in that case they would occur in some characteristic bands, and this is not the case as far as we know.

There is a magnesian rock says Daubrée that is very closely allied to peridotite and therzolite although it presents a great many peculiarities which are not characteristic of these. Although serpentine is hydrated, infusible and without distinct crystallisation, it occurs with eruptive rocks, and the general view of geologists is that it is derived in many cases from peridotite, since it exhibits very often the characteristic form of crystals of that rock.

By his synthetic studies, Daubrée has discovered that very often serpentine has a tendency to change to a peridotite and he is of the opinion that it is derived from the hydration of olivine rocks. There

are many views expressed as to the genesis of serpentines and an enumeration of them would require more time than we have at our disposal. It can be stated however that in the opinion of some, serpentines are formed (by metasomatosis) from feldspathic rocks, such as diorites, diabases, granulites, &c., &c., or by a complete elimination of alumina and lime and the replacement of these bases by magnesia; others maintain that they are derived from the transformation of silico-magnesian deposits. Again would it not be possible to suppose that they might be formed from the limestones themselves, when we take into consideration the serpentinic structure of the Eozoon Canadense.

It is also mentioned by some that they are due to the hydration of eruptive olivine rocks, while others hold that they were ejected from the earth's interior in a state of aqueous magma or mud. Some of those who maintain their origin from the hydration of olivine rocks suppose such eruptive rocks to have passed into a hydrous state before being ejected.

If we consider all the transformations we can perform, with different temperatures and under different pressures in our laboratories which are so imperfect as compared to the great, wonderful, and unknown laboratory of the whole universe, we are at no loss in finding theories enough as regards the genesis of serpentines, for hypotheses are easily adopted, even by following the strict and well established chemical and physical laws.

This is not the place nor the time to enter into discussion as to the mode of formation of the rocks which will be described in this short notice as it is the intention of the writer to show, in the best way possible, the characters of our serpentines and their association with rocks of very highly scientific as well as of economic interest, without questioning mother Nature too much as to the course followed by her in giving rise to serpentine and the interesting series of minerals associated with it.

Let us then consider the sepentine as it actually is, a rock which enterprising capitalists, most serious chemists and zealous geologists look upon with so much speculating spirit and such contradictory views, without trying to solve the great problem of origin, a thing beyond reach.

Serpentine occurs in many places in this country, from the far west to the extreme east, associated with strata of different ages, and one would be surprised at the area it occupies on our maps although a great extent of the Dominion is still geologically unknown.

Our serpentine may be divided into four groups:—

1st. The Archæan group, or group No. 1, consisting of the Laurentian, Huronian and Pre-Cambrian serpentines;

2nd. The Palæozoic group, or group No. 2, consisting of the Cambrian and Carboniferous serpentines;

3rd. The Cenozoic group, or group No. 3, consisting of the Tertiary serpentines.

4th. Group No. 4, consisting of those of doubtful age.

LAURENTIAN SERPENTINES.

This serpentine is found associated with limestone and dolomite but is most abundant in the limestone. It is frequently disseminated in grains varying in size, occasionally in scattered masses, and sometimes in interstratified beds. Its color varies from light green, greenish-yellow, pale-yellowish or greyish-green. It sometimes presents masses of yellowish-green spotted with crimson or blood-red patches from disseminated peroxyd of iron. It has a lower specific gravity, contains less oxyd of iron and more water than ordinary serpentines. It is very widely spread all over the country, and is found in nearly all the provinces.

Near Pisarinco Cove, New Brunswick, are reported crystalline limestones, grey and beautifully white, alternating with quartzites and diorites, and with occasional bluish argillites. Along with these limestones there are also some thinner beds of yellowish and purplish colours which contain serpentine. At another point apple-green and pinkish limestone is enclosed in a bed of diorite, both rocks being traversed by veins of serpentine holding chrysotile. Again, on the west side of the Narrows of the St. John River, in this same Province, can be seen pale grey and white crystalline limestone with a conglomerate of limestone pebbles in a serpentine paste. What is worthy of mentioning of the St. John River serpentinous limestone is that it contains the Eozoon Canadense.

The next areas of the Laurentian rock, which occur in a westward direction, are found in the township of Grenville, on the Ottawa River, Province of Quebec, where it is massive and nearly pure. Its colour is generally pale-yellowish, wax-yellow, or greyish-green, unless it has been penetrated in parts by red peroxyd of iron. In the serpentine of this township have been found very good specimens of Eozoon Canadense. A white lamellar dolomite from this township contains a large proportion of grains of honey-yellow serpentine.

Serpentine rocks analogous to these last are found in the seigniory of La Petite Nation, which adjoins the Township of Grenville. The serpentinous structure of the Eozoon Canadense is beautifully shown in many places in this seigniory, and the best specimens of that fossil exhibited in our museum were first collected there by Mr. James Lowe, who was for some time attached to the Geological Survey staff. Proceeding westward we find serpentinous rock in the Township of Templeton, where it is associated with the so well known mineral apatite. About 50 miles farther west, at the Calumet Falls, on the Ottawa River, pale green serpentine, associated with brown phlogopite and apatite, in a white crystalline limestone, has been described under the name of loganite. To trace the Laurentian serpentine westward we shall have now to cross the Ottawa River and enter the Province of Ontario, where it is first seen in the Township of Ramsay, Lanark County, and about 30 miles south-west of the Township of Templeton. It appears there sometimes of a beautiful amber-color, and in some parts of the township the mineral occurs entirely as disseminated grains through a pure white carbonate of lime, while in others it is distributed in lumps or patches from the size of a pea to that of a medium sized cannon ball. We find very analogous serpentine in Lanark township, and where this mineral is interstratified with the limestone, it forms a rock of striking beauty. On lots 23 and 24, range 3, Township of Dalhousie, the serpentine is interlaminated with a finely granular and brown-weathering crystalline limestone, which, on its weathered surfaces, shows forms very much resembling Eozoon. Similar limestone, without Eozoon structure, is found on lots 26 and 27, range 2.

In the township of South Sherbrooke, which lies due south of the township of Dalhousie, can be seen spotted serpentine limestones which

resemble very much those of Grenville on the Ottawa. They abound in veins of chrysotile, present a very rough weathered surface, and appear to be devoid of Eozoon.

In North Burgess, which adjoins Dalhousie, is found massive and nearly pure serpentine. Eozoon Canadense has been found in the serpentine limestone of this township, from which are also reported pure dolomites, with grains of steatitic pyroxene and green or yellowish-green serpentine, also accompanied by Eozoon.

About 20 miles farther south, and in the township of Loborough, county of Frontenac, white and coarsely crystalline dolomite is seen on lot 4, range X. This dolomite leaves, when dissolved in acids, a residue of quartz and serpentine, and contains traces of oxyd of iron and of phosphate.

Serpentine of probable Laurentian age is believed to occur on Wollaston or Hatchet Lake, as well as at the head of Reindeer Lake. Dr. Lawson reports having met serpentine in the Keewatin area, on the west side of Clear Water Lake, a tributary of Rainy Lake. This rock is massive and occurs there in a band, immediately followed to the west by hornblende schist and to the east by another band of green hornblendic schists and altered traps. Another mass of serpentine, in very analogous position, is seen on South Bay of Lake Despair, and Dr. Lawson reports this as occurring with some degree of constancy in the middle portion of the Keewatin trough, and thinks these serpentines are the altered remains of olivine rocks. A small boss of this rock has also been examined by the same gentleman at the south-west end of Sucker Lake, coming in with green schist. Dr. Lawson, speaking of the serpentines of the Keewatin area of the Lake of the Woods, says :

"This interesting class of rocks is not of extensive occurrence in this area, but is found irregularly distributed in patches of rather ill-defined character and extent." Of the Wiley Point serpentines he speaks thus :

"The quartz-porphyry occupies the greater portion of a small island two and three-quarters miles south-west of Wiley Point, and is evidently associated with a mass of serpentine which occupies a small island beside the north, and the neighboring point on the main shore a little to the south-west. The serpentine on this point presents no definite relations

to the other rocks, beyond the fact that it is in contact to the west with dark green somewhat chloritic hornblende schists, and that on the east the point is tipped with a nob of hard crystalline dioritic rock. On another point of the shore, one and a-half miles to the north-east of this occurs a second mass of serpentine, under conditions very similar to those just described. It is in contact to the west with green schists as before, and the extremity of the point occupied by the same dioritic rock, but with this difference, that between the dioritic and the serpentine there is a dyke fifteen feet wide of the quartz-porphyry, evidently an off-shoot from the main mass occupying the island off shore a little to the south. The masses of serpentine in these two points, and on the small island in immediate proximity to the quartz-porphyry, are nearly in a line, and also in a line with the general strike of the rocks at this locality; but whether the serpentine is interbedded with the schists, or was originally intrusive, it is difficult to say from the evidence available in this particular case. The presence of the quartz-porphyry as an intrusion, associated with what appear to be dykes of diorite striking parallel to the dyke of quartz-porphyry, would seem to warrant us in regarding all these rocks—serpentine, diorite and quartz-porphyry—as different manifestations of outflows along a line of fissure, probably at widely-separated intervals, and altered according to the well-known tendency of these rocks, or rather of their original forms." Mr. Bayley has made microscopical examinations of these serpentines, and says that in many of them the forms of the original olivine can be clearly seen, although there is no trace of the mineral left. Dr. Lawson also reports serpentine to be more largely developed on the inland and shore of Shoal Lake Narrows than elsewhere in the region. He mentions also a boss of serpentine projecting through the black hornblende schists in the immediate vicinity of their contact with the gneiss.

Many minerals are associated with the Laurentian serpentine, but very few are found in workable quantity.

Small quantities of chrysotile have been mined for asbestos in lot 2, range 7, Templeton, but the fibre was so coarse and short that these works were soon abandoned.

The magnetic ore formerly smelted at the Marmora iron furnace was obtained from lot 8, range 1, of Belmont. This deposit presented

a succession of beds of ore interstratified with layers of greenish talcoid slate and of crystalline limestone, with which were also met serpentine, chlorite, diallage, and a greenish epidotic rock. Iron of a superior quality was manufactured from this deposit.

Pyrallolite, a mineral similar to steatite in chemical composition, softness, and refractory properties, is often met with in the Laurentian series. A bed of it, associated with serpentine, occurs between the gneiss and the limestone on lot 13, range 5, of Grenville. It may be traced thence into range 6, and appears to be in considerable quantity. The colour of this mineral is generally greenish-white or sea-green; some varieties of it are nearly white and have the translucency of porcelain. Very dark-coloured, nearly black varieties, have been described by Dr. Emmons, who says this mineral is capable of being turned in a lathe and wrought like soapstone, and has been made into small vases, inkstands and similar objects. Much of the figure-stone, or pagodite, of which the Chinese carve various ornaments, appears to be pyrallolite. It was used by the aborigines to make pipes and calumets.

The serpentine of lot 13, range 5, Grenville, and of some parts of the Township of Burgess, is of a pale-green colour, marked with spots of iron, and forms a fine ornamental stone.

The limestones of the Laurentian series are very important, not only on account of their extent, or their association with serpentine and apatite, but from the fact that wherever they occur the Laurentian region presents fine fertile valleys fit for cultivation. The principal settlements found among these rocks are upon the outcrop of the limestone bands. These limestones afford excellent lime as well as good materials.

The Laurentian serpentine on account of being light in colour in many places could be ground, and subsequently impregnated, by a peculiar process, with various mineral and vegetable colour, and then used for the manufacture of cheap and durable paints of various hues.

HURONIAN SERPENTINES.

These are but little known and of very limited extent.

Messrs. Bailey and Matthew report as follows of a series of rocks of Charlotte County, New Brunswick, which they suppose to belong to the Laurentian system :—

" With the ordinary type, however, there occur at two points to the north-east of St. Stephen, rocks of very different aspect. These are the dark grey dioritic rocks containing serpentine, diallage and chromic oxyd. About two miles north of St. Stephen, may be seen *ledges of coarse grained, dark grey granitoid diorite, having thin layers* of picrolite or fibrous serpentine in the joints as well as serpentinous matter in the body of the rock. In crossing these ledges towards St. Stephen, the rock becomes somewhat darker, and portions are met with exhibiting thin lamination, the laminæ being separated by layers of serpentine about one-eighth of an inch in thickness." There seems to be some doubt as to the age of these serpentinous rocks, and although supposed to be of Laurentian age, they are here placed under the head of Huronian rocks. The presence of chromic oxyd in them and the want of crystalline limestone in their association with other rocks give them quite a different character to those of the Laurentian series of this Province. The first outcrops of these serpentines which we know of, in a north-westward direction from these last mentioned are on Lake Abittibi where they are found to be associated with micaceous, hornblendic, and chloritic schists, fine grained hard quartzites, diorites and dioritic schists. A little island in this lake is composed of strongly magnetic serpentine with splintery fracture, resinous lustre and weathering dull white. An analysis of it was made by Dr. Harrington who found it to contain grains of chromic iron and a very small quantity of nickel besides silica, alumina, protoxyd of iron and magnesia.

According to Dr. Bell there is, in the middle of Pigeon Lake, and at about one mile from the lower end of it, a small island composed of very dark green serpentine, with strings of calcspar and crysotile. It weathers rusty, and Dr. Harrington, on analysis, found it to contain oxyd of chromium, both in the form of small grains and in chemical combination with the rest of the rock.

No mineral of economic importance has yet been found in these serpentines, but perhaps when the country where they are more abundantly met with is settled, some wandering geologist or hard-working *habitant* will discover in them large deposits of asbestos or other valuable mineral.

PRE-CAMBRIAN SERPENTINES.

Of these very little can be said; they seem to be limited to the almost extreme easterly portion of the Dominion. Mr. Hugh Fletcher, who so very carefully studied that section of the country, reports serpentines to occur in three different places:—

First, in Macdonald Brook, Cape Breton Island, where white, pyritous crystalline limestone, lemon-yellow serpentine limestone, and pale-green brown-weathering limestone, and tremolite in small fibrous tufts, occur between bluish-grey and red felsite and bluish-porphyritic felsite. Then on Kelvin Brook, in the same island, a cliff of coarse, reddish felsite, associated with greenish and red, mottled, soft serpentine, is in immediate contact with reddish coarse grit and conglomerate along an irregular line which runs N. 9° E.

On Campbell Brook, eastern Nova Scotia, some white crystalline limestone appears, some beds of which are covered on the surface with large knobs of light-greenish and white serpentine, but the hills are composed mainly of syenite.

These resemble very much the Laurentian serpentines in colour and in their association with crystalline limestones. No minerals of economic value were found in them.

CAMBRIAN SERPENTINES.

The most easterly outcrops of these are found in the Shickshock Mountains, Gaspé Peninsula.

*Mount Albert, which is one of the main peaks, is composed of serpentine. The thickness of this great mass is estimated to be about 1,000 feet The whole of it presents evidence of stratification, in some parts remarkably clear and distinct, in others more obscure. Much of the lower 600 feet is bottle-green in colour, with beds towards the top of a streaked and mottled reddish and greenish brown, much studded with small crystals of diallage. The upper 400 feet display the bedding very beautifully, by difference of colour on the weathered exterior, as well as in freshly exposed surfaces. The weathered surfaces are marked by a set of red and opaque white bands, the white broader than the red, varying from one-eighth of an inch to an inch in thickness, and becoming often interstratified with layers of a brownish fawn colour, which

*From Geology of Canada, 1863, page 266.

vary in breadth. When cut and polished, this serpentine displays dark brown parallel bands, with thin blood-red vein-like lines, running through those which are red on the weathered surface. These red lines are sometimes disposed after the manner of false bedding. Very thin parallel bands of asbestos are found separating the red layers, together with occasional crystals of diallage; both of these, in certain lights, give golden-red reflections. With the red bands, chromic iron ore is associated, which is sometimes diffused in grains along the layers. Occasionally minute faults displace the layers, and where they cross those which contain chromic iron, the fissures connected with the fault are filled with the ore for some distance on each side. Beds of chromic iron, of two and three inches in thickness, are met with in several parts, and somewhat above the well stratified serpentine, the ore occurs on the surface in considerable quantity, in large loose angular blocks, which are traceable on the strike for some distance, showing that workable masses are probably imbedded in the rocks.

Mr. Richardson's explorations during the summer of 1878 have shown that this serpentine is close to important rock-masses of olivine, which have undoubtedly given rise to it. Dr. Harrington made a microscopical examination of a sample collected by Mr. Richardson, and reports on it as follows:

"It shows a few minute black grains, probably of chromite, and rarely a little of a fibrous mineral which resembles enstatite." According to Dr. Harrington the olivine rock from Mount Albert is probably not eruptive.

Speaking of that part of the Notre Dame range, Dr. Ells, in the Geological Survey Report for 1882-83-84, says:

"Among the prominent features of the Shickshock range are the two bare hills of serpentine, the one on the eastern extremity overlooking the forks of the Ste. Anne River, and known as Mount Albert; the other twelve miles west, on the Salmon branch, and called by Sir Wm. Logan the South Mountain. Of these the former was carefully studied and is described by Mr. A. P. Low, while the latter was the only one accessible to us. The latter presents a bold bluff on the south and west, rising to a height of over 1,200 feet above the Salmon branch, and extends for about two miles and a half east. The surface, like that of

Mount Albert, is either bare rock or is slightly clothed with a scattering growth of stunted spruces from five to twelve feet high, and small ponds with marshy edges occupy the depressions. The width of this mass of serpentine and associated rocks is about three-eighths of a mile. It rests upon the south flank of the hornblende schists, and terminates abruptly on the east bank of the branch, though a spur from its southern flank, of forty yards in width, crosses the stream in close contact with crystalline dolomitic rock.

The serpentine of this mountain apparently lacks the stratification seen in that of Mount Albert, and no traces of asbestos or chromic iron were discovered. On weathered surfaces it is exceedingly rough and ochreous.

Although the serpentines of this area have generally been regarded as an integral portion of the metamorphic series and contemporaneous in age, there are indications, at several places, which point to an eruptive origin. The position of the eastern or Mount Albert mass in particular, breaking, as it does, apparently across strata of Pre-Cambrian and Silurian age, gives it the aspect of an immense dyke, while the exposure noted as crossing the Salmon Branch, much of which is of peculiar character, is also like an intrusive rock.

In the Geological Survey Report for 1882-84, Mr. A. P. Low reports as follows of the olivine and serpentine of the Shickshocks :—

"These rocks are largely developed at the eastern extremity of the Shickshock range, and form the prominent peak of Mount Albert. They extend in a south-westerly course from the west side of Table-top Mountain across the south branch of the Ste. Anne River to Mount Albert, which is about the centre of the mass, and thence to the head water of the east fork of the Salmon Branch of the Cascapedia River, making a total length of twelve miles. The greatest breadth is four miles, on Mount Albert, but the average is not more than two and a half miles.

The rocks are chiefly olivine, more or less changed into a dark green serpentine, associated with patches of mottled brownish-red, the whole overlaid by banded beds. The green serpentine has sometimes a course, fibrous structure (picrolite), but the quantity is small and the quality not fine enough to make it commercially valuable as asbestos.

All the rock seen in Mount Albert was altered into the above serpentine, but on the eastern slopes, along the Ste. Anne River, olivine was found only slightly decomposed upon weathered surfaces.

These rocks all change to a light buff colour where they are exposed to the action of the atmosphere; and as the soil above them is very poor, supporting little or no vegetation, a dead appearance is given to the scenery.

Banded structure is distinctly seen amongst the serpentine in the mountains, but the direction of the strike of the beds is not continuous nor parallel to that of the surrounding stratified schists, and is supposed to be due to flow structure, as the olivine is undoubtedly of igneous origin. Chromic iron is found associated with the green serpentine, and seems to be confined to certain beds of the rock, as it is found scattered along the strike in loose blocks, some of which are ten inches in diameter. This mineral was observed on the surface near the banded beds of serpentine, at the north-east side of the mountain, and also along a bed about two miles south of the first place. The ore was found to occur in small, widely separated pockets, scattered through the serpentine, and where seen is not in sufficient quantity for profitable mining.

Where the olivine crosses the Ste. Anne River, veins of steatite of a light green colour were observed, but the cost of transportation renders them of no economic value."

Mr. Frank D. Adams made a microscopical examination of a slice of the Mount Albert rock, and gives the following description of it:

"This rock, which is very fresh, is in section seen to be composed of olivine, arranged in very irregular bands of larger and smaller grains, together with a small quantity of an opaque-black iron ore, which, judging from its association with the olivine, is probably iron ore. A few grains of a very light brownish-green fibrous mineral, some of which show parallel extinction, are also present. These are probably enstatite, but none of them are cut so as to enable this to be determined with certainty. An interesting point in connection with this rock is that each grain of iron ore is surrounded by a greenish ring composed of an aggregate of wavy fibres, which in a few cases, where they were sufficiently large for examination were found to have a parallel extinction, and which resemble serpentine. It is an olivine rock."

The next areas of Cambrian Serpentines are those which occur in Eastern Canada, or more generally known as the Eastern Townships serpentines. They are by far the most important ones of the whole Dominion, not only on account of affording rich minerals, but also as being considered by some as an altered metamorphic rock contemporaneous in age with those highly metamorphosed strata which constitute the Quebec group.

Ever since the establishment of the Geological Survey, work has been done almost every year in that part of the Province of Quebec called the Eastern Townships, and very highly interesting facts have been collected by the different gentlemen of the Geological staff who were given this section of the country to work out; but it is not until 1886 that the first geological map of a part of that section of our territory was published to accompany Dr. Ells's report of that same year. Though no map had previously been published, much had been said of the complicated set of rocks of that region, not omitting the famous serpentines which very often form vast masses almost without admixture, and at other times, enclose diallage, actinolite, garnet, and chromic iron, or are intermingled with carbonate of lime, dolomite and sometimes with ferruginous magnesite, forming varieties of ophiolite rock into which talc often enters. They almost always contain small portions of chrome and nickel while these two metals appear to be altogether wanting in the similar rocks of the Laurentian series.

These serpentines which are closely allied to a band of diorite and dioritic rocks, extend from the Township of Potton, on the west side of Lake Memphremagog, and a few miles only north of the International Boundary line, in a north eastward direction across the St. Francis River, or a stretch of about 115 miles. They appear in irregular but generally well defined masses and bosses, and although showing only here and there, the most of that distance, they do not deviate from the aforesaid direction except in the Townships of Shepton and Cleveland where they were around eastward towards the Township of Ham, whence they follow the general trend of all the formation, which is north-east. Sir Wm. Logan and Dr. T. Sterry Hunt held these serpentines to be of sedimentary origin, but Dr. Selwyn in the Geological Survey report of 1877-78, says :—

" I think there are very few who would agree with Dr. Hunt in the general proposition that the diorites and serpentines of the Quebec group are of sedimentary origin...."

Most of these serpentines however are almost always associated with dioritic rocks of which Dr. Ells reported as follows in 1885 :—

" Dioritic rocks are found at many points throughout the Townships, sometimes in masses of large extent, as in the Big Ham and Little Ham Mountains, and in the peaks along the western side of Lake Memphremagog; at others, as bosses and dykes. With these are often associated dioritic agglomerates, serpentines and serpentinous breccias."

In places massive serpentines are in immediate contact with black slates, and in others, very much broken and slaty serpentines, different in character, in colour and in touch, are found in what appear to be exactly the same black slates. To say that all the Eastern Township serpentines are or are not intrusive is a question that can be solved only after a long and very careful study of the whole region. There are undoubtedly two very distinct sets of serpentines in this field, but whether their difference is due to age, or origin, or both, is still an unsolved problem.

These serpentines are generally darker coloured, tougher and better fitted for ornamental purposes than those of the Laurentian series. Ophiolites, which are chiefly mixtures of limestone or of dolomite and serpentine, the latter predominating, are found in many places in the Eastern Towships.

Many minerals of great importance are found either associated or in close proximity to serpentine in this region, and in order to show the importance attached to the study of this class of rocks, an idea of the economic value of these will be given.

The old Huntington copper mine, in the Tonship of Bolton, is just in the midst of serpentine and serpentinous rocks; the Brompton Lake copper mine, in the Township of Orford, is also located in the serpentine. Variegated and vitreous sulphurets of copper disseminated in small masses in a bed of grey tough serpentine rock, four feet in width and flanked by serpentine on each side, occur on lot 28, range 9, Brompton. According to the Crown Land survey, a quartzose chloritic rock near a band of serpentine, in Orford, contains a small amount of

copper pyrites. On lot 9, range A, Orford, and near the junction of the serpentine with a diallagic diorite, six quartz veins occur in the latter rock within a breadth of twenty-five feet. Some of these are ten inches wide, and they all contain portions of yellow copper ore which is associated with a greenish serpentine-like material. On lot 22, range 1, Garthby, a large mass of iron and copper pyrites is found subordinate to the stratification of the enclosing rock, which is a calcareous serpentine.

Iron ores are also found in many places in the Townships associated with serpentine. Large loose blocks of magnetic ore, sometimes half a ton in weight, are found on the second lot of the tenth range of Leeds. They are near a band of serpentine, and probably not far removed from the parent rock.

An important deposit of magnetite is found on the west side of Nicolet Lake in serpentine.

Of chromic iron, Dr. Ells reports as follows:

"Chromic iron is found in connection with the serpentines at several places in the area under consideration" (the Eastern Townships). "A deposit on the south side of Lake Nicolet, lot 4, range 2, Ham, was open some years ago, and about ten tons extracted, but the indications were not sufficiently favorable to warrant a continuation of the work. Within the last five years, several openings have been made near Bellmina (lot 24, range 3, Wolfestown), on the crest of the serpentine ridge at this locality. The deposits are apparently of the nature of irregular pockets. From the most important of these about twenty tons were extracted from a shaft fifteen feet deep. The vein was five feet wide at the surface, but decreased to three feet at the bottom of the shaft. Two hundred yards east of this spot, a second opening was made, which produced two to three tons in pieces scattered through the serpentine. Other small deposits were also found, and in all about 25 tons were obtained."

An opening has been made by Dr. Reid in chromic iron on lot 16, range 4 of Thetford. The mineral occurs there in pockets and very small irregular veins in an asbestos-bearing serpentine.

In the seigniory of St. Francis Beauce, there is a bed of granular iron ore, forty-five feet wide, in serpentine. This ore is composed of common magnetic oxyd of iron and ilmenite.

As already stated, nickel is seldom or never absent from the serpentine of this area, but rarely forms more than two or three thousandths of the minerals in which it generally appears to be combined as a silicate. With the chrome-garnet of Oxford, the sulphuret of nickel (millerite), occurs in small grains and prismatic crystals, disseminated through the mixture of garnet and calcite in small quantity.

The most important mineral found in the Eastern Township serpentine is chrysotile, generally called asbestus, although the true asbestus is a fibrous tremolite or hornblende.

Of this mineral, which traverses the serpentine in irregular veins, varying in size from mere threads to a thickness of five or six inches, much has been said by Dr. Ells in his two last reports on the Eastern Townships. This mineral, which is undoubtedly a segregated one, is supposed by some to have been formed during the cooling of the mass in which it is found. They compare the cooling serpentine to a mass of cooling molasses, and say that asbestus is formed in the same way as the thin sugar fibres are produced in this substance when it is drawn out in the working. Acccording to this theory the longer asbestus veins would be the finer; but it happens to be the contrary. Moreover, how in this way could the presence of chromic iron, which is sometimes highly magnetic, be explained as occurring in veins in the asbestus veins themselves, cutting the latter very often into two equal parts?

The existence of asbestus in this country was detected by Sir Wm. Logan in 1851; bnt it was only iu 1877 that the first deposit of any commercial value was discovered. A *habitant* by the name of Fecteau was the happy finder.

In 1878 Messrs. Ward, John Johnston, Andrew Johnston and the Honorable George Irvine opened the first asbestus mine.

Asbestus was but little known by the ancient people, who used it only for the manufacture of cloths in which were placed the bodies of the great and distinguished men for cremation. By so doing they could keep their ashes from being mixed with any impurity. This minera was then scarce and very costly; its property of not being consumed by fire made it a wonderful and even a marvellous thing. It used to be then kept as an object of curiosity rather than of commercial value. Even in the seventeenth century asbestus was employed in the manufac-

ture of handkerchiefs and a few garments which were used in scientific lectures and representations of all sorts to illustrate, in a pleasant way, the non-conductibility of this silicate, which serves to-day for the manufacture of paints, cements, putties, wall-papers, mill boards, parchments and cloths. Mixed with tripoli it is used for packing and insulating steam and other pipes, as well as for lining safes. It is also used in the manufacture of drop-curtains and the sceneries in theatres, of suits for firemen, of safety ladders, of belts used in chemical works, and the last but not the least in the making of pipes.

Soapstone, which is more or less compact talc, is found in many places in the Townships, and is very often associated with serpentine. When pure and compact this mineral is much used as a refractory material for lining furnaces, especially those destined for anthracite. From its softness it is readily cut with knives and saws into the required shape, and it is infusible in any ordinary furnace heat. It is also used in the construction of small portable furnaces, and of open stoves, which are made of plates of it held together by iron bands and rods. Culinary vessels are made of it, and it has also been bored for water-pipes, and for the lining of cisterns for acid and alkaline liquids. When very strongly heated, soapstone looses the small quantity of combined water which it contains, and becomes much harder and susceptible of a polish. It may then be colored by various solutions, and it has been used in this manner for the manufacture of buttons and of some other small articles. Jets for gas-burners are also made of this hardened soapstone, and have the advantage of not being liable to rust or corrode. When reduced to powder its softness and unctuosity have caused it to be used, like plumbago, as a lubricator, and when mixed with a small proportion of white lead it forms a hard cement-like pigment, which is claimed to equal in resistance many of the more expensive fire-proof paints. It is also well adapted for a filer in the manufacture of paper. Slate pencils and tailors' chalk are also made of it.

Among the rocks of the Quebec group, in Eastern Canada, argillites fit for roofing slates occur in many places and have been successfully worked.

In the Township of Melbourne these slates, which are in contact with dark-green serpentine, afford excellent roofing slates, and are

extensively quarried for that purpose by the New Rockland Slate Co.

This serpentine is not only well adapted for interior decorative purposes but can also be used for the manufacture of small articles such as chandeliers, inkstands, paper weights, etc., etc.

In France serpentine is used for the manufacture of sulphate of magnesia or epsom salt. The magnesia which may easily be obtained from this sulphate makes fine hydraulic cements particularly well fitted for constructions exposed to the action of sea water.

CARBONIFEROUS SERPENTINES.

These constitute the last of group No. 2 or the palæozoic serpentines, and so far as we know, are of very limited extent.

In the Geological Survey report for 1877-78, page 93 B, Dr. Dawson speaking of the rocks of Cache Creek series, British Columbia, says:

"Whatever uncertainty might remain with regard to the region now in question has been set at rest by the discovery of fusuline limestone on the Bonaparte, interbedded with the siliceous and serpentinous rocks. The occurrence of serpentine and other metamorphic rocks of ancient appearance in beds of carboniferous age, is in its kind a point of considerable interest. In the place above referred to, it is said that "the limestones holding these fossils are so intimately associated and interbedded with the serpentines and other crystalline rocks above described, as to leave no doubt that they all belong to the same series." This statement I have been able to confirm by the examination of many additional localities. Between Hat Creek and 124 miles past (Mundorf's) numerous exposures in the roadside show the intimate association and interbedding of the cherty siliceous rocks with serpentines pure and impure, and of the latter with volcanic breccias of greenish-grey colour."

Of the serpentines of the Bonaparte River, Dr. Dawson reports as follows:—

"They may often be recognized at a distance by the bluish banks, bare of vegetation, which they produce on weathering. Here the relation between the serpentine and other rocks was most clearly seen. . . There can be little doubt that serpentines in this group of rocks have been igneous materials of some sort, and perhaps owe their conversion

to serpentine to the same hydrothermal or other action which has produced from siliceous sediments, the great mass of cherty quartzite."

CENOZOIC SERPENTINES.

These, also, like the last referred to, occur in British Columbia.

Dr. Harrington reported as follows on them :—

"Olivine has 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 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."

No economic minerals have yet been found in these serpentines, as well as in the carboniferous ones, but future researches and study may lead to some valuable finds in them.

We have now come to the last group or the one in which have been classed the serpentines of doubtful age, and which are found to the north of Lake St. John, Province of Quebec, and in the Yukon district.

Of these north of Lake St. John, Mr. Richardson reported as follows :

"About 200 yards west of the portage road, a cone-shaped hill, which rises over the waters of the narrows about 160 feet, is entirely composed of serpentine. This rock is traced on one side to the portage, and on the other it is supposed to form part of Juggler's Mountain, which is about 400 feet high, and is about two miles distant. On the highest part of the cone referred to, there is a blackish limestone, about one foot thick, interstratified with serpentine."

Dr. Hunt, while examining these rocks, had a portion of the limestone sliced for examination under the microscope, which revealed a structure resembling that of some coral. The serpentines, which are

dark-coloured opaque, and contain much disseminated magnetic iron, yield by analysis considerable portions of chrome and traces of nickel.

Dr. Dawson in his report on the Yukon district says :

" A specimen of asbestus (chrysotile), being part of a small vein of that material about half an inch in thickness, has been brought from the Stewart River, and the occurrence of serpentine in large mass elsewhere tends to show that valuable asbestus deposits may yet be found in the region."

If we now go out of our own Dominion we see that the Cambrian serpentines of the Eastern Townships which extend to Gaspé Peninsula are spoken of as occurring in the island of Newfoundland, and Mr. Alexander Murray, in 1876, speaking of the different ores found in this island, said :

" The more valuable ores hitherto discovered upon this island, notably those of copper, nickel and chromic iron, have usually been found to be closely associated with serpentinous rocks ; and the presence of such rocks has frequently instigated close inspection of the ground, resulting in the discovery of satisfactory metallic indications." In a paper read by Dr. . D. Peters at the last meeting of the American Institute of Mining Engineers, which was held here last fall, is found the following statement : " The entire world's production of nickel annually is less than 1000 tons, the bulk of this being produced by the New Caledonian nickel mines, which are oxyd deposits situated in serpentine dyke."

In the Urals, platinum associated with chromic iron is found in a rock of serpentinous matrix.

In Science, vol. 8, 1886, is given a very interesting article on the genesis of the diamond, by H. C. Lewis. He refers to the diamonds of Kimberley, South Africa, and on examination of the adamantiferous rock, as well as of the ore which is free from diamonds, he says that :—

" Both are dark, heavy basic rocks, composed essentially of olivine, and belong to the group of peridotites. Both are similar in structure and construction, differing only in the presence or absence of inclusions. The rock consists mainly of olivine crystals lying porphyritically in a serpentinic ground-mass."

Let us, then, hope that our Canadian serpentines, which are proved

to be in many places the altered remains of olivine rock, not only contain asbestus, the mineral of the day, which is not attacked by fire, but that we will find them, in a close future, affording also the mineral which the greatest heat and pressure of our laboratories could not yet produce, the diamond.

——:o:——

BOOK NOTICE.

ARTIFICIAL KEYS TO THE GENERA AND SPECIES OF MOSSES in Lesquereux and James's Manual of the Mosses of North America; by Charles R. Barnes; pp. 72; 1890.

Under the above caption Prof. Barnes has published in the Transactions of the Wisconsin Academy of Sciences (and also separately) a most useful article. After the Ferns there is perhaps no order of plants which is more invariably admired by those who love nature than the Mosses; their study, however, has been almost impossible owing to the want of an intelligible work which could be used by a beginner. In this way many who might have had their attention drawn to the study of botany by these beautiful objects, have been lost to the science. For botanists, unlike poets, need not be born botanists, but can be made by accident or training. By the publication of Prof. Barnes's pamphlet a great obstacle to the study of mosses is removed, and we feel sure that many of our members will now avail themselves of this opportunity. This should be particularly the case with our local members, for we have in Prof. Macoun, who is always courteous and willing to help beginners, the highest Canadian authority upon mosses. The above mentioned pamphlet is well printed, and sewed so as to open flat, and can be obtained through the editor for 50 cents a copy. J. F.

NEW MEMBERS.

Bethune, Rev. C. J. S., *M.A., D.C.L.* (Port Hope).
Campbell, A. M. (Perth, Ont.)
Decks, W. E., *B.A.*
Macfarlane, T., *M.E., F.R.S.C.*
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Ross, Niles G.
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Smith, Miss Eloise.
Sutherland, Miss Christine F.
Sutherland, J. C. (Richmond, Q.)
Topley, W. J.

SUMMARY

—OF—

Canadian Mining Regulations.

NOTICE.

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

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

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

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

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

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

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

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

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