CANADA

DEPARTMENT OF MINES

HON. R. B. BENNETT, ACTING MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

ECONOMIC GEOLOGY SERIES
No. 2

Talc Deposits of Canada

BY

M. E. Wilson

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

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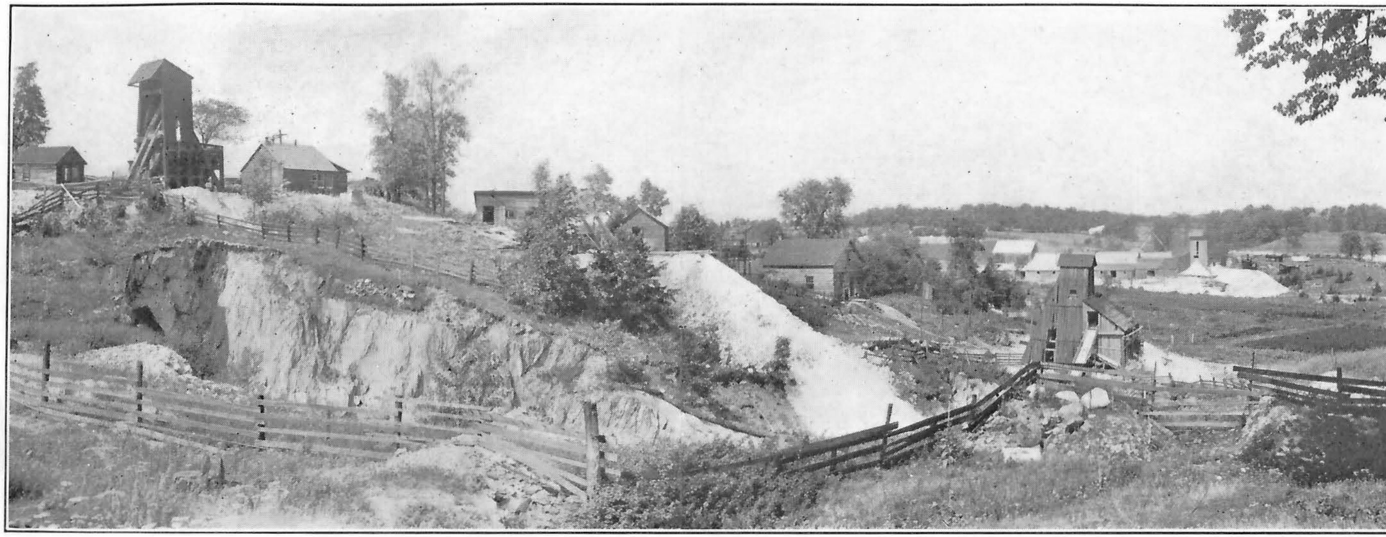
PLATE I



Henderson and Connolly talc mines, Madoc, Hastings county, Ontario. (Page 1.)

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PREFACE

This report upon talc and soapstone deposits in Canada has grown out of a geological examination of the Madoc and Marmora map-areas in southeastern Ontario, where important deposits of talc occur and are mined. There are numerous deposits of talc and soapstone in other parts of Canada, descriptions of which are scattered through the reports of the Geological Survey, the Minister of Mines for British Columbia, the Department of Mines, Ontario, and other sources, but most of these are incomplete and are not easily available for consultation. It was decided, therefore, to enlarge the report on the talc deposits of Madoc district so as to include descriptions of all the known talc and soapstone deposits in Canada. To accomplish this as economically as possible, deposits in western Ontario and British Columbia were examined and described by members of the staff of the Geological Survey who were engaged in field work nearest the different deposits in these regions and who were, therefore, most familiar with the geology of the district in which the deposits occur. The descriptions of the deposits in southeastern Ontario and the Eastern Townships of Quebec, with a few minor exceptions, are by the writer.

The present report deals chiefly with the distribution, general relationships, supplies, and commercial possibilities of talc and soapstone in Canada. It is intended to be complementary to a report by H. S. Spence on "Talc and Soapstone in Canada," published in 1922 by the Mines Branch, which deals mainly with the technology of talc and soapstone, although brief descriptions of the deposits are included.

The thanks of the Geological Survey are due to George H. Gillespie, manager of George H. Gillespie and Company and Henderson Mines, Limited; to Edward Phillips, superintendent of the Henderson mine; to H. B. Hungerford, president, and J. D. Decker, manager, of the Asbestos Pulp Company (Connolly mine); to Thos. Carswell and William Roberts, successively in charge of underground operations at the Connolly mine during the years 1920–24; to Christopher Henderson, Donald Henderson, and Chesley Pitt for information regarding the early operations at the Henderson and Connolly mines, and to R. C. Bryden, C. M. and G. M. Wallbridge, and many other residents of Madoc district, for their kindly interest in the work of the department.

The writer is indebted to C. E. Cairnes, V. Dolmage, J. D. MacKenzie, and J. F. Wright for descriptions of properties in British Columbia and northwestern Ontario; and to M. F. Bancroft for information regarding talc deposits in Lardeau and Revelstoke mining divisions, British Columbia. Acknowledgments are also due to Robert Ford, F. L. Finley, Alfred Bell, R. Goranson, H. M. Bannerman, and H. D. Squires, who assisted the writer in field work in Madoc map-area.

Talc Deposits of Canada

CHAPTER I

INTRODUCTION

The mineral talc possesses several peculiar and valuable characteristics that have made it useful to man from very early times. In its massive form, known as soapstone, it has been used for carving into ornaments and to a less extent into cooking utensils by primitive man in many parts of the world. It was used extensively for pipes, ornaments, and cooking vessels by the North American Indians and is still used and highly prized for these purposes by the Eskimo (Plate II). But talc is as useful in modern industry as to the aborigines, for in ground form and as soapstone it is being applied to a great variety of industrial uses.

Deposits of talc are found in association with magnesia-rich rocks where these rocks have been deformed and mineralogically altered. They are, therefore, confined either to regions that are now mountainous, such as the Alps in Europe, and the Appalachian mountains of eastern North America, or to regions that were formerly mountainous but have since been worn down to low elevations, such as the Precambrian highlands of eastern Canada. Most talc deposits belong to one or other of two classes, those associated with and derived from dolomite of sedimentary origin, or those associated with and derived from serpentinized ultrabasic igneous rocks. Deposits of the first class are light coloured and can, therefore, be used for talcum powder and other purposes for which a white colour is essential. The talc composing the deposits of the second class is dark grey, or green, and for this reason is less valuable than the white variety.

Deposits of talc, especially of the dark grey or green varieties, are exceedingly common in all parts of the world, but most of the high-grade, white talc is produced from four regions, northern Italy, southern France, California, and Madoc district, Hastings county, Ontario. There are several deposits in Madoc district, but the most extensive is that on the Henderson and Connolly properties. Until very recently this was the principal source, and is still the principal single source, of high-grade talc in America. Deposits of talc of the dark variety occur in several places in British Columbia, here and there throughout the great Precambrian area of eastern Canada, and in numerous localities in the Appalachian mountains of the Eastern Townships of Quebec. Little talc of this class has been mined in Canada. A small quantity of ground talc has been produced from two properties in British Columbia, and some soapstone has been quarried during the past three years in Thetford district, Megantic county, Quebec. Recently, deposits of dark green soapstone have been discovered near Wabigoon in western Ontario, but no shipments have been made.

MINERALOGY

Talc is a hydromagnesian silicate ($3\ MgO\ 4SiO_2\ H_2O$) composed approximately of: magnesia, 31·7 per cent; silica, 63·5 per cent; and water, 4·8 per cent; but talc in which no visible impurities are present generally contains small amounts of alumina, iron, lime, and in some cases, nickel. It is white, pale green, dark green, dark grey, or less commonly resinous brown. It fuses at a relatively high temperature (over 1,100° C., or 2,000° F.). It is chemically inert and hence is not attacked by acids or alkalis. It has a low conductivity both for heat and electricity. It is one of the softest of solid minerals, is sectile and flexible, and has a greasy feel and a pearly lustre. It occurs chiefly in two forms, a flaky variety, generally described as talc schist, and a fine, compact, massive variety known as soapstone, but in a few localities it occurs in semi-translucent laminæ resembling white mica (muscovite).

There are few minerals from which talc cannot be easily distinguished. It most closely resembles brucite, chlorite, and white mica, but is much softer than any of them. It is usually lighter in colour than chlorite, and less elastic and less uniformly laminated than muscovite. It is most difficult to identify in its fine-grained schistose form, especially when mingled with impurities. In general, the characteristics that distinguish it from all other minerals are that it can easily be scratched with the finger nail and that it has a greasy or soap-like feel. The following are definitions of the various names that have been applied to talc in its different modes of occurrence:

Foliated Talc: The micaceous or laminated semi-translucent variety. The best example in Canada is the Indian Creek deposit in Grimsthorpe township, Ontario. It also forms irregular veins together with ankerite on the Porter property near Clapham, in Ireland township, Quebec.

Talc Schist: A rock composed entirely or partly of talc flakes having a parallel distribution. Most of the talc in Madoc district belongs to this type.

Soapstone: Massive, fine-grained talc generally sufficiently compact to be sawn into blocks. Many of the talc deposits in the Eastern Townships of Quebec, and in British Columbia are soapstone.

Steatite: A name used in the early reports of the Geological Survey for impure soapstone.

Rensselaerite: Talc derived from pyroxene and which retains the form of the pyroxene.

Pyrallolite: Pyroxene in various stages of alteration to talc.

USES

Most of the uses to which talc is applied are dependent on individual physical properties or a combination of physical properties that it may possess; and certain qualities that are exceedingly important for one use are unimportant, or even detrimental, for other uses. The most essential of these qualities are its colour and its physical condition, that is, whether it can be used as soapstone blocks or merely for grinding into talc flour. Other important properties are its smoothness or "slip," its chemical inertness, its low conductivity for heat and electricity, and its high temperature of fusion. Of these properties its smoothness and white colour render it useful for talcum powder, its chemical indestructibility when exposed to weathering, for paint, roofing paper, and asbestos roofing, and its low electrical conductivity in the form of soapstone for electrical switchboards. Similarly, its softness makes it useful as a polishing powder for polishing glass and finishing leather, and its "slip" for use in the rubber industry to prevent sticking. It is for this last purpose that talc is supplied for placing between the inner and outer tubes of automobile tires to prevent adhesion.[1]

The different varieties of talc may be classified according to their principal uses as follows:

I. Powdered talc or talc flour

(a) High-grade variety: white and free from grit and hence possessing good "slip", suitable for use in toilet preparations, etc.

(b) Low-grade variety: grey or green and generally containing serpentine, tremolite, actinolite, or other impurities, used for all those purposes in which a white colour and purity are not essential.

II. Massive talc or soapstone

(a) Lava variety: talc that can be cut for use as gas-burner tips, electrical insulators, pencils, etc.

(b) Block variety: soapstone that can be cut into blocks for use in table-tops, furnace linings, as moulds, etc.

Since most of the uses to which talc is applied are dependent on its physical qualities, chemical analyses of talc are not of great assistance in demonstrating its usefulness, except that they may serve to determine the presence of mineral impurities and thus, indirectly, its physical character. It is stated by Ladoo[2] that some consumers of high-grade talc object to talc that is shown by analysis to contain lime. The effect of lime on the quality of high-grade talc depends largely, however, on the form in which it is present. If the lime is contained in tremolite or other lime silicates the effect of even a small percentage on the "slip" or smoothness of the talc will be considerable, whereas if it is present in calcite (calcium carbonate) the effect will be almost negligible. Tremolite and other lime silicates have a splintery fracture and a hardness of 5 to 6 compared with 1 to $1\frac{1}{2}$ for talc and 3 or less for calcite; moreover, lime constitutes only 13·4 per cent of tremolite and 56 per cent of calcite, hence, 1 per cent of lime is equivalent to about $7\frac{1}{2}$ per cent of tremolite and only 2 per cent of calcite. Both tremolite and calcite are chemically inert under ordinary conditions and usually white, so that their effect on the talc for most purposes for which it is used is wholly mechanical.

[1] For more complete statements of the uses of talc and soapstone *See* Ladoo, R. B.: "Uses of Talc and Soapstone"; U.S. Bureau of Mines, May 1920, and Spence, H. S.: "Talc and Soapstone in Canada"; Mines Banch, Dept. of Mines, Canada, 1922.

[2] Ladoo, R. B.: "High Grade Talc and the California Industry"; Reports of Investigations, U.S. Bureau of Mines, 1921.

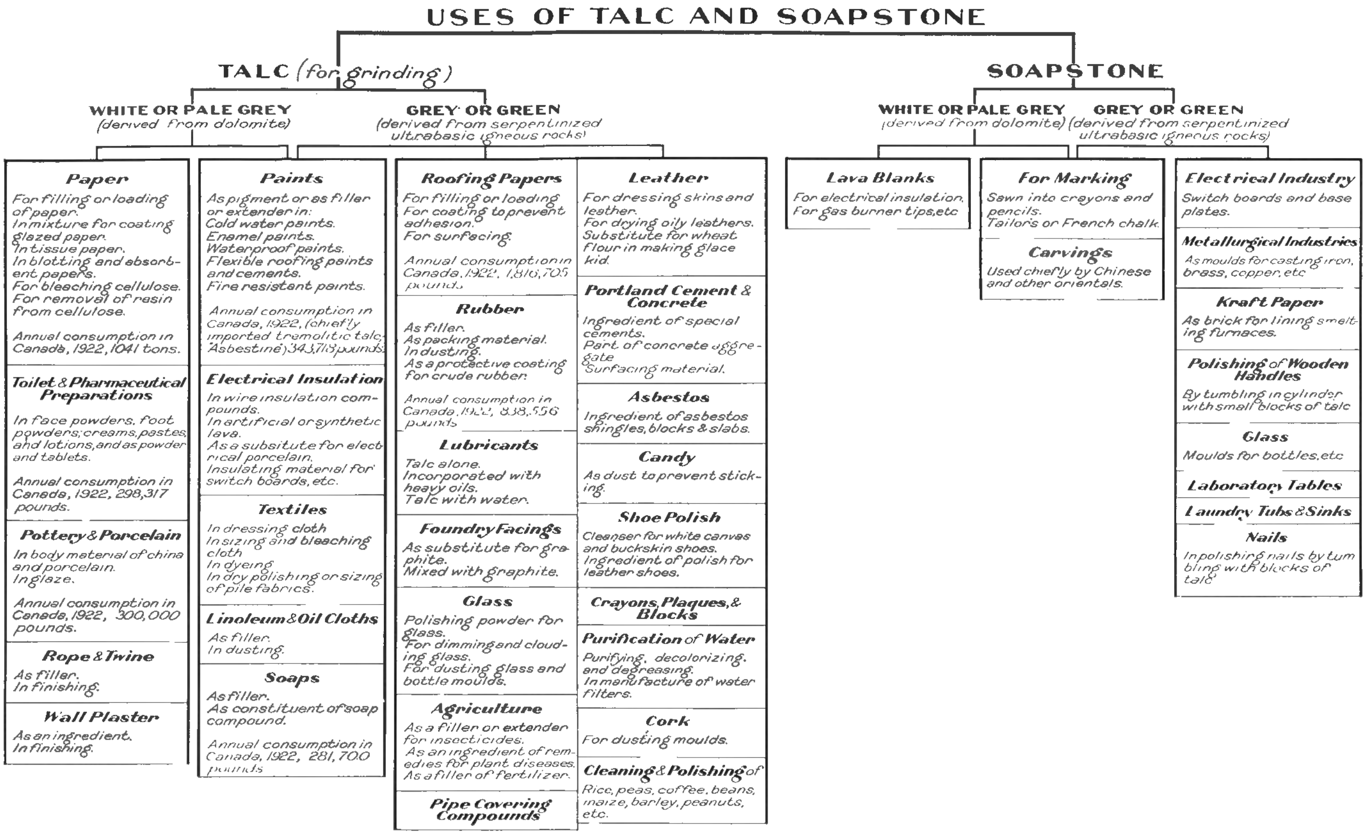

Figure 1. Uses of talc and soapstone.

CHAPTER II

TALC-BEARING GEOLOGICAL PROVINCES IN CANADA

Talc and soapstone are formed by the transformation of rocks (dolomite, gabbro, peridotite, etc.) containing a high proportion of magnesia, and hence belong to the metamorphic class of mineral deposits. They are thus confined to regions where igneous rocks are abundant and where the rocks have been profoundly folded. There are three geological provinces in Canada where these conditions exist: the Cordilleran region, the Eastern Belt of Folding (Appalachian Mountains and Acadian region), and the Canadian (Precambrian) Shield. In the other parts of Canada, the great plains of the west, the lowlands of the St. Lawrence, and the Hudson Bay Coastal plain, where the rocks lie relatively undisturbed and igneous intrusions are almost entirely absent, talc is unknown.[1]

CORDILLERAN REGION

The Cordilleran region is the mountainous belt that extends along the west coast of America and lies between the Great Plains and the Pacific ocean. In Canada it has a width of about 400 miles and includes nearly all of British Columbia, the Yukon, and the western parts of Alberta and the North West Territories. It is composed of three zones, known as the Eastern, Central, and Western belts.[2] This division into belts is based on differences in physiographic character, which in turn are related directly to differences in geological formations and history. The geological relationships of the talc deposits of the Cordilleras can best be indicated, therefore, as they occur in each of these belts.

EASTERN BELT

This belt includes the highly mountainous eastern part of the Cordillera—the Rocky mountains proper, and the Mackenzie and Franklin mountains. The rocks composing these mountains are almost wholly sedimentary. They range in age from Precambrian (chiefly late Precambrian, or Beltian) to Eocene, but belong for the most part to the Palæozoic and Mesozoic. The igneous rocks so far reported to occur in the belt include the Purcell lavas and associated dykes in the Precambrian (Beltian)[3], an extensive bed of volcanic ejectamenta in the Upper Cretaceous (Crowsnest volcanics),[4] an intrusive mass of nepheline syenite

[1] For a more extended account of the geology of Canada the reader is referred to "The Geology and Economic Minerals of Canada"; Geol. Surv., Canada, Pub. No. 1085, and the two maps (No. 1042 and No. 1084) that accompany that report.

[2] "Nomenclature of the Mountains of Western Canada"; Geog. Board of Canada, 1918.

[3] Daly, R. A.: Geol. Surv., Canada, Mem. 38, pp. 207–220 (1912).

[4] MacKenzie, J. D.: Geol. Surv., Canada, Mus. Bull. No. 4.
Dawson, G. M.: Geol. Surv., Canada, Ann. Rept., vol. I, pt. B, pp. 57, 79, 82, 88, 164, 166 (1886).

and related rocks of post-Cretaceous age on Ice river, near Field[1], and diabase intrusive into Ordovician sediments on Gravel river[2].

Deposits of talc are known to occur in this belt only in the territory west of Banff (Figure 3). They lie only a few miles east of the Ice River intrusion and may, therefore, be related to these rocks in origin.

WESTERN BELT

This belt is composed of: (1) the Pacific system or northwesterly-trending mountain chain that extends along the west coast of British Columbia; and (2) the Insular system or partly submerged mountains that form the island zone to the westward. The Pacific system includes the Coast, Cascade, and Bulkley mountains. The Insular system includes the Vancouver, Queen Charlotte, and St. Elias mountains.

The dominant geological feature of the western belt is the Coast Range batholith, an intrusive granitic massif, which, as shown on the geological map of Canada (No. 1277), is over 1,000 miles long and 30 to 125 miles wide. It is almost co-extensive with the Pacific system and is believed to have been intruded at the time these mountains were uplifted. This batholithic massif is not a continuous mass of igneous rock, for it contains inclusions of older rock and is bordered on either flank by a zone consisting of older rocks intruded and metamorphosed by apophyses of the massif which take the form of small batholiths, laccoliths, sills, and dykes. The rocks composing the massif range from gabbro to granite, but granodiorite predominates. The batholith is believed to have been intruded chiefly in the late Jurassic, although in places in the eastern border zone formations of early Cretaceous age are intruded by granodiorite and related rocks that are thought to belong to the batholith.

The rocks in the western belt that are older than the Coast Range batholith range in age from Silurian or older to late Jurassic. They consist of limestone, conglomerate, sandstone, and other sedimentary rocks and contemporaneous volcanics, chiefly basalt and andesite. They are, as a rule, deformed and metamorphosed and are intruded by sills and dykes of basic igneous rock, which have been more or less transformed to chlorite, serpentine, and related minerals. Rocks that are younger than the batholith belong to the Upper Cretaceous and Tertiary. Like the pre-batholithic rocks they include an abundance of contemporaneous lava flows, but they are less metamorphosed and the sediments are more largely clastic. They have been much folded and faulted in places and are intruded by dykes, sills, and laccoliths of gabbro diorite, lamprophyre, porphyrite, and granite, the greater part of which are of Tertiary age.

Highly magnesian igneous rocks such as basalt, pyroxenite, serpentine, gabbro, and porphyrite are common in the western belt, and in many places have been highly metamorphosed through the contact action of the Coast Range granite batholith or other intrusive masses. It is possible, also, that some of the rocks described in reports as limestone may be

[1] Allan, J. A.: Geol. Surv., Canada, Mem. 55, pp. 121–158 (1915).
[2] Keele, J.: "Reconnaissance Across the Mackenzie Mountains on the Pelly, Ross, and Gravel Rivers, Yukon and Northwest Territories," pp. 41–42(1910).

dolomitic, especially where they are associated with rocks high in magnesia, and where dolomite is found talc deposits may be present. Conditions necessary for the formation of talc, therefore, exist throughout a considerable part of the western belt, but chiefly in the contact zones along the batholithic border. Talc is known to occur in serpentine in the Coquihalla district, in a shear zone traversing diorite porphyry on mount Richard, Vancouver island; in a fault zone cutting argillites and carbonaceous slates in the Eagle claim, Vancouver island; in greenstone in the Lucky Jane claim near McGillivray creek on the Pacific Great Eastern railway, and in the Gisby group of claims 3 miles west of Keefer station on the main line of the Canadian Pacific railway (Figure 3). The last three occurrences are all associated with sediments of presumably Carboniferous age. These sediments include a large proportion of argillite and slate that might be transformed to talc along a fracture or fault-plane or other channel by which magnesia-bearing emanations from igneous intrusions could penetrate. This may have occurred in the case of the Leech River fault, on the Eagle property.

CENTRAL BELT

This is the wide zone of mountains and plateaux that lies between the Pacific and Rocky systems. The rock formations range from Precambrian to Recent and include the most diverse types. They can best be described in groups according to the division of the geological time scale to which they belong. The rocks of the Precambrian, Palæozoic, and Mesozoic divisions are for the most part highly metamorphosed, whereas those of Tertiary or later age, except locally, are relatively unchanged.

The formations of the belt that have been classified as Precambrian, or probably Precambrian, belong to the two main groups: (1) a complex of crystalline schists and gneisses, and (2) the Belt terrain. To the first class belong such rock complexes as the Shuswap series and the Yukon group. They consist of mica schist, garnet schist, hornblende schist, amphibolite, and other rocks that result from the metamorphism of sediments or lava flows. They have been classified as Precambrian because of their highly altered condition and because they appear to underlie formations of early Palæozoic age. Recent field work indicates, however, that some of these rocks may belong to the Palæozoic. The Belt terrain is the extension of this rock-group from the Rocky mountains into the Columbian system situated at the southeast corner of the Central belt. It consists of a great thickness of quartzite, phyllite, with some conglomerate and lava flows. It is either entirely Precambrian or Precambrian and Cambrian.

There are two principal groups of rocks in the Central belt that have been classified as Palæozoic or probably Palæozoic: (1) a complex of crystalline schists which includes the Niskonlith series, the Selkirk series, and the Adams Lake series;[1] and (2) a group of metamorphosed sediments, volcanic flows, and minor basic igneous intrusions, of which the Cache Creek series is the most typical example. The rocks of the first division

[1] Dawson, G. M.: Bull. Geol. Soc., Am., vol. XII, pp. 66–68 (1901).

are dominantly metamorphosed clastic sediments, but they include some schists derived from volcanic material and in places calcareous schists and limestone. They were placed in the Cambrian by Dawson because they seemed to be equivalent to rocks that were definitely known to be Cambrian in the Rocky mountains. Daly has since suggested that they are in part Precambrian, whereas Bancroft has shown that they include some rocks that are of later age than Cambrian. It seems probable, therefore, that these series will eventually be found to range in age from Precambrian to late Palæozoic. The second group, the Cache Creek series, consists of argillite, slate, quartzite, volcanic material (both flows and ejectamenta), intrusive greenstone, and limestone in which Carboniferous fossils have been found in places. For this reason they are generally described as Carboniferous, although sediments belonging to either later or earlier periods may be included in the series.

The geological record during the Mesozoic and Cenozoic eras is represented in the Central belt by formations belonging to nearly every period from the Triassic to Recent. The outstanding features of these formations are: (1) the abundance of clastic sediments as compared with limestone; (2) the recurrence of epochs of volcanic activity, which reached their culmination in the Tertiary; (3) the intrusion of numerous batholiths, laccoliths, dykes, and sills of granite, granodiorite, and related rocks during the late Jurassic or early Cretaceous; and (4) the abundance and variety of other igneous intrusions, including some batholiths and stocks of granite and granodiorite in the Tertiary.

The possibilities for the development of talc in the Central belt are thus very similar to those existing in the Coast batholithic belt. There is an abundance of basic igneous intrusives and lava flows, a large part of which have been highly metamorphosed by intrusions of granite and other igneous rocks. There is also some crystalline limestone in the various sedimentary series, notably the Cache Creek rocks, which may be dolomitic in places, and these may at such points carry talc. The deposits of talc so far discovered in the belt are confined almost entirely to metamorphosed basic igneous rocks (greenstone), where the talc occurs as an alteration production accompanied in most cases by serpentine. Deposits of this class are known to occur at White's camp at the head of Koomoos creek, Greenwood mining division, in the Asbestos group of claims, and on Silver Cup mountain in Lardeau Mining division to the north and east of Trout lake, and in slates near Illecillewaet in Revelstoke mining division (Figure 3).

SUMMARY

(1) The conditions for the development of talc in the Cordilleran region are more favourable in the Western and Central belts than in the Eastern belt, although talc is known to occur in the Eastern belt west of Banff.

(2) Most of the known talc deposits in the Western and Central belts are found in association with metamorphosed basic igneous rocks. One deposit occurs along a fault-plane intersecting slate and argillite.

(3) Talc may be found in the crystalline limestone of the Western and Central belts, especially near its contacts with granite or granodiorite intrusions.

(4) It is not probable that talc will be found in granite or granodiorite, except where these contain inclusions of older rock.

(5) Talc is a product of metamorphism and, therefore, will not be found in the Tertiary or Quaternary rocks, which are usually unaltered, or in older rocks that have not been metamorphosed.

EASTERN BELT OF FOLDING

The Eastern Belt of Folding includes all of Canada lying east of a line extending from lake Champlain through Quebec and eastward beneath St. Lawrence river (the Champlain or Logan fault). It corresponds in the east to the Cordilleran region of western America. It has been called the Acadian region by Dawson[1], using this name in an extended sense, and the Appalachian region, meaning the region of Appalachian folding, by Young.[2]

The Eastern Belt of Folding is a region in which the geology is exceedingly complex and in which much additional detailed work is required before its geological history can be completely worked out. The known data, however, show that the rocks nearly everywhere are folded in a northeasterly direction parallel to the trend of Appalachian mountain building. The rocks of the belt include nearly all types—sediments, lava flows, and basic and acidic intrusives—much of which has been highly metamorphosed. It is a region, therefore, in which, in places at least, the geological conditions favourable for the development of talc deposits are present. For the purpose of geological description it may be divided into: (1) the Appalachian mountain belt; (2) the highlands of New Brunswick; (3) the lowlands of New Brunswick; (4) the highlands of Nova Scotia; and (5) the lowlands of Nova Scotia.

APPALACHIAN MOUNTAINS

This division includes the belt of northeasterly trending mountains and highlands that extends from the Vermont boundary to Gaspe and is the continuation in Canada of the Appalachian mountains of United States. It is sharply separated from the St. Lawrence lowland on the west by a zone of faults along which the Palæozoic sediments have been overthrust to the northwest. The geology of the belt is exceedingly complex, and fossils are either uncommon or absent in many of the formations. On structural and stratigraphical grounds it is believed that the formations range in age from Precambrian to Devonian and fall into seven groups: (1) belts of altered Precambrian sedimentary and igneous rocks—mica schist, hornblende schist, chlorite schist, porphyry, etc.—exposed where erosion has removed the crests of major anticlinal folds; (2) slate, sandstone, quartzite, cherty limestone, conglomerate, ellipsoidal greenstone, etc., not known to contain fossils but believed to be Cambrian

[1] Dawson, G. M.: "Physical Geography of Canada"; Toronto, 1897, p. 7.
[2] Young, G. A.: "Geology and Economic Minerals of Canada"; Geol. Surv., Canada, p. 30 (1909).

because unconformable beneath Ordovician formations; (3) graphitic dark grey limestone, slate, conglomerate, rhyolite, tuff, etc., containing Ordovician fossils in places; (4) infolded remnants of Silurian and Devonian sediments in the Eastern Townships and the Gaspe sandstone and limestone in Gaspe peninsula; (5) the Bonaventure formation of Gaspe believed to be of late Devonian or early Carboniferous age and to be separated from the preceding groups by a great unconformity; (6) a group of igneous rocks—pyroxenite, peridotite, dunite, gabbro, etc.—the Serpentine series, which was probably intruded in mid-Palæozoic time; and (7) intrusive masses and batholiths of granite thought to be of late Devonian age.

The rocks of this belt of greatest interest in connexion with this report are the Serpentine series, for with them are associated the talc and soapstone deposits of the Eastern Townships of Quebec. They occur as sills, dykes, and irregular masses in a zone extending from the Vermont boundary to Gaspe, but are most extensive along the east slope of the Sutton Mountain anticline from Megantic county southwest through Thetford district to Brome county (Figure 18).

NEW BRUNSWICK HIGHLANDS

This division of the Eastern Belt of Folding includes the western and southern part of New Brunswick. It may be divided for the purpose of description into: (1) the northwestern highlands, an upland region in the northwestern part of the province underlain chiefly by Silurian, or Silurian and Devonian, sediments and related geologically to the western part of the peninsula of Gaspe that adjoins it on the north; (2) the central highlands, a zone of greater relief extending diagonally across the province from Chaleur bay to the state of Maine, and occupied mainly by Devonian and older sediments and volcanics folded and invaded in places by masses of granite; and (3) the southern highlands, a belt up to 40 miles wide lying along the northwest shore of the bay of Fundy and composed of a Precambrian igneous-sedimentary complex, Palæozoic sediments, and intrusions of granite.

A large part of the rocks underlying the New Brunswick highlands are more or less metamorphosed, but so far as can be ascertained from published reports the only ones that contain an abundance of magnesia are dolomite in the Precambrian near St. John city (Figure 19) and other places in the southern highlands, and basic volcanics and intrusives found chiefly in the Precambrian complex. It is also possible that some of the early Palæozoic limestone of the region includes some dolomite beds which may carry talc where they adjoin intrusions of granite. The known deposits of talc in the highlands are confined to the Precambrian of St. John district.

NOVA SCOTIA HIGHLANDS

Nova Scotia consists mainly of upland areas which, except for the narrow zone of Triassic lava flows that lie along the south shore of the bay of Fundy and scattered areas of Carboniferous strata, are underlain by pre-Carboniferous formations, most of which are highly metamorphosed.

Geologically they fall into two main divisions: (1) the southern part of the peninsula of Nova Scotia (southern upland), and (2) an irregular elevated zone extending eastward from the bay of Fundy to the straits of Canso (Cobequid mountains and Antigonish highlands) and the upland parts of Cape Breton island. The first of these divisions is underlain chiefly by the Gold-bearing series, a folded group of sediments—largely quartzite and slate—of late Precambrian age, and by batholiths and smaller masses of granite intruded in late Devonian time. The second division, the northern upland, resembles geologically the highlands of New Brunswick. It is underlain by a complex of Precambrian and early Palæozoic sedimentary and igneous rocks.[1]

In the northern upland both basic igneous rocks and dolomite are known to be present; and, since all the rocks of this region have been more or less metamorphosed, these might be transformed into talc or soapstone in places. In the southern upland, dolomite is very sparingly present in the Gold-bearing series and more extensively in the Silurian and Devonian strata that lie along the northern edge of the upland. The only other known occurrences of magnesia-rich rocks in the belt are the numerous dykes of diabase that intrude the Gold-bearing series, but these have not been greatly metamorphosed except adjacent to granite batholiths. It is possible, therefore, that talc is present in the southern upland in places, especially where dolomite adjoins intrusive batholithic masses of granite.

The known deposits of talc and soapstone in Nova Scotia are confined to the pre-Carboniferous complex of Cape Breton island and Antigonish county in the northern uplands (Figure 19). There are no recorded occurrences of talc in the southern upland, but some of the schistose phases of the Gold-bearing series are talcose.[2]

LOWLANDS OF NEW BRUNSWICK AND NOVA SCOTIA

Throughout central and eastern New Brunswick and in places in Nova Scotia there are extensive lowland areas underlain for the most part by gently folded or flat-lying sediments, belonging chiefly to the Carboniferous and Permian, but including Triassic strata near the bay of Fundy. These rocks are not known to carry talc and since thay have not been highly metamorphosed it is improbable that talc is present in them.

SUMMARY

(1) The known talc deposits in the Eastern Belt of Folding occur: (a) in association with the Serpentine series of the Appalachian mountains, (b) associated with Precambrian dolomite near St. John, New Brunswick, and (c) in the pre-Carboniferous complex of Cape Breton island and Antigonish county, Nova Scotia.

(2) With the exception of the lowlands of New Brunswick and Nova Scotia, most of the formations of the Eastern Belt of Folding are metamorphosed, and, hence, may contain talc wherever rocks containing considerable magnesia are present.

[1] *See* Geol. Surv., Canada, Map 39 A and Mem. 140.
[2] Faribault, E. R.: Personal communication.

(3) Basic igneous rocks (both extrusive and intrusive) which might be transformed to talc by metamorphism are known to occur here and there in the highlands of New Brunswick and Nova Scotia, but occur more extensively in the Appalachian mountains of Quebec.

(4) Dolomite is known to occur in several localities in the Appalachian mountains and in the southern highlands of New Brunswick. It is also probable that other undiscovered occurrences of dolomite are present in association with the limestone of the Eastern Folded Belt. Since emanations from granitic intrusions may transform dolomite to talc, an examination of the dolomite or limestone areas in regions where granite intrusions are present may result in the discovery of deposits of talc or soapstone.

CANADIAN SHIELD

The Canadian Shield is the name given by Suess to that huge upland nearly 2,000,000 square miles in area that occupies the greater part of northeastern North America. Except for local remnants of Palæozoic sediments, all this territory is underlain by Precambrian rocks and for the most part by types that show by their schistose and gneissoid structure and their relationships that they have been subjected to intense deformation and constitute what is generally described as a basal complex.

By far the greater part of our information regarding the geology of the Canadian Shield has been obtained in the territory lying along its southern border within the basin of St. Lawrence river, but even in this region investigation has been confined largely to four subprovinces: (1) the region northwest of lake Superior which might now be extended to include eastern Manitoba; (2) the region south of lake Superior in United States; (3) the region extending from the east end of lake Superior and Georgian bay northeastward across Timiskaming region to lake Mistassini (Timiskaming subprovince); and (4) southeastern Ontario, the southern Laurentians of Quebec, and the Adirondack region in United States (Grenville subprovince). For the purpose of geological description the Canadian Shield in Canada may be divided into four parts: (1) the northwest subprovince; (2) the Timiskaming subprovince; (3) the Grenville subprovince; and (4) the vast northern part of the Shield, the geology of which is comparatively unknown. The approximate succession of formations in these regions is shown in the following table:

	Northwestern subprovince	Timiskaming subprovince	Grenville subprovince		Northern part of shield
			Western part	Eastern part	
Late Precambrian		Olivine diabase Killarney granite		Grenville and Rigaud stocks of granite, and syenite	
	Keweenawan series Conglomerate, sandstone, etc., lavas, diabase dykes, and sills Animikie series Conglomerate, iron formation and slate Granite (Algoman of Lawson) Lamprophyre, gabbro, etc. Seine and Steeprock series [2]	Diabase, norite, dykes, and sills; conglomerate and sandstone Whitewater series Conglomerate, tuff, slate, sandstone Cobalt series Conglomerate, argillite, greywacke, quartzite, limestone Bruce series Conglomerate, quartzite, limestone, indurated silt	Diabase dykes	Diabase dykes Lamprophyre mass, and dykes	Diabase dykes, and sills Quartz porphyry dykes Athabaska sandstone and conglomerate Coppermine River series Nastapoka series Mistassini series Koksoak River series, etc.
Early Precambrian	Granite (Algoman of Lawson) Lamprophyre, gabbro, etc. Seine and Steeprock series,[1] etc. [2]	Granite, syenite, etc. Lamprophyre dykes	Granite, syenite, etc. Gabbro, diorite	Granite, syenite, etc. Buckingham series (igneous) Peridotite, gabbro, anorthosite (including Morin mass), syenite, etc.	Granite, syenite, etc.
	Granite, etc. Gabbro, anorthosite, etc. Complex of sediments and volcanics, including the Keewatin, Couchiching, Rice Lake series, etc.	Complex of sediments, and volcanics Sediments Timiskaming series Dore series Pontiac series, etc. Iron formation Volcanics Abitibi volcanics, Pre-Huronian schist complex, or Keewatin of some reports	Hastings series Conglomerate, argillite, limestone Grenville series Acid and basic lavas Mica schist, quartzite, limestone	Grenville or Grenville-Hastings series Limestone, quartzite, sillimanite-garnet gneiss	Complex of metamorphosed sediments and volcanics

[1] Classified as Huronian and hence late Precambrian by Lawson.
[2] Relationship to formations of other subprovinces in doubt.

With the exception of the Seine and Steeprock series, which are possibly early Precambrian, and the altered phases of the Bruce and Cobalt series where they adjoin the Killarney intrusive granite, the rocks classed as late Precambrian have not been intensely metamorphosed and do not, therefore, carry talc. On the other hand, all of the rocks classed as early Precambrian are highly metamorphosed and may carry talc wherever rocks containing a high percentage of magnesia occur. It is chiefly the early Precambrian rocks, therefore, that are of interest from the standpoint of this report.

NORTHWESTERN SUBPROVINCE

The highly magnesian rocks that occur in the early Precambrian complex of the northwestern subprovince, except for dolomite on Red lake, Patricia district, and a few other occurrences of small extent, so far as known, are all basic igneous intrusives and lava flows. It is in these basic rocks, therefore, that talc will most probably be found. The known deposits in the region include aggregates of talc in the Keewatin hornblende schists of some of the islands in Lake of the Woods; and zones or masses of soapstone, in gabbro near Wabigoon; in Keewatin schist on the tug channel 1¾ miles southeast of French portage, Lake of the Woods, Kenora district; on Rock Island bay in Watten township; and north of Pipestone lake, Rainy River district (Figure 6).

TIMISKAMING SUBPROVINCE

In the Timiskaming subprovince carbonate rocks that might be transformed to talc occur here and there in the basal complex, as for example the nodules of carbonate (probably magnesite) in the rock known as the "mica dyke" at the Magpie mine, Michipicoten district,[1] and the ferruginous dolomite or ankerite in Larder Lake, Porcupine, and other districts in the region north of lake Timiskaming. The limestone member of the Bruce series (Lower Huronian) is also dolomitic in places[2] and such dolomitic phases, where they adjoin intrusive Killarney granite, may be transformed to talc. The most extensive magnesian rocks in the Timiskaming subprovince, however, are the altered basic igneous rocks (greenstones and green schists) of the basal complex, most of which are highly metamorphosed and may carry talc or soapstone, especially in zones of deformation near intrusions of granite, syenite, or other acidic rocks. Among the greenstones there are serpentinized peridotites (highly magnesian ultrabasic rocks) similar to the Serpentine series of the Eastern Townships of Quebec. Such rocks occur on lake Abitibi,[3] in Duhamel township east of lake Timiskaming[4], at Porcupine[5], on Pigeon lake[6], and in many other localities. With such rocks, talc and soapstone are most

[1] Collins, W. H.: personal communication.
[2] Collins, W. H.: "The North Shore of Lake Huron"; Geol. Surv., Canada, Mem. 143.
[3] Baker, M. B.: "Lake Abitibi Area"; Ann. Rept., Ont. Bureau of Mines, vol. XVIII, p. 273 (1909).
[4] Wilson, M. E.: "An Area Adjoining the East Side of Lake Timiskaming"; Geol Surv., Canada, p. 15 (1910).
[5] Burrows, A. G.: "Porcupine Gold Area"; Ann. Rept., Ont Bureau of Mines, vol. XIX, pt. 2, p. 12 (1911).
[6] Collins, W. H.: "Gowganda Mining Division"; Geol Surv., Canada, Mem. 33, p. 33 (1913).

commonly associated, although, so far, they have not been discovered in the Timiskaming subprovince.

Talc occurs in the Timiskaming subprovince on the west shore of lake Timiskaming about 4 miles south of Montreal river; at the Frood mine, Sudbury district; on Panache lake, and in the "mica dyke" at the Magpie mine, Michipicoten district. Talc or steatite has also been reported to occur in the township of May and other localities, but these deposits are more probably soft schists and contain little if any talc.

GRENVILLE SUBPROVINCE

The Grenville subprovince, except for a few intrusions of unmetamorphosed lamprophyre, diabase, granite, and syenite of late Precambian age, is entirely underlain by a highly metamorphosed complex of igneous rocks and sediments in which dolomite, basalt, and other magnesian rocks are abundant. Dolomite occurs here and there throughout the whole subprovince, in beds or masses associated with either the Grenville or Hastings limestone. It would seem possible, therefore, since intrusions of granite are common everywhere, that talc formed from dolomite by silication may be found almost anywhere in the region, but the only important deposits of this type so far discovered are those of Madoc district (Figure 7). These, however, are the principal deposits of high-grade talc in Canada. Basic lava flows and their foliated equivalents, hornblende schists, etc., are interstratified with the limestone and mica schists of the Grenville series throughout a large part of southeastern Ontario. A serpentine phase of these has been transformed to a mixture of actinolite, dolomite, and talc in places near its contact with a batholith of granite in Elzevir township, near Actinolite (formerly Bridgewater), Ontario. Some peridotite forms a part of the Buckingham series in Buckingham district, Quebec, but the amount of the rock is small, and this, except for the serpentine in Elzevir, is the only known occurrence of ultrabasic rock (the type most commonly transformed to talc) in the whole subprovince.

NORTHERN PART OF SHIELD

The northern part of the Canadian Shield is a vast region known only from explorations along its shores and reconnaissances by canoe along some of its principal waterways. It is underlain, apparently, by a complex of granite, gneisses, and crystalline schists (chiefly altered clastic sediments and volcanics) overlain in places by areas of relatively undisturbed strata —conglomerate, sandstones, slate, iron formation, and limestone—which, because of their relationship to the underlying basal complex and their lithological similarity to the Keweenawan, Animikie, or the original Huronian, have been generally correlated with one of these series. In any case, it is almost certain that they are late Precambrian. Since they have not been intensely metamorphosed it is not probable that they contain talc or soapstone.

The basal complex of the northern part of the Shield includes some dolomite on lake La Ronge[1], also crystalline limestone with which dolomite may be associated, on Baffin island, and on Eastmain river near its outlet into James bay. With these exceptions, the known rocks with which talc or soapstone might be associated are the altered basic igneous rocks—chiefly lava flows—that form extensive belts here and there in the granite and gneiss.

The known deposits of talc within the northern part of the Canadian Shield are not numerous. A number of occurrences of soft rock described as steatite or soapstone are recorded in the reports of the Geological Survey, but it is not certain that all these rocks carry talc. They are generally soft, altered greenstones used by the natives for cooking utensils. Talc occurs, however, in Chibougamau district[2] on Rapid river, 2 miles above its outlet into lake Chibougamau; near Mosquito bay on the east coast of Hudson bay; and near Coronation gulf in the North West Territories.

SUMMARY

(1) A large part of the rocks composing the Canadian Shield belong to a basal complex of highly metamorphosed formations. Hence talc or soapstone may occur almost anywhere in the Shield where rocks containing a large proportion of magnesia are present.

(2) Dolomite, or crystalline limestone with which dolomite is commonly associated, occurs extensively in the Grenville subprovince and on Baffin island, but elsewhere is almost unknown. It is probable, therefore, that talc of the white, high-grade variety that results from the metamorphism of dolomite will be found in the Canadian Shield, chiefly in the Grenville subprovince and on Baffin island.

(3) Basic igneous rocks from which talc deposits of the grey or green soapstone variety are commonly formed are abundant in the numerous belts of crystalline schists that compose the basal complex of the Canadian Shield.

(4) The principal deposits of talc so far discovered in the Canadian Shield are the high-grade talc deposits of Madoc district, in the Grenville subprovince, and the deposits of soapstone at Wabigoon and other localities in the region northwest of lake Superior (northwestern subprovince).

[1] McInnes, Wm.: "The Basins of Nelson and Churchill Rivers"; Geol. Surv., Canada, Mem. 30, p. 48 (1913).
[2] Faribault, E. R.: personal communication.

CHAPTER III

GENERAL CHARACTER AND ORIGIN OF TALC DEPOSITS

Talc in Canada occurs for the most part, if not entirely, in association with either magnesia-rich sediments—chiefly dolomite—or altered ultra-basic igneous rocks, and hence as regards relationships belongs to two principal types of deposits. There is, however, a micaceous variety of talc formed in veins, which, although not differing from the two main types in its association, is so different in character and mode of occurrence that it is generally regarded as a separate type of deposit. The deposits of this class found in Canada are all associated with basic igneous rocks, but there is no apparent reason why similar veins might not be found in association with dolomite. They are small and are of interest chiefly because of the purity, peculiar character, and mode of occurrence of the talc composing them. Thus, the talc deposits of Canada, with the possible exception of a single occurrence, that on the Eagle claim, Victoria mining division, Vancouver island, fall into three classes:

(1) White or light grey, high-grade talc associated with dolomite.
(2) Grey or green (usually impure) talc associated with basic igneous rocks.
(3) Micaceous talc in veins cutting soapstone or serpentine.

GENERAL CHARACTER

(1) WHITE OR LIGHT GREY TALC ASSOCIATED WITH DOLOMITE

To this class belong the talc deposits of Madoc district, Ontario; the deposit near mount Whymper, in British Columbia close to the Alberta boundary; and probably the deposits of the Gisby group, near Chaumox, British Columbia. Their essential characteristics are that they are light-coloured and are associated with dolomite from which they have evidently been formed by reaction with siliceous emanations from nearby acidic igneous intrusives.

Madoc District

The deposits of Madoc district are the most important examples of the type so far discovered in Canada. They are situated in Hastings county, 25 to 32 miles north of Belleville, on the north shore of lake Ontario, and close to the border of the Laurentian highlands. They occur in two localities: a northeast-trending belt commencing about one-half mile east of Madoc village, and near Eldorado, a village about 6 miles north of Madoc. The belt lying east of Madoc is about 1 mile long and includes at least six separate occurrences of talc. Practically all the talc produced from Madoc district has come from the deposit in the Henderson and Connolly properties, at the west end of this zone, those deposits so far discovered at the east end being too small or too much mingled with impurities to be workable. The Eldorado deposit consists of talc disseminated through dolomite, and, so far as exploration has shown, does not include a mass of high-grade talc of workable extent. It is of interest, however, because its relationships are very like those of the deposits of the main zone at Madoc.

The rock in which the talc occurs in both localities is a buff to grey-weathering dolomite or limestone-dolomite which in places contains quartz either in veins (Plate III) or in fine interlaminated zones (*Eozoon canadense*, Plate IV). Tremolite occurs abundantly in the dolomite either in fine needles, aggregates (Plate V), or in parallel zones that stand up as ridges on the weathered surface. In the underground workings of the Henderson and Connolly properties a black rock, madocite, consisting chiefly of brown tourmaline, occurs in dykes up to 20 feet wide. In places this cuts across the talc mass, but in other places lies parallel to its footwall. The only other rocks near the deposits are masses of quartzite, a few remnants of basal Palæozoic sandstone and conglomerate, and intrusions of granite. In the Eldorado property there are two dykes of granite, probably apophyses from batholithic intrusions of granite lying about 1 mile to the west. The Henderson-Connolly talc mass lies about 1,000 feet northwest of the margin of the Moira granite batholith (Figure 2).

The talc deposit in the Henderson and Connolly properties is in the main a snow-white, cream-white, or pale grey, flaky talc, but becomes fine-grained, massive, and deep grey, or even resinous-brown in colour along the margin and at the extremities of the mass. The principal impurities are lenticular aggregates of calcite and dolomite, scattered crystals of pyrite, and a few prismatic crystals of tremolite. The flakes of talc range from mere specks to sheets one-half inch or more in diameter in the more micaceous varieties. The pyrite crystals are most abundant in the massive grey phases of the deposit. Under the microscope the fine, massive, grey talc is seen to consist entirely of either a felt of fine, fibrous talc, or of frayed-out flakes of talc included in a fine, fibrous matrix. The coarse, schistose phases of the talc consist chiefly of frayed-out flakes having a roughly parallel arrangement, but in some sections transverse crystals up to $\frac{1}{4}$ mm. in diameter and 1 mm. or more in length are present. Many of these are partly transformed into the fine, fibrous type of talc, the foliation trending either obliquely or transverse to the longer direction of the flake. The talc in all these sections is much bent and broken and has evidently been subjected to intense deformation.

The deposit, wherever its relationships are exposed, conforms to the structure of the enclosing tremolitic dolomite, and, like the dolomite, has been intensely crumpled. At the surface it has roughly the form of a very much elongated interrogation mark with its top to the west (Figure 14). At the 200-foot level it is more crenulated and 50 feet west of the No. 2 shaft on the Henderson property it is interrupted by a northwest trending thrust fault, so that the deposit on the east side of the fault now lies 50 feet towards the northwest of that on the west. At some points, as along the line between the Henderson and Connolly properties at the 200-foot level, the flaky talc schist passes into massive, fine-grained talc (soapstone), but except where it is cut across by madocite dykes, the talc is

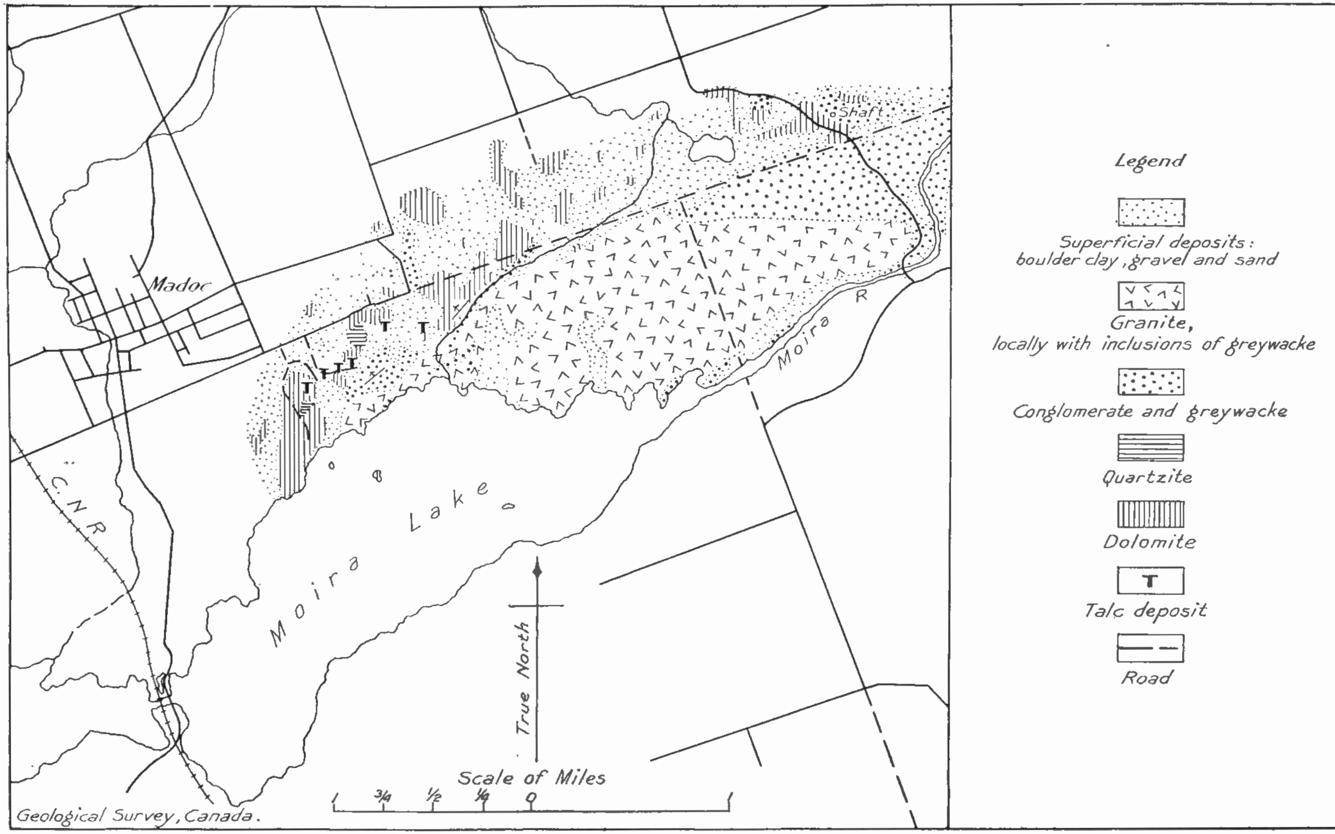

Figure 2. Position of talc deposits relative to the Moira granite batholith, Madoc, Ontario.

continuous. The total length of the deposit in a straight line is about 1,100 feet, but following the crenulations about 1,300 feet. The maximum width is 65 feet in the Henderson and about 25 feet in the Connolly; the average width is about 30 feet in the Henderson and about 15 feet in the Connolly. The variation in width is evidently due to the relative incompetence of the talc as compared with the wall-rock, the soft talc flowing to the crest of folds where the pressure is least. The depth to which the deposit has been mined is 200 feet, but, since it is almost certainly of deep-seated origin, it probably extends to considerably greater depth.

Mount Whymper or Silver Moon Claim

This property is on the east slope of mount Whymper, about 25 miles west of Banff and 11 miles southwest of Castle station on the Canadian Pacific railway. The rock enclosing the talc is a grey, flat-lying dolomite of Lower Cambrian age, but intrusions of nepheline syenite and related rocks are exposed in Ice River district, 20 miles to the westward, so that acidic igneous rocks probably occur at no great depth beneath the deposits. The talc, except for some pockets of a fibrous type, is a massive, dense, greenish grey variety, so much fractured that unbroken masses more than 2 feet in diameter would be difficult to obtain. It occurs in four irregular masses or lenses which, according to H. S. Spence, lie at about the same horizon in the dolomite. These masses are from 15 to 20 feet wide and have a maximum vertical extent of 75 feet. The principal impurities contained in the deposits are quartz and dolomite.[1] Chemical analyses show that except for the dolomite and quartz the deposit consists of pure talc.

Gisby Group

This group of claims is situated in British Columbia on the west side of Fraser river, 2 miles above Chaumox station on the Canadian Pacific railway. They lie near the eastern border of the Coast mountains and hence in the contact zone adjoining the east side of the Coast Range batholith. The rocks exposed in the claims consist chiefly of slate, calcareous greywacke, chert, ferruginous dolomite, and other sediments highly folded and intruded by diorite dykes.

Deposits of talc are known to occur in six different localities in the property: in an adit in the Gisby claim, in an adit in the Salmon River claim, and in four outcrops near Nahatlatch river (Figure 5). All the deposits occur in zones conforming to the structure of the enclosing sediments. In the adit in the Gisby claim there is a zone of impure, dark green, much fractured, talcose rock 150 feet wide in which a lead of high-grade, pale green talc 5 to 8 feet wide is included. In the Salmon River claim and in the outcrops near Nahatlatch river the talc zones consist of green to white talc mingled with varying proportions of magnesite and other carbonates. They have a width of 10 to 100 feet. The principal impurities in the talc-carbonate zones are a few disseminated grains of

[1] Allan, J. A.: "Second Annual Report on the Mineral Resources of Alberta"; 1920, pp. 122-24.
Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 18.

iron sulphide and small veins of quartz along their margins. They are regarded by C. E. Cairnes as the product resulting from the interaction of siliceous emanations from the intrusive batholith which lies a few miles to the northwest, with magnesite and other magnesium carbonates.

(2) GREEN OR GREY TALC ASSOCIATED WITH ULTRABASIC IGNEOUS ROCKS

Deposits of this class are very numerous in Canada. Some of the most extensive are: talc near Anderson lake, Lillooet mining division, and northwest of Trout lake, Lardeau mining division, British Columbia; soapstone near Wabigoon, Kenora district, northwestern Ontario; talc associated with actinolite, Elzevir township, Hastings county, southeastern Ontario; and the numerous soapstone deposits scattered throughout a wide belt in the Eastern Townships of Quebec.

Lucky Jane Claim

The talc deposits in this claim are situated near the northeast shore of Anderson lake and adjacent to the Pacific Great Eastern railway at a point about 90 miles north of its terminus at Squamish. The rocks exposed in the district consist of a complex of impure quartzite, argillite, limestone, and chlorite-talc schist, intruded by granodiorite and miarolitic granite. The talc-chlorite schist in which the talc occurs is a foliated, medium to fine but irregularly grained rock consisting chiefly of plagioclase, biotite, chlorite, talc, actinolite, hornblende, and titanite. The talc is a grey to green mottled variety and occurs in two zones, the larger of which is 8 to 10 feet wide. The principal impurities contained in the talc are small amounts of pyrite, magnetite, limonite, and, in a few places, veins of actinolite. It is believed by Dolmage that the talc has been derived from the chlorite-talc schist or from the rock of which the schist is an alteration product.

Asbestos Group

Numerous bands of serpentinized basic igneous rocks that in places have been transformed to talc occur in association with the Palæozoic sediments of Lardeau district, British Columbia, but up to the present development work has been attempted on only one group of claims, situated east of Columbia river and 1½ miles in a direct line from Sidmouth, on the Canadian Pacific railway 3 miles north of Arrowhead. These have been staked on a mass of serpentine 800 to 1,000 feet wide and one-quarter mile long, that has been more or less transformed to talc throughout its whole width. The largest deposit of talc observed in the serpentine is a zone of variegated greenish grey talc schist occupying the bottom of a pit 20 feet wide, 50 feet long, and up to 6 feet deep.[1] Under the microscope this schist is seen to consist of coarse grains of carbonate (probably magnesite), granular magnetite, and fine, micaceous talc.

[1] Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1921, pt. A, p. 112, and personal communication.

Wabigoon Lake District

Deposits of massive talcose rock—soapstone—occur in several places in northwestern Ontario. The most extensive are those on the north shore of Wabigoon lake about 1 mile west of Wabigoon station on the Canadian Pacific railway, and on Trap and Mile lakes, about 15 miles southwest of Wabigoon (Figure 6). The bedrock of this district consists of a complex of metamorphosed Keewatin lava flows and sediments intruded by gabbro, syenite, and granite. The soapstone is intimately associated with the gabbro.

The soapstone deposits on the north shore of Wabigoon lake occur in two zones separated by 100 feet of grey, syenite-like rock. The northeasterly of these zones is 35 feet wide and about 400 feet long and consists of soapstone practically throughout the mass. The southeasterly zone is 75 feet wide and about 300 feet long, but includes some masses of unaltered or only partly altered gabbro. Microscopic examinations of thin sections of the soapstone show it to be composed of about 50 to 75 per cent of talc, the remainder of the rock consisting of chlorite, serpentine, dolomite, and magnetite. In places the soapstone is much jointed, but in other localities it is apparently free from fractures throughout considerable areas.

On Trap and Mile lakes there are five separate deposits of soapstone all enclosed within a single lenticular mass of gabbro (Figure 9). The most extensive of these is that composing a V-shaped island about 500 feet in diameter in Trap lake. This soapstone mass, like those in Wabigoon lake, is composed of talc with varying proportions of chlorite, serpentine, dolomite, and magnetite. It has been subjected to some deformation as shown by the presence of slickensided fracture surfaces and zones of schistosity adjoining fractures. Some of the fractures are filled with veins of white flake-talc.

The soapstone deposits both at Wabigoon and on Mile and Trap lakes are thought by J. F. Wright to have been formed either from the gabbro with which the soapstone is associated or from an ultrabasic phase of the gabbro, through the metamorphic action of residual solutions emanating from the gabbro mass as it cooled.

Elzevir Township

In the southwestern part of the township of Elzevir, Hastings county, Ontario, there is an extensive area of Precambrian, Grenville volcanics—serpentine, gabbro, etc.—that is cut off on the northeast by an intrusive batholithic mass of granite gneiss. Here and there in a belt about one mile wide adjoining the contact of the granite, masses or zones of schistose rock up to 50 feet wide and several hundred feet long occur within the serpentine phase of the volcanics. These masses or zones have been described as deposits of actinolite, but examination under the microscope shows that they consist chiefly of talc, dolomite, serpentine, and disseminated grains of magnetite. The fibrous actinolite which occurs in zones up to 1 foot wide along planes of movement in the schist, forms only a small part of the whole.

Eastern Townships of Quebec

The folded Palæozoic and pre-Ordovician (probably Precambrian) sediments composing the Appalachian mountains of southeastern Quebec are intruded in many places by masses and sills of serpentinized ultrabasic rocks, known as the Serpentine series. Numerous deposits of talc and soapstone occur in association with these serpentinized intrusives, throughout a belt up to 25 miles wide and 125 miles long extending from the International Boundary to the region southeast of Quebec. The talc and soapstone occur for the most part along the margin of the intrusive, but in a few localities along zones of deformation within the serpentine mass. They are generally grey or green and are more or less schistose. They vary considerably in composition, in some cases consisting of almost pure talc, and in others of a mixture of talc, magnesite, dolomite, and disseminated chromite, or chromite and millerite. The last material resembles the phase of the talc deposits of Vermont state known as "grit". As a rule, where the deposit lies on the border of a serpentine mass it is schistose and fairly pure on the outer margin, and gradually becomes massive and less pure in the direction of the serpentine. In three properties the schistose talc along the outer margin of the deposit is cream-white and except for disseminated magnetite is practically pure. The greatest width of this type of material observed was 10 feet in a pit in the George Pibus property, in Bolton township, Brome county. In the Porter property, Ireland township, Megantic county, a massive soapstone developed on the margin of a serpentine sill includes veins and aggregates of pale green, foliated mica, and ankerite, up to one foot wide. In the Fraser asbestos mine, Broughton township, Beauce county, a zone or vein of pale grey, massive, fine-grained soapstone 1 to 2 feet wide was found associated with asbestos along the margin of a serpentine mass. The widest zone of talc and soapstone so far discovered either on the margin or within the serpentine intrusives of the Eastern Townships is about 30 feet and the greatest exposed length about 400 feet. This, however, may be considerably less than the greatest actual extent of some deposits, for little if any development work has been attempted on most of the outcrops.

(3) MICACEOUS TALC

A micaceous, pale green, pure talc occurs in two localities in Canada: the Indian Creek property, Grimsthorpe township, Hastings county, Ontario (Plate XIV), and the Porter property, Ireland township, Megantic county, Quebec. In the first, the talc forms a vein 10 to 18 inches wide, cutting a serpentinized basic igneous rock. In the second the talc occurs with ankerite in aggregates and veins up to 1 foot wide in soapstone lying on the margin of a sill of serpentinized basic igneous rock. Neither of these deposits is sufficiently extensive to be workable. They are of interest chiefly because of the great purity and peculiar character of the talc and because of the way in which it occurs. Some of the talc from Grimsthorpe township was ground in the Ore Dressing laboratory of the Mines Branch and was found to require twice as much grinding for its reduction to talc flour as talc of the Madoc type.

Eagle Claim (Vancouver Island)

The deposits in this property differ from those previously described in that they occur in lenticular masses interbedded with argillites and schists, and are not associated so far as known either with dolomite or basic igneous rocks. They are situated close to the Leech River fault.[1]

ORIGIN

SUMMARY STATEMENT OF HYPOTHESES

Although talc is an abundant mineral and has many and varied industrial uses, its origin has not received much attention. There are three principal ways in which it has been suggested that it may originate:

(1) As an alteration product from tremolite or other magnesian silicate minerals associated with crystalline limestone or dolomite

(2) As an alteration product from ultrabasic igneous rocks, and

(3) By the transformation of graphitic chlorite schist through the agency of emanations from intrusive granite

In addition to these hypotheses, two other modes of development have been suggested that are in most cases stages in one or more of the preceding processes. These are:

(4) By the weathering of magnesia-bearing minerals

(5) By deposition in veins

(1) The first of these hypotheses is that mentioned by Sahlen[2] and more fully outlined by C. H. Smyth, jun.,[3] to account for the formation of the talc deposits of Gouverneur district, St. Lawrence county, New York state. Smyth assumes that tremolite was formed by the recrystallization of impure Grenville limestone and that talc in turn was formed from the tremolite under the influence of subterranean waters carrying carbon dioxide. An origin similar to this has been suggested by Pratt[4] and by Keith[5] for some of the talc deposits of North Carolina; by Peck[6] for the talc deposits of Pennsylvania and New Jersey; by Diller[7] for the talc deposits of California; by Miller and Knight[8] for the talc deposits of Madoc district, Ontario; and by Hopkins for some of the talc deposits of Georgia. Peck[9] ascribes the formation of the tremolite to the metamorphic effect of pegmatite dykes, and Miller and Knight suggest that the nearby Moira granite is the probable source of the silica and water of the Madoc talc. The formation of the talc from tremolite according to this hypothesis takes place thus: $CaMg_3\ (SiO_3)_4 + CO_2 + H_2O = H_2Mg_3\ (SiO_3)_4$ (talc) $+ CaCO_3$, and hence involves the formation of calcite, which is presumably carried away in solution.

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[1] Clapp, C. H.: Geol. Surv., Canada, Mem. 96, p. 195 (1917).

[2] Sahlen, A: "The Talc Industry of the Gouverneur District, New York"; Trans. Am. Inst. of Min. and Met., vol. XXI, p. 584 (1893).

[3] Smyth, C. H.: New York State Mus., Ann. Rept., vol. XVII, pp. 706–8 (1894).

[4] Pratt, J. H.: "Talc and Pyrophyllite Deposits of North Carolina"; North Carolina Geol. Surv., Econ. Paper No. 3, 1900.

[5] Keith, Arthur: "Talc Deposits of North Carolina"; U.S. Geol. Surv., Bull. No. 213, pp. 433–8 (1903).

[6] Peck, F. B.: "The Talc Deposits of Phillipsburg, N.J., and Easton, Penn."; Geol. Surv. N.J., Ann. Rept., 1904 (pt. 3), pp. 163–185.

[7] Diller, J. S.: "Talc and Soapstone"; Mineral Resources of United States, U.S. Geol. Surv., 1913, pp. 158-160.

[8] "The Precambrian Geology of Southeastern Ontario"; Ann. Rept., Ont. Bureau of Mines, vol. XXII, p. 113 (1913).

[9] "Asbestos, Talc, and Soapstone Deposits of Georgia"; Geol. Surv. of Georgia, 1914, pp. 200–1.

(2) The second mode of origin, by the alteration of ultrabasic igneous rocks, has been proposed by numerous geologists. It was suggested by Hitchcock[1] and by Jacobs[2] for the talc deposits of Vermont; by Keith,[3] Pratt and Lewis[4], Smith[5], Clark and Matthews[6], and Hopkins[7] for some of the talc deposits in the Appalachian and Piedmont belts of southeastern United States; and by Dresser[8] for the talc deposits of the Eastern Townships of Quebec. In Europe, this mode of origin has been proposed by Hezner[9] and by Heim[10], for the talc deposits of Switzerland.

(3) The third mode of origin was proposed by Weinschenk[11] for the talc occurrences near Mautern in Steiermark, Austria. These deposits occur on the contact of graphitic chlorite schists and limestone and are thought by Weinschenk to have been formed by the interaction of magnesia-bearing solutions with the graphite schist. Weinschenk associates the development of the talc with the intrusion of granite and seems to imply, although he does not explicitly say so, that the magnesia-bearing solutions were derived from the granite; but Redlich and Cornu[12] cite objections to this and suggest that the basic intrusives of the region are the source of the magnesia.

(4) Several geological writers hold the view that talc forms extensively by the weathering of magnesia-bearing minerals. Thus, Van Hise states that talc "is especially likely to form under conditions of weathering"[13], and more recently Lindgren[14] and Hall[15] make similar statements. None of these authors, however, gives actual observations in support of his conclusions. In opposition to these writers Julien points out that "in the decay of olivine, for example, on weathered outcrops of dunite or other peridotite, ... not a trace of newly formed talc has ever been distinguished among the products of decay."[16] It would be difficult to prove that talc does not form by weathering, but in the case of most extensive deposits at least, there is ample evidence that the talc has been formed as an accompaniment of either igneous intrusion or deformation, or of both these agencies. In Madoc district, Ontario, for example, the talc deposits are not only intimately associated with a batholithic intrusion of granite, but have been intensely crumpled, and hence were certainly formed at considerable depth.

The only reference in geological literature to the deposition of talc in veins, so far as known to the writer, is a description of certain talc deposits

[1] Hitchcock, C. H.: Jour. of Geol., 1896, p. 58.
[2] Jacobs, E. C.: Rept. of the Vermont State Geologist, 1913–4, pp. 423–5.
[3] Keith, Arthur: U.S. Geol. Surv., Folio No. 70, 1901, p. 3; "Talc Deposits of North Carolina"; U.S. Geol. Surv., Bull. 213, pp. 436–8 (1903).
[4] Pratt, J. H., and Lewis, J. V.: North Carolina Geol. Surv., vol. I, p. 160 (1905).
[5] Smith, W. B.: Maryland Geol. Surv., Cecil co., 1902, pp. 93–7.
[6] Clark, W. B., and Matthews, E. B.: "Maryland Mineral Industries"; Md. Geol. Surv., vol. VIII, p. 160 (1909).
[7] Hopkins, O. B.: "Asbestos, Talc, and Soapstone Deposits of Georgia"; Geol. Surv. of Georgia, Bull. No. 29, p. 213 (1914).
[8] Dresser, J. A.: Can. Min. Inst. Trans., vol. XII, p. 177 (1909).
[9] Hezner, L.: Vierteljahrsschrift der Naturforshende Gesellschaft. Zurich, vol. 54, pp. 250–252 (1909).
[10] Heim, A.: Zeitschrift für Praktische Geologie, vol. 26, pp. 9–10 (1918).
[11] Weinschenk, E.: Zeitschrift für Praktische Geologie, vol. VIII, pp. 41–44 (1900).
[12] Redlich, K. A., and Cornu, F.: Zeitschrift für Praktische Geologie, vol. XVI, p. 152 (1908).
[13] Van Hise, C. R.: "Treatise on Metamorphism"; U.S. Geol. Surv., Mon. XLVII, pp. 350–1.
[14] Lindgren, W.: "Mineral Deposits"; 1919, p. 394.
[15] Hall, A. L.: Union of South Africa, Dept. of Mines and Industries; Geol. Surv., Mem. 9, p. 312 (1918).
[16] Julien, A. A.: Ann. New York Acad. of Sci., vol. 24, p. 25 (1914).

in Switzerland by Heim.[1] These deposits are described as veins of pure, translucent, iceberg-blue-green secretion talc, that has segregated from talcose rock and, like the veins of dolomite, etc., is secondary in origin. The talc occurs either in coarse flakes or in fibres. In the latter case the fibres stand at right angles to the wall of the fracture.

TALC DEPOSITS OF CANADA

The talc deposits of Canada, in common with those of other parts of the world, are everywhere found in association with highly metamorphosed rocks. On the other hand, they are never found in association with rocks of similar composition where these have not been metamorphosed. It seems reasonable to assume, therefore, that talc, wherever it occurs, is the product of chemical reactions that take place as a part of the metamorphism to which the rocks with which it is associated have been subjected. The talc deposits thus differ mainly in origin according to whether the rock from which they were formed was dolomite, an ultrabasic igneous rock, or possibly in the case of the Eagle claim, Vancouver island, an argillite. There is, however, another class of deposit, the micaceous variety, that, although not different in origin from this standpoint, differs in its mode of development.

Talc Associated with Dolomite

The deposits of this class in Canada occur in association with dolomite near its contact with intrusions of acidic igneous rocks. A discussion of their origin involves several problems of which the following are the most important: the source of the magnesia contained in the talc; the source of the silica and water contained in the talc; and the process by which the talc was formed.

The immediate source of the magnesia was undoubtedly the dolomite with which the talc is associated, but its original source varies with the way in which the dolomite may have originated. In the case of the Madoc deposits the dolomite may have been deposited originally along with the limestone with which it is interstratified, or it may have been formed through the agency of emanations from either the dykes and masses of basic igneous rock or the masses of granite that intrude the Grenville-Hastings sediments. That the dolomite was an original part of the Grenville-Hastings sediments seems probable, because, in places in the district, uniform beds, in some cases only a few feet thick, can be traced continuously for several miles. Moreover, it is known that, at the time the limestone with which the dolomite is interstratified was deposited, basic and ultrabasic lava flows were being extruded and eroded. The Grenville-Hastings sediments in Madoc district are intruded by masses and dykes of basic igneous rock, but these intrusions are not especially abundant and, in some places, are entirely absent where the dolomite occurs. There is, therefore, no positive evidence that the dolomite has been formed through the agency of emanations from these in-

[1] Zeitschrift für Praktische Geologie, vol. 6, p. 10 (1918).

trusives. Nor does it seem probable that the magnesia of the dolomite was derived from the nearby batholith of Moira granite, for extensive zones of similar dolomite occur elsewhere in the district that are not associated with granite (Plate VI). Furthermore, magnesia is not an abundant constituent of granite—generally less than 0·5 per cent—and the composition of pegmatite and other acidic differentiates from granite does not indicate that magnesia tends to be concentrated in these differentiates.

The silica contained in the talc may have been derived from either the dykes or batholiths of granite that occur in the district or the beds of quartzite and quartzose tremolitic dolomite that adjoin the deposits, but it is most probable that both the silica and the water required for the formation of the talc came either directly or indirectly from the granite. The talc deposit at Eldorado, for example, is closely associated with dykes of granite. The deposit in the Henderson and Connolly properties to the east of Madoc, on the other hand, is intimately associated with dykes of a peculiar rock, madocite, consisting chiefly of tourmaline, a mineral commonly present in siliceous differentiates from granite. This deposit, therefore, is probably related in origin to the madocite dykes which in turn were probably derived from the batholith of granite that outcrops about 1,000 feet to the south of the deposit. The madocite dykes cut across the talc mass in places, but for the most part lie parallel to its walls. Both the talc and the madocite have been intensely faulted and crumpled. It might be inferred from the manner in which the madocite dykes cut across the deposit that they were intruded into the talc, but it is equally possible that the talc was formed along the dyke after it was intruded. In any case, since the deformation of the talc and madocite almost certainly accompanied the intrusion of the granite batholith, it is probable that the dykes were not intruded long after the talc was formed. The most probable explanation of the relationships of the talc to the madocite, therefore, is that, while the granite batholith was being intruded, a zone of fractures developed in the dolomite; that these fractures, although locally cutting across the bedding of the dolomite, in general conformed to its structure; and that the transformation of the dolomite to talc was effected by emanations ascending along these fractures, the madocite being the material that consolidated in the fractures after the transformation was completed.

The process by which talc deposits of the Madoc type are formed, according to Smyth and the other geologists who have adopted this hypothesis, takes place in two stages: (1) by the development of tremolite or related magnesian silicates; and (2) by the alteration of the tremolite or other silicates to talc. In a few thin sections of the tremolitic dolomite that forms the wall-rock of the Madoc deposits, the tremolite was observed to be traversed by fractures filled with talc, but with this exception no evidence of the transformation of tremolite to talc was observed. The talc forms an almost continuous mass in which the banding (presumably bedding) of the original dolomite is well preserved. It is doubtful whether this structure would have been preserved if tremolite had been formed first. In any case whether the formation of the talc took place in two stages, thus: 3 ($MgO\ CO_2$, $CaO\ CO_2$) + 4 SiO_2 = $CaO\ 3MgO_4\ (SiO_2)$ + 2 ($CaO\ CO_2$) + $4CO_2$; $CaO\ 3MgO_4\ (SiO_2)$ + H_2O + CO_2 = $3MgO$, 4 (SiO_2), H_2O + CaO, CO_2; or in a single reaction as follows: 3 ($MgO\ CO_2\ CaO\ CO_2$) + 4 SiO_2 + H_2O = $3MgO\ 4\ (SiO_2)$, H_2O + 3 (CaO, CO_2) + 3 CO_2, the final result is the same, that is, talc, calcite, and carbon dioxide are formed. If it be assumed that the calcite and carbon dioxide are carried away in solution, the volume increase resulting from the formation of the talc from dolomite is about 60 per cent.

This discussion of the origin of Canadian talc deposits of the type associated with dolomite has been confined to those of Madoc district, because they are the most important commercially and because they are the only deposits of the type that the writer has examined. From the descriptions of the Mount Whymper deposits and those of the Gisby group, British Columbia, the only other important deposits of this type in Canada, it seems probable that these were formed in a similar manner by the interaction of emanations from nearby acidic igneous intrusives with dolomite.

Talc and Soapstone Associated with Serpentinized Ultrabasic Igneous Rocks

The deposits of this class are found within or on the margin of sills, dykes, or lava flows of serpentinized ultrabasic igneous rocks, from which they have evidently been formed by the transformation of their magnesia-bearing minerals—olivine, hypersthene, enstatite, augite, etc. It is difficult to determine the reactions by which talc has been formed, because in most cases the original minerals composing the rock have entirely disappeared and because a comparison of the analyses of the original rock and the talc deposit shows that an addition or abstraction of material has occurred. Some of the most simple reactions that may take place in the development of talc deposits are the following:

Mineral	Reaction
Enstatite.........	$4MgSiO_3+H_2O+CO_2=H_2Mg_3Si_4O_{12}+MgCO_3$
Hypersthene......	$4MgFeSiO_3+H_2O+CO_2=H_2Mg_3Si_4O_{12}+MgFe\ CO_3$
Forsterite.........	$4Mg_2SiO_4+H_2O+5\ CO_2=H_2Mg_3Si_4O_{12}+5\ MgCO_3$

Other more complicated reactions may occur in the alteration of more complex minerals such as diopside, augite, etc. It is probable, also, that talc is formed from serpentine by reactions with silica or carbon dioxide thus:

$$\underset{\text{(Serpentine)}}{3MgO,\ 2SiO_2,\ 2H_2O}+2SiO_2=\underset{\text{(Talc)}}{3MgO,\ 4SiO_2,\ H_2O}+H_2O$$

$$2(3MgO,\ 2SiO_2,\ 2H_2O)+3CO_2=3MgO,\ 4SiO_2,\ H_2O+3\ (MgO,\ CO_2)+3H_2O$$ [1]

It has been suggested by Hezner[2], Julien[3], and Jacobs[4] that talc may form from magnesia-bearing silicates by a reaction with water and oxygen, such as follows:

$$12\ (MgFe)_2\ SiO_4+3H_2O+5O=3H_2Mg_3Si_4O_{12}+5Fe_3O_4$$
$$12\ (MgFe)\ SiO_3+3H_2O+O=3H_2Mg_3Si_4O_{12}+Fe_3O_4$$

[1] Jacobs, E. C.: Rept. of the Vermont State Geol., 1915–16, p. 267.
[2] Hezner, L.: Vierteljahrsschrift der Naturforshende Gesellschaft, Zurich, vol. 54, pp. 252 (1909).
[3] Julien, A.: Anns., New York Acad. Sci., vol. 24, pp. 29, 31 (1914).
[4] Jacobs, E. C.: Rept. of the Vermont State Geol., 1915–16, p. 267.

In the case of the Canadian deposits, at least, this is improbable, for the talc in most deposits is foliated and was evidently formed at considerable depth, where oxygen would not be abundant.

The greater part of the deposits of this class in Canada are found in association with the serpentinized basic igneous intrusives of the Eastern Townships of Quebec, known as the Serpentine series. In the tables that follow five analyses of the rocks of the Serpentine series and two analyses of the ultrabasic rocks from other regions have been included. Rocks Nos. 1 and 2 are described by Dresser as dunite, but the large proportion of water that they contain indicates that they consist largely of serpentine. A comparison of these analyses with those of the talc deposits 1 to 4 in the second table shows that the talc contains a much higher proportion of silica and correspondingly less magnesia than the serpentine and that it would be impossible for the talc to form from the serpentine or the original igneous rock from which the serpentine was formed without the addition or removal of material. All the analyses of talc in the table are from deposits consisting almost entirely of talc and magnetite, but in places in the region, especially in the transition zones from the talc schist to serpentine, deposits occur that consist of talc, serpentine, magnetite or chromite, and carbonate—either magnesite, dolomite, or ankerite. No

	I	II	III	IV	V	VI	VII
SiO_2	38·16	38·24	46·30	40·08	37·66	38·40	38·98
Al_2O_3	0·63	0·70	2·58	2·11	1·61	0·29	4·69
Fe_2O_3	3·32	3·50	3·45	1·13	6·15	3·42	4·29
FeO	4·76	4·25	3·57	1·70	1·87	6·69	7·71
MgO	41·84	41·92	23·18	37·90	38·66	45·23	31·56
CaO	0·68	0·68	15·20	0·20	trace	0·35	3·26
MnO	....	....	....	....	....	0·24	0·12
K_2O	} 0·20	0·20	0·15	0·10	0·20	0·08	0·96
Na_2O							1·03
H_2O–110	0·47	0·60	0·66	1·35	0·75	0·24	0·09
H_2O+110	9·63	9·76	4·77	13·89	12·49	4·11	4·86
CO_2	....	....	....	....	....	1·10	1·40
TiO_2	....	....	trace	....	trace	....	0·56
P_2O	....	....	....	....	....	trace	....
S	....	....	....	....	....	0·06	....
NiO	....	....	....	....	....	0·10	....
Cr_2O_3	....	....	....	....	....	0·07	....
Total	99·69	99·85	99·86	98·76	99·61	100·38	99·75

I. Dunite, near Black Lake station, Megantic county, Quebec. Dresser, J. A.: Geol. Surv., Canada, Mem. 22, p. 28 (1913). Analysis by M. F. Connor.
II. Dunite, lot 28, range II, Ireland township, Megantic county, Quebec. Dresser, J. A.: Geol. Surv., Canada, Mem. 22, p. 28 (1913). Analysis by M. F. Connor.
III. Pyroxenite, lot 40, range II, Garthby township, Wolfe county, Quebec. Dresser, J. A.: Geol. Surv., Canada, Mem. 22, p. 31 (1913). Analysis by M. F. Connor.
IV. Serpentine, near Black Lake station, Megantic county, Quebec. Dresser, J. A.: Geol. Surv., Canada, Mem. 22, p. 29 (1913). Analysis by M. F. Connor.
V. Serpentine, lot 40, range II, Garthby township, Wolfe county, Quebec. Dresser, J. A.: Geol. Surv., Canada, Mem. 22, p. 29 (1913). Analysis by M. F. Connor.
VI. Dunite, Tulameen district, British Columbia. Camsell, C.: Geol. Surv., Canada, Mem. 26, p. 53 (1913). Analysis by W. F. Hillebrand.
VII. Wehrlite, lot 18, range XII, Buckingham township, Quebec. Analysis by M. F. Connor.

—	I	II	III	IV	V	VI
SiO_2	59·78	59·62	54·88	59·66	23·53	61·06
Al_2O_3	1·82	1·40	3·59	1·67	2·45	3·63
Fe_2O_3	0·44	1·21	1·44	0·37	Fe	
FeO	3·96	4·25	4·63	4·12	5·26	S 2·89
CaO	0·02	none	1·10	none	10·26	trace
MgO	29·23	28·49	27·22	29·26	28·14	28·60
CO_2	0·02	trace	1·52	none	29·04	....
					MnO	
$H_2O+105°$	4·79	4·61	5·86	4·90	1·40	3·92
	100·06	99·58	100·24	99·98	100·08	100·10

I. Lot 26, range II, Bolton township, Brome county, Quebec. Spence, H. S.: Mines Branch, Dept. of Mines, Canada, 1922, p. 40.
II. Lot 9, range V, Thetford township, Megantic county, Quebec. Spence, H. S.: Mines Branch, Dept. of Mines, Canada, 1922, p. 43.
III. Lot 7, range V, Thetford township, Megantic county, Quebec. Spence, H. S.: Mines Branch, Dept. of Mines, Canada, 1922, p. 43.
IV. Lot 5, range V, Thetford township, Megantic county, Quebec. Spence, H. S.: Mines Branch, Dept. of Mines, Canada, 1912, p. 43.
V. "Grit" Williams mine, Vermont State, Report of the Vermont State Geologist, 1913–14, p. 421.
VI. Talc Mountain mine, Vermont State, Report of the Vermont State Geologist, 1915–16, p. 265.

analyses of these deposits have been made, but the material occurring in Vermont state, called "grit," an analysis of which is included in column V, of the table page 30, has approximately the composition of the dolomite phase.

From the preceding data it may be inferred that there are two ways, at least, in which the talc deposits of the Eastern Townships of Quebec may have been formed: (1) by the alteration of the original ultrabasic intrusive to talc and carbonates through the agency of water and carbon dioxide; or (2) by the alteration of the intrusive to talc by a reaction with siliceous emanations; and that both of these operations may take place either directly, or in two stages, by the formation of serpentine, which in turn is transformed to talc. The abundance of carbonates associated with talc in some of the deposits in the southern part of the Serpentine belt would indicate that these deposits, at least, were formed by reactions in which carbon dioxide played an important part. On the other hand, calcite or other carbonates are not generally abundant in the Serpentine belt, and for that reason both Dresser and Graham[1] concluded that the original intrusives were transformed to serpentine by reactions with silica rather than carbon dioxide. It is noteworthy in this connexion that ultrabasic rocks as a rule alter to serpentine rather than to talc and that the formation of talc must, therefore, be due to some special condition not ordinarily present. This special condition, in the case of the talc deposits of the Eastern Townships, seems to have been either the presence of especially free channels for circulation, or deformation, or both of these factors. Most of the talc deposits occur on the margin

[1] Dresser, J. A.: "Preliminary Report on the Serpentine and Associated Rocks of Southern Quebec"; Geol. Surv., Canada, Mem. 22, p. 61 (1913).
Graham, R. P. D.: "Serpentine and Crysotile-Asbestos"; Econ. Geol., vol. XII, pp. 170–182 (1917).

of intrusive serpentinized sills that have been folded since they were intruded. It is known, also, that part of this folding, at least, occurred in Devonian time, and was accompanied by intrusions of masses of granite from which siliceous emanations would almost certainly be given off. All the conditions necessary for the circulation of heated silica-bearing waters were, therefore, probably present. Limestone is fairly abundant in the sediments of the region, however, so that carbon dioxide would also be present in such circulating waters. It is probable, therefore, that the transformation of the talc occurred in part, at least, by reactions with carbon dioxide and water, especially since carbonates are present in some of the deposits; but it is uncertain whether it was also formed by reactions with silica. The presence of high-grade talc and the absence of carbonates at points where deformation occurred may be due either to a reaction with silica or to the effect of deformation on the solubility of the carbonate originally present.

The deposits of talc associated with serpentinized ultrabasic rocks near Actinolite, in Elzevir township, Hastings county, Ontario, and those near Wabigoon in northwestern Ontario, were presumably formed in about the same manner as those of the Eastern Townships of Quebec. They both contain considerable quantities of dolomite and both occur in rocks that have been intruded by extensive batholithic masses of granite. The deposits in Elzevir township contain zones of actinolite as well as large proportions of dolomite. The alterations that resulted in the formation of the Wabigoon deposits are thought by J. F. Wright to have been effected by emanations from the intrusive itself.

Micaceous or Vein Talc

From a commercial standpoint the micaceous variety of talc is not important. There are only two known deposits in Canada, one in a vein with ankerite, cutting soapstone, in the Porter property, Ireland township, Megantic county, Quebec, and the other in a vein with dolomite cutting serpentine in the Indian Creek property, Grimsthorpe township, Hastings county, Ontario. Both of these are associated with serpentinized ultrabasic rocks, but there is no apparent reason why such veins might not also develop in talc derived from dolomite. The micaceous talc differs from ordinary talc in that it has been deposited in a fracture as vein material. Its occurrence in a vein cutting soapstone indicates that it is a secondary form resembling the columnar graphite that occurs in veins cutting deposits of disseminated flake graphite. Like the columns of the graphite the micaceous structure of the vein talc generally stands at right angles to the vein-wall.

Eagle Claim (Vancouver Island)

The talc deposits in this property, as described by J. D. MacKenzie, are lenticular masses interbedded with argillite and schist. They occur almost on the line of the Leech River fault, an association that suggests that the talc may have been formed by magnesia-bearing solutions circulating along the fault-plane in a manner somewhat similar to that suggested by Weinschenk,[1] for talc deposits near Mautern in Austria. The source of the solutions would presumably be basic intrusives that occur in the region. The sample from the deposit given the writer by MacKenzie, however, consists of talc, carbonate, magnetite, and pyrrhotite, and hence has a composition strikingly similar to the talc deposits formed from serpentinized basic igneous rocks. It is possible, therefore, that the talc is an alteration product from basic volcanics which, according to Clapp, occur in the Leech River formation.[2] Since the writer has not seen the deposits on the Eagle claim and Mackenzie in his report on the property does not discuss their origin, the manner in which they were formed is as yet an unsettled problem.

[1] Zeitschrift für Prakt. Geologie, vol. 8, pp. 41–44 (1900).
[2] Clapp, C. H.: Geol. Surv., Canada, Mem. 96, p. 88 (1917).

CHAPTER IV

DESCRIPTION OF DEPOSITS

BRITISH COLUMBIA

Victoria Mining Division

(1)[1] EAGLE CLAIM

J. D. MacKenzie and M. E. Wilson[2]

Previous Descriptions. Report of the Minister of Mines, British Columbia, 1919, pp. 193 and 240-41; 1920, pp. 24 and 222.

Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 21–23; 1923, pp. 25 and 270.

Location and History

"The property of the Eagle Talc and Mining Company, Limited, is situated a half-mile above the mouth of Wolf creek, a tributary of Sooke river, Malahat district, Vancouver island. The Canadian National railway passes within a half-mile of the workings, with which it is connected by a motor road. The deposit may also be reached by a good trail, 5½ miles long, which leaves the Sooke road 8 miles from Victoria." Operations on the Eagle claim were commenced early in 1919. Up to 1921 the crude talc was shipped for treatment to a mill at Sidney, Vancouver island, but in that year a mill was constructed on the property in which the talc is now prepared for market.

Geology

"Wolf creek flows along the outcrop of a large fault that forms the southern boundary of the Leech River formation.[3] The talc deposits occur in the rocks of this formation, outcropping in the bed of the creek and in its steep northern bank. The Leech River formation is composed of several varieties of metamorphic sedimentary rocks, presumably of Carboniferous age. Schistose rocks of various types, argillites, and crushed and broken carbonaceous slates[4] make up the bulk of the formation. The rocks exposed on the north side of Wolf creek near the Eagle workings are black, carbonaceous, slaty shale, soft and plastic when weathered; black, hard, feldspathic and quartzitic argillites with talcose layers; brown, soft, talc schist; and hard, dense argillites in one to two layers. These

[1] Number of property in Figure 3.

[2] Parts of the description in quotations are from the report prepared for the Geological Survey by J. D. MacKenzie, who examined the property, on May 22, 1922, in company with Mr. Dickinson, the owner, by whom every assistance was kindly rendered.

[3] Clapp, C. H.: Geol. Surv., Canada, Mem. 96, p. 67, and Map 44 A (1917).

[4] Idem, pp. 67–72.

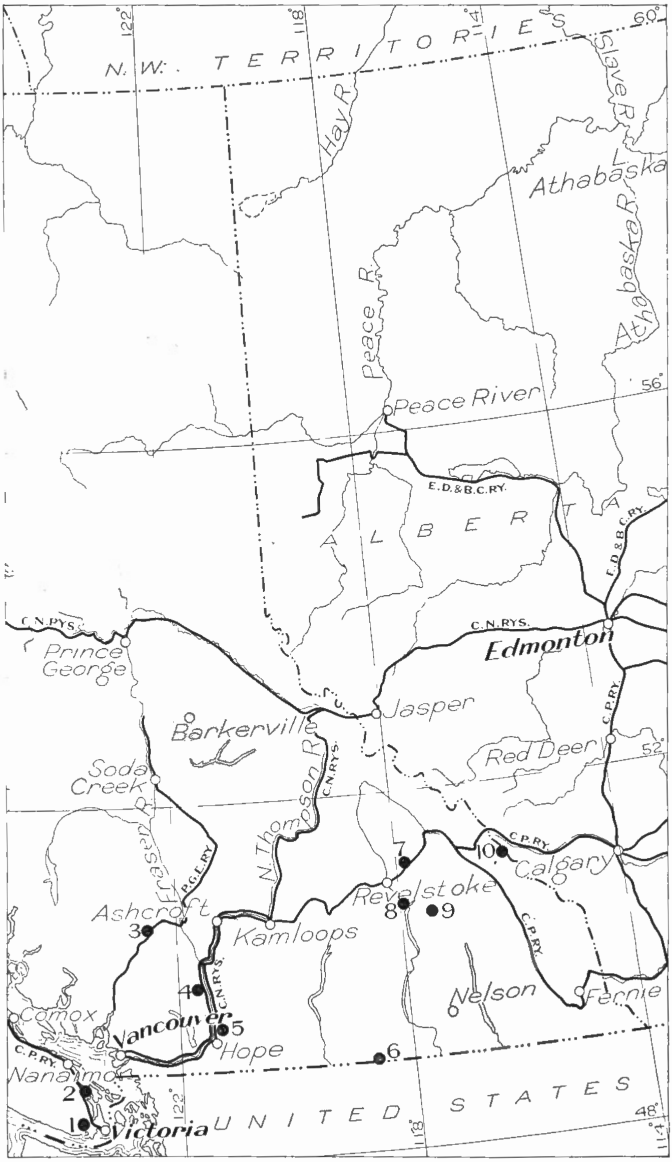

Figure 3. Index map showing location of talc deposits in British Columbia: 1, Eagle; 2, Iron Clad; 3, Lucky Jane; 4, Gisby group; 5, Coquihalla River; 6, White's Camp; 7, Illecillewaet; 8, Asbestos group; 9, Silver Cup Mountain; 10, Mount Whymper.

rocks have been severely crushed and folded. They now stand at high angles, striking generally north 80 degrees west and dipping 60 to 65 degrees northeast, but with considerable local variations of attitude."

Relationships and Extent of Deposit

"The talc occurs in lenticular masses interbedded with the argillites and schists. At the mine three such lenses may be recognized, only one of which is at present being developed. This one, which is the upper of the three, is 7 feet thick at the top of the bank, but 40 feet below it is 15 feet thick. The rocks underlying this lens are not well exposed, but 50 feet stratigraphically below a second lens of talc outcrops, which Mr. Dickinson states is 10 to 12 feet thick. Below the second layer, there are black, soft, slaty argillites and talcose slates followed by the third talc lens, which outcrops in the creek, where it is well exposed and is 7 feet thick. Mr. Dickinson states that outcrops of talc have been found at several places for a distance of 5 miles westward on the strike of this deposit."

"The general strike of the talc bed now being worked is north 85 degrees west, and the dip 65 degrees north. Development work consists of an adit above high-water level in the creek, running north 65 degrees west for 70 feet. This adit is wholly in the talc, which was 14 feet wide at the face at the time of my visit. The hanging-wall is evenly bedded, slightly wavy, black, hard, siliceous argillite. The foot-wall is much softer, evenly laminated, carbonaceous, slaty shale. The talc is sharply separated from both walls, though there is a slight amount of interfolding with the foot-wall."

"No systematic development besides the workings mentioned above has been made, so an estimate of the quantity of talc in the deposit can only be tentative. Allowing a length of 500 feet for the talc lens now being worked, and allowing the conservative figures of 10 feet for thickness and 30 feet of height above the level of the adit, from 12,000 to 15,000 tons of talc is virtually proved, and the possible quantity, considering the recoverable talc below the adit, and that in the other two beds, may be several times this amount."

The Talc

"The talc lens is homogeneous, and the material mined is practically uniform. It is mottled grey, faintly specked with occasional black dots. Much of the talc has a light greenish grey tint, and some pieces are pale nile green, sub-translucent, and very soft and soapy. It is granular and distinctly schistose, friable, and easily broken with a hammer. Pieces up to 18 by 15 by 6 inches are obtained in mining, and an approximate estimation of the 'run of mine' material is

Pieces 1 inch and under, 25 per cent
" 6 inches to 1 inch, 25 per cent
" over 6 inches, 50 per cent

"The talc crushes to a pale, whitish grey powder. Mr. Dickinson states that it is highly refractory."

The following analyses indicate its chemical composition:

—	I	II
SiO_2	33·68	56·76
Al_2O_3	1·65	2·40
Fe_2O_3	none	3·24
FeO	4·97	
CaO	15·32	0·98
MgO	22·88	32·32
CO_2	18·23	
Water above 105°C	3·20	
Loss on ignition	....	3·92
Undetermined	....	0·38
Total	99·93	100·00

I. Analysis of sample collected by H. S. Spence: "Talc and Soapstone in Canada"; Mines Branch, Department of Mines, Canada, 1922, p. 22.
II. Analysis of the average of four samples from different parts of the deposit, supplied to J. D. MacKenzie by Mr. Dickinson.

The approximate mineral composition corresponding to these analyses would be as follows:

—	I	II
Talc	53·00	89·00
Dolomite	28·00	11·00 (Dolomite, Calcite, Pyrrhotite and magnetite)
Calcite	11·00	
Pyrrhotite and magnetite	8·00	

Under the microscope the talc is seen to consist mainly of minute flakes of talc and irregular aggregates of fine, granular carbonate (dolomite or calcite). Within the carbonate numerous irregular aggregates and zones of pyrrhotite and a few scattered grains of magnetite are included. No other minerals are present in the section, so that the alumina shown in the two analyses is probably contained in the talc. The mottled grey and speckled appearance of the talc is evidently due to its impurities, the dolomite with its disseminated pyrrhotite and magnetite forming the grey areas and the larger magnetite grains the black specks.

Production and Uses

"A small mill having a capacity of 6½ tons in 8 hours has been built on the property. In this three grades of talc are produced. The finest (200 mesh), which constitutes about 8 per cent of the whole, is used in the manufacture of paint, the second grade (150 mesh) is used by paper mills as filler in paper, and the coarse (coarser than 150 mesh) is used by the Sydney Roofing and Paper Company, of Victoria, for dressing roofing paper and for preventing the paper from sticking when rolled up. When the mine is fully developed it is hoped to extract sufficient solid blocks to saw into bricks for use in acid resisting and refractory linings."

SOOKE LAKE

Mr. J. R. Carmichael, of Victoria, in 1923 submitted to the Geological Survey a sample of talc, similar to that composing the Eagle deposit, which he stated was obtained from a lead situated about one mile west of the south end of Sooke lake and between 2 and 3 miles northwest of the Eagle claim. According to Mr. Carmichael the talc is exposed in the banks of a creek and occurs in a northwest-trending zone 14 to 18 feet wide enclosed in slate belonging to the Leech River formation.

Nanaimo Mining Division

(2) IRON CLAD

The highly metamorphosed igneous rocks of the Sicker series[1] on mount Richards about 2½ miles southwest of Crofton, Vancouver island, are traversed by mineralized shear-zones on which several claims have been staked. In one of these claims, the Iron Clad, talc up to 3 feet in width is said to occur in the sheared zones. The deposit is described by J. A. Allan as follows[2]:

"A large area, about 2 square miles, of diorite-porphyry, on mount Richards, to the north of the Lenora railway, contains finely disseminated particles of chalcopyrite (and probably some chalcocite), to such an extent that, in almost any part of the mass, it is said to assay as high as one per cent in copper. The sulphides have also become segregated out along certain sheared zones. No work is being carried on at present, and the development to date consists of a number of small prospect holes. The most work has been done on the Iron Clad, Ureka, Lord Roberts, and Jena mineral claims".

"The Iron Clad seems quite promising, but sufficient development has not yet been done to warrant a definite conclusion. The deposits are necessarily low grade: but it might be suggested that further prospecting along the contacts is advisable—especially between the more basic diorite and the sheared rocks. The rock along the sheared zones is sometimes quite talcose, and in one of the shafts at the 30-foot level, a 3-foot vein of talc is said to have been exposed".

Lillooet Mining Division

(3) LUCKY JANE CLAIM

By V. Dolmage

Previous Descriptions. Camsell, C.: "Reconnaissance along the Pacific Great Eastern Railway, between Squamish and Lillooet"; Geol. Surv., Canada, Sum. Rept. 1917, pt. B, p. 22.
Spence, H. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept., 1920, p. 15. "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 21–22.

Location and History

On the northwest shore of Anderson lake, a few miles northeast of D'Arcy station, on the Pacific Great Eastern railway (which is at the

[1] Clapp, C. H.: Geol. Surv., Canada, Mem. 96, p. 127.
[2] Geol. Surv., Canada, Sum. Rept. 1909, p. 101.

southwest end of the lake), there are two bands or seams of talc. Both outcrop adjacent to the Pacific Great Eastern railway, which follows the shore of the lake, and at 90·2 and 91·25 miles respectively from Squamish, the coast terminal of the railway, about 35 miles north of Vancouver.

The deposit was owned by the Pacific Roofing Company, of Granville island, Vancouver, B.C., until this company went into liquidation in the summer of 1923. A new company was organized under the same name, but whether it acquired the talc deposit is not known. According to Spence the old company mined about 150 tons of talc in 1919, which was used in their roofing plant in Vancouver. The new company buys its talc from the Pacific Talc and Silica Company, which operates the Gisby deposits near North Bend on the main line of the Canadian Pacific railway.

Geology

The talc occurs in shear zones in a band of Devono-Carboniferous schist, about 3¼ miles wide, which lies between an intrusion of granodiorite about 2 miles wide, to the northeast, and one of miarolitic granite from 1 to 2½ miles wide, to the southwest (Figure 4). The talc bands are much nearer to the miarolitic granite than to the granodiorite. Besides these two large intrusions, the schist in the vicinity of the talc is cut by small, irregular dykes of granodiorite (*See* Figure 4). The schist is part of a thick series of Devono-Carboniferous rocks, which except for the two intrusions of granitic rocks mentioned above, occupies virtually the entire shores of Anderson and Seaton lakes, which have a combined length of nearly 30 miles. These old rocks are bounded on the northeast by Lower Cretaceous sediments and on the west are faulted against a series of sedimentary rocks of Jura-Triassic age.

The Devono-Carboniferous rocks consist mainly of greyish quartzose rocks in thin beds interstratified with schists, argillites, and some narrow bands of limestone. In the vicinity of the talc deposits these rocks consist entirely of dark green chlorite and talc schist containing a number of siliceous gneissic bands from 10 to 20 feet wide and having a nearly parallel strike of about north 11 degrees east, magnetic. The schist is a medium-fine but irregularly grained rock with a well-developed schistosity, and in places a blotchy appearance, which is probably due to the fragmental nature of the original rock. In its present form it consists chiefly of plagioclase, biotite, chlorite, talc, and amphibole. The latter forms an important proportion of the groundmass in the form of actinolite, but also occurs as large, radiating phenocrysts of hornblende up to an inch in diameter. Under the microscope was also seen a rather larger proportion of titanite than is commonly found in such rocks. Near the talc seams the schist is considerably sheared and contains an increasingly large proportion of talc.

The granodiorite intrusion lying to the northwest is a part of the great Coast Range batholith, which occupies the greater proportion of the British Columbia coast. It consists of light grey, coarse-grained, quartz diorite, granodiorite, and granite, and is considered to be largely of

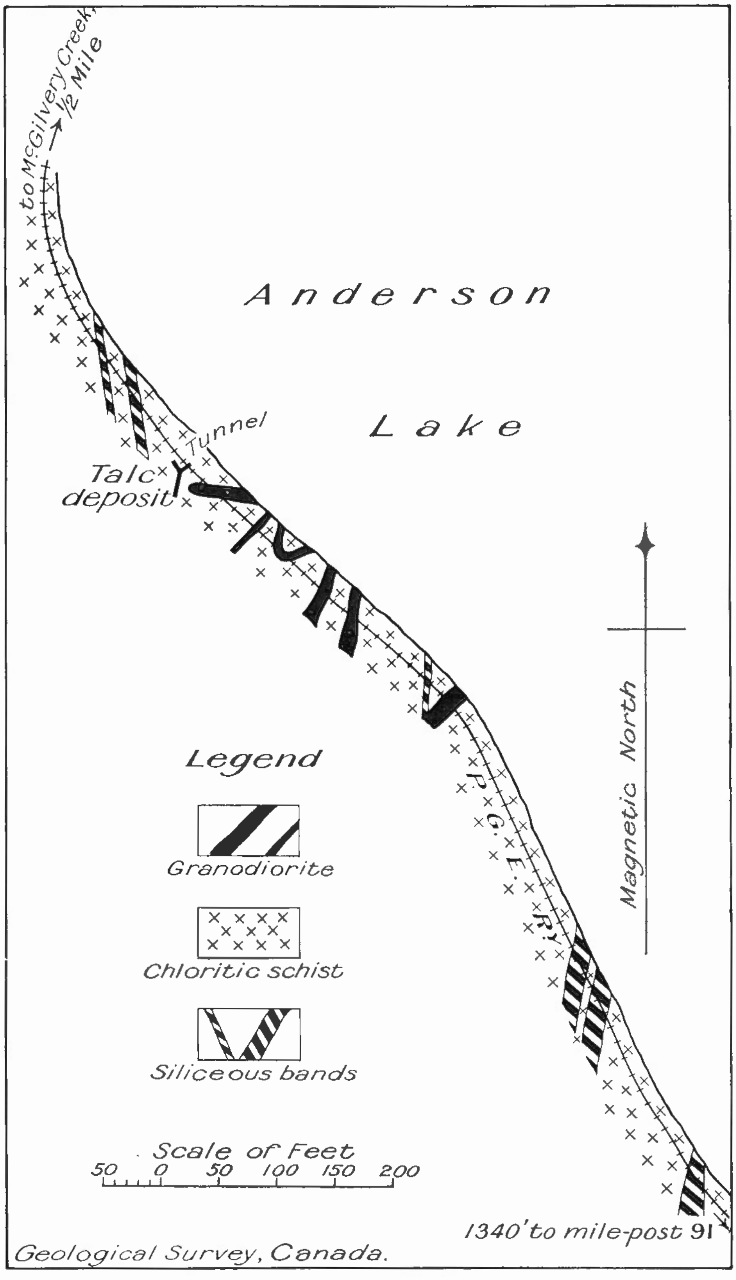

Figure 4. West shore of Anderson lake, in the vicinity of Lucky Jane mineral claim Coast district, B.C.

Upper Jurassic age. The intrusion to the southwest of the talc deposits is a beautiful pink, medium-grained, and highly miarolitic granite. The miarolitic cavities are more than ordinarily abundant. They range from $\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter and are lined with well-developed euhedral crystals of quartz, orthoclase, and microcline. The rock consists principally of orthoclase, quartz, and albite-oligoclase, with small amounts of micropegmatite, microperthite, hornblende, and chlorite. The accessory minerals are apatite and fluorspar, the latter being more abundant. The quartz is crowded with minute fluid inclusions, and the feldspars are generally clouded with kaolin. The mineralogical composition of the rock shows that it is high in silica and the alkalis—potash predominating—and low in iron, lime, and magnesia. The miarolitic granite is known to be younger than the Coast Range batholith and is thought to be Cretaceous.

The dykes (Figure 4) consist of a medium fine-grained granodiorite similar to the large intrusion lying to the northwest, except that they contain more biotite, and are more sheared and crushed. Many of them have a distinct gneissic structure parallel to the schistosity of the greenstones and talc bands. This indicates that these dykes were intruded prior to the shearing which produced the talc and that they are, therefore, probably related in age to the Coast batholith, and are much older than the miarolitic granite.

Composition, Extent, and Origin of the Talc

The talc is confined to shear zones in the greenstone. The northerly talc band is the more important. It is 8 to 10 feet wide, strikes north 10 degrees east (magnetic), and dips 80 degrees west. A short adit was driven on this zone in 1919, from which the 150 tons of talc, mentioned above, was mined. When examined by the writer (1923) the mouth of the adit was blocked by fallen rock, consequently only a small section of the talc seam could be examined. This showed a width of from 2 to 5 feet of light greenish grey talc of a fair quality. The only impurities observed were small amounts of pyrite, magnetite, limonite, and, in places, a few small veins of unaltered actinolite.

These facts suggest that the talc was formed by alteration of the greenstone, and that this alteration was largely induced by the shearing stresses, but to some extent also by the action of hydrothermal solutions. Since the adjacent dykes are strongly sheared and rendered gneissic, with the foliation somewhat parallel to the shear zones containing the talc, it is virtually certain that the hydrothermal solutions did not originate in the magma of these dykes. The only other magma which could have produced such solutions is that of the miarolitic granite, and it seems highly probable that this was their source.

SHULOPS AND BENDOR MOUNTAINS

In the Summary Report of the Geological Survey for 1915 C. W. Drysdale states that talc is found in considerable quantities in the Cadwallader series of the Shulops and Bendor mountains, Bridge River district. Beyond this no information is available regarding this occurrence.

CAYUSE RIVER

In the Geological Survey collection of economic minerals there is a block of soapstone which was given to E. Poitevin by Joseph Russell, of Lillooet, and which Mr. Russell stated was obtained on Cayuse river, 5 miles from Lillooet. The soapstone is a dark green, highly talcose variety with a poorly developed foliation in places.

Yale Mining Division

(4) GISBY GROUP

By C. E. Cairnes

Previous Descriptions. Spence, H. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1920, pp. 14-15. "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 19-20.

Location and Method of Examination

The Gisby group is situated on the west side of Fraser river 3 miles below Keefers and 2 miles above Chaumox stations on the Canadian Pacific railway. It adjoins the railway, and the milled products are carried by a short chute from the mill to a railway siding. A wagon road leads to Chaumox, the shipping point prior to the construction of the railway siding. Nahatlatch river cuts across the northern end of the property and has exposed a cross-section of the rock formations.

The first four days in October, 1923, were spent in a general survey of the property and in a more particular examination of the talc and silica deposits. A compass and tape survey was made of the wagon roads and railway and up Nahatlatch river. This survey formed a base upon which features of topographic or geologic significance were placed. An aneroid barometer was used to obtain approximate differences in elevation.

Ownership and History

The property has an area of 640 acres, and includes two homesteads, five mineral claims, and three mineral claim fractions (*See* Figure 5). The claims were first staked for gold, about thirty-three years ago, by Gisby and Allen, and early development was directed towards the search for auriferous quartz veins. In 1919, the property was taken up by Victory Investors Company, of Vancouver, who realized the importance of its non-metalliferous deposits. In the following year the British Columbia Talc and Silica Company, of Vancouver, undertook to work the property on a royalty basis, but without success, and it reverted to the original owners, who subsequently sold out to the Pacific Talc and Silica Company, organized in 1922, with offices in Rogers building, Vancouver.

Geology

The Pacific Talc and Silica Company, as its name implies, obtains talc and silica from the property. Both minerals are associated with a

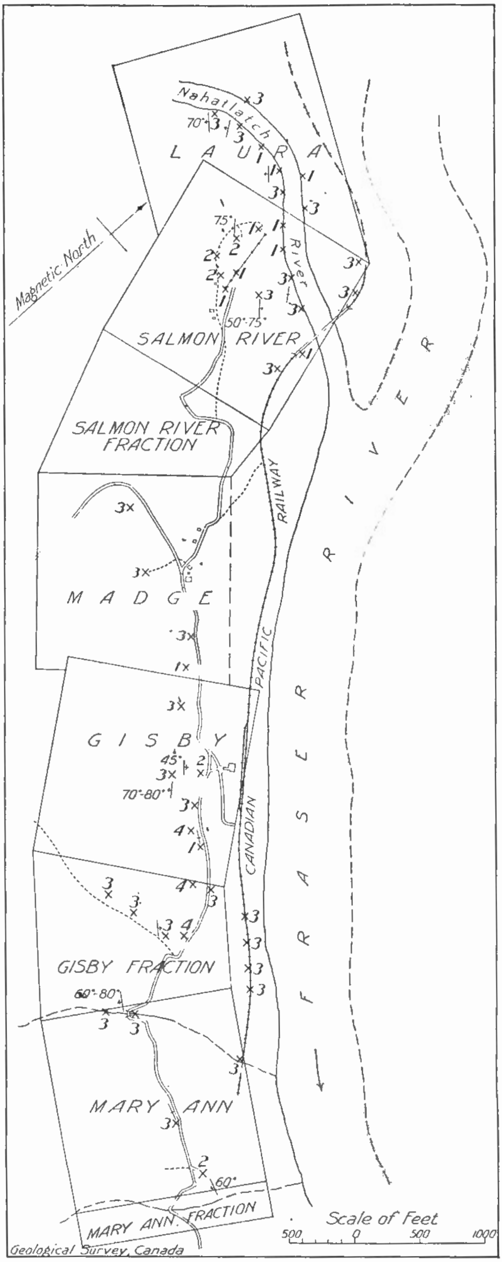

Figure 5. Gisby Mineral Claim group, Yale district, B.C. Rock outcrops are indicated by crosses with numbers attached. (1 = talc-bearing rock; 2 = quartz and sediments; 3 = slate, mica schist, limestone, and other sediments; 4 = diorite).

series of greatly deformed sedimentary rocks, probably of Carboniferous age, ranging in composition from fine-grained, cherty, and argillaceous beds to moderately coarse, calcareous greywackes. The predominating member is a black, slaty type impregnated by innumerable veins and veinlets of quartz (Plate VII). The other members of the series are characterized by a variable proportion of carbonate minerals and range in composition from beds of almost pure limestone to moderately coarse-grained, calcareous greywackes. In many cases the carbonate minerals carry a high percentage of magnesia and a smaller percentage of iron. It is with the less calcareous varieties that the talc deposits are associated. Some of the limestone beds along Nahatlatch river show an abundance of small acicular crystals of tremolite. Other minerals present in the less carbonaceous beds include quartz, feldspar, reddish biotite, green (chrome) mica garnet, and many alteration products, among which chloritic and talcose minerals are conspicuous. Sulphides of iron, and, to a less extent, of copper, are minutely disseminated through all members of the sedimentary series. Closely associated with the slaty rocks, and grading into them, are thinly bedded, fine-grained, dark, cherty rocks composed almost entirely of silica which was probably chemically precipitated. These cherty beds show gradations into, or are intercalated with, the slaty members of the series and, like the latter, are penetrated by many quartz veinlets.

The sediments are intruded along the strike by dyke-like igneous bodies, mostly less than 5 feet wide, but from 20 to 75 feet or more in width near the southwestern end of the property. Their composition averages about that of a diorite; the larger bodies are fully crystallized and carry hornblende as their chief ferromagnesian constituent. They all show a certain amount of alteration, but, on the whole, are massive and comparatively fresh. They are evidently much younger than the enclosing sediments and probably have some bearing on the origin of both the silica and talc deposits. They are probably contemporaneous, or nearly so, with a great body of batholithic rocks which form the bulk of the hills to the northwest of the property. Except as indicated in Figure 5 the rocks on the property are covered by a mantle of Quaternary deposits including bench gravels and less well-sorted drift.

The silica favours the more argillaceous members of the sedimentary series, where it forms quartz-veins from a fraction of an inch to over 50 feet in width (Plate VII). Only the larger veins are of commercial importance. The talc has resulted from the alteration and replacement of the more calcareous members of the sedimentary series. The deposits vary greatly in size, composition, and physical characteristics; in only a relatively small proportion of the exposures is the percentage of talc sufficiently high to furnish a high-grade commercial product, but much of the lower grade material can doubtless be used for purposes where purity is not essential.

Silica

The silica deposits are all so similar in character and geological associations that they may be described together. They occur at three principal localities—namely: the silica quarry to the west of the mouth of Washout creek on Mary Ann claim; the long adit near the mill on Gisby claim; and on Salmon River and Laura claims between the hoist at the end of the wagon road, and Nahatlatch river. These three localities are in a line parallel to the general trend of deformation of the enclosing rocks which are chiefly slaty sediments intersected by numerous quartz veinlets. The greatest observed variation in the country rock is on the south bank of Nahatlatch river, where a 4-foot ledge of quartz, that dips to the southwest at a high angle, is overlain by a belt of micaceous slaty schists and underlain by other slaty rocks which have a rather talcose feel. A specimen of the latter when examined under the microscope was found to contain graphite.

The largest outcrop of vein quartz is at the silica quarry south of Washout creek, where a single vein has been exposed for a width of 50 feet without being entirely crossed. A large vein or lens of quartz 35 feet wide is also exposed on either side of, and is cut by, the upper of the two short adits on the Salmon River claim, to the northwest of the hoist. A sample of this quartz analysed by the Department of Mines, Ottawa, was found to contain 98·24 per cent silica. No attempt has been made to correlate the exposures of these larger quartz veins, but it is not improbable that they are connected and that the quartz in these exposures was all formed at about the same time along a prominent fracture zone in the sediments. The smaller quartz veinlets, so abundant in some sections of the slaty rocks, may have been introduced under different conditions of rock deformation and not at the same time as the larger deposits of quartz. The origin of the silica is probably related to that of the talc, since both minerals seem to have formed during the period of deformation and intrusion of the large body of igneous rocks lying to the west of the property. They are also nearly, if not quite, contemporaneous with the small intrusive bodies on the property.

Talc

The principal showings of talc occur in the long adit by the mill on Gisby claim; in the lower of the two adits near the hoist on Salmon River claim; and at a number of exposures along Nahatlatch river.

Until recently the only talc mined on the property came from the long adit near the mill. This adit intersects a zone of talcose rock between 150 and 300 feet from the portal. In this talcose rock is a body of talc at least 5 feet wide that grades into the less pure talcose rock on either side. A short crosscut and raise have been run along this talc band or lens. The prevailing colour of the talc is dark green. It has a uniform dense texture, is translucent in thin pieces, and is abundantly slickensided. A sample of the talc analysed by the Department of Mines, Ottawa, was found to have the following composition[1].

Silica	59·88
Ferrous oxide	4·54
Ferric oxide	...
Alumina	1·18
Lime	0·10
Magnesia	29·51
Carbon dioxide	0·02
Water above 105°C	4·73

[1] Spence, Hugh S. :"Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, p. 922.

It is a clean variety of good grade, with good slip, and grinds to a white powder.

The associated talcose rock on either side of the talc is about 150 feet wide and includes a large percentage of talc and related magnesia-rich hydrated minerals, as well as a variable proportion of less completely digested country rock. The whole is intersected by veins of quartz and calcite and is greatly sheared, flawed, and checked. Between this talcose belt and the face of the adit are black slates intersected by numerous, small quartz veins and veinlets and containing some disseminated iron sulphide whose oxidation has stained the roof and walls of the adit and deposited a quantity of ochre on the floor. Between the talcose belt and the portal of the adit is an assemblage of slaty rocks intersected by a diorite dyke 33 feet wide and by a vein of quartz 12 feet wide. The sediments intersected by this adit strike north 40 to 50 degrees west (magnetic) and dip at high angles, in part to the southwest and in part to the northeast. The deformation they have undergone probably had an important bearing on the alteration of the rocks to talc and talcose materials.

The only other talc body at present being mined occurs on the slope leading down to Nahatlatch river from the hoist at the end of the wagon road. Here at 110 feet above the river a 35-foot adit has been driven south 23 degrees west (magnetic) into a bluff of talcose rock. An aerial tram has been constructed from below the portal of this adit to a hoist at the top of the hill at the end of the wagon road. The talcose rock is uniform across the section exposed. It ranges in colour through shades of green to almost white and crushes to a nearly white powder which has a smooth talcose feel. It is generally greatly fractured and squeezed, with the lamination planes dipping at high angles to the northeast. A sample taken along the adit was found to contain about 42 per cent soluble materials, chiefly carbonate carrying a high percentage of magnesia. The insoluble residue is chiefly talc. This talcose belt is probably continuous with one or other of two upper wide belts of talcose rocks that cross Nahatlatch river, and is very similar to the talcose rock forming the last 21 feet in an upper adit, less than 200 feet to the southwest.

In all, four main belts of talcose rock outcrop along or close to the southern bank of Nahatlatch river; some other exposures of sedimentary rocks also contain talc, but it is not sufficiently concentrated in these to warrant separate mapping. The four belts have an aggregate width of not less than 350 feet and probably not more than 500 feet (Figure 5). They are much alike in character and mineral composition, being composed essentially of carbonate and talc in varying proportions. The carbonate is always comparactively abundant and may be in excess of the talc. The chief carbonate mineral is a ferruginous magnesite of brownish or flesh colour; along the banks of the river, where subjected to water action, this weathers above the talc in a nodular fashion. The associated talc is commonly light green or pearl grey and massive to slightly laminated. Other impurities are granular quartz and vein-quartz—which, however, are rarely as abundant as either the carbonate or talc—and occasional particles of iron sulphide. Near the contact of these talcose belts with the slaty rocks both rock types are commonly intersected by small quartz veinlets which, however, are comparatively rare elsewhere in the talcose bodies. The powder of these talcose rocks is uniformly white and, in spite of the high percentage of carbonate present, has a well-pronounced "slip." The bulk of these rocks is very great, but the amount of impurities present renders a large part of them of doubtful commercial value unless some economic method is devised to separate the talc from the carbonate minerals.

The comparatively narrow belt shown in Figure 5 as the uppermost of the series of talcose belts along Nahatlatch river carries only a small percentage of talc, but is quite distinct from the other members of the slaty argillaceous rocks. It is composed of a light-coloured rock carrying sufficient bright green mica to give a mottled appearance. The greenish colour is thought to be due to the presence of chromium. This rock is composed chiefly of carbonate and includes a considerable percentage of granular quartz and vein quartz showing comb structure and filled with minute inclusions. The carbonate is a ferruginous magnesite and effervesces only in heated acid solutions. Very similar rock occurs on the top of the hill near the hoist, where it forms an outcrop to which the cable is anchored; also associated with the large exposures of quartz near the hoist. In its various exposures this green carbonate rock carries a varying small percentage of talc, and the carbonate in it is very similar in appearance and composition to the carbonate in the talcose belts along Nahatlatch river and elsewhere on the property.

Genesis

The talc deposits seem to be intimately related in origin to the silica. Both minerals were probably formed at about the time the sediments were intruded by the large bulk of batholithic rocks that lie beyond the western limits of the property and are represented on the property by dykes or sills. Whereas the silica represents entirely new material introduced from depth into the older sedimentary rocks, the talc bodies are secondary products formed apparently from certain sedimentary strata by dynamic and hydrothermal agencies accompanying the igneous intrusions. These strata all contain carbonate minerals in proportions varying from a small percentage to limestone beds composed of nearly pure calcium carbonate. A specimen of finely crystalline dark-coloured limestone obtained along Nahatlatch river between the second and third talcose belts above the railway bridge was found by M. F. Connor, of the Geological Survey, Ottawa, to have the following approximate composition:

	Per cent
Insoluble	0·10
Iron and aluminum oxides	0·03
Magnesium carbonate	0·39
Calcium carbonate	99·23
	99·72

The carbonated-bearing strata vary from these nearly pure limestone beds through limestone containing a considerable percentage of acicular tremolite to beds in which there is very little calcium-carbonate but an abundance of a carbonate high in magnesia and carrying some iron. It is with these beds that the principal deposits of talc occur. All the talcose showings on the Laura and Salmon River claims are of this type. In these showings talc and a ferruginous magnesite are the principal and usually the only abundant minerals, and both in the hand specimen and under the microscope the talc appears to be the later mineral and to be replacing the magnesite. The magnesite may have originated either by concentration of magnesia, and to a less extent of iron, in beds of dolomitic composition, or by replacement of limestone by magnesium and iron carbonate solutions originating with the more basic intrusives of the area, such as those occurring on the property. The presence of a chromium-bearing mica with the magnesite in some of the smaller and less talcose beds, is thought to favour the latter view. The formation of the talc from the magnesite is regarded as a later phenomenon connected with the circulation of thermal silicate solutions related to the batholithic intrusives of the district. This circulation would be facilitated by deformation of the sediments before or during batholithic intrusion and the development thereby of zones of weakness along which the thermal solutions could advance and permeate the adjoining strata. The intimate association of small quartz veinlets with talc and magnesite, especially near the contact of the talcose belts with the more argillaceous slaty sediments, indicates that silicate solutions were introduced at about the time the talc was formed, as both of these minerals appear to replace the carbonate. The silicate solutions may have carried some magnesia and thereby assisted in the development of magnesium silicate minerals, but most of the magnesia in the talc was more probably acquired from the associated carbonate, either directly or through the intermediate development and subsequent alteration of magnesium silicate minerals, such as tremolite. The tremolite mentioned as occurring in some of the limestone beds along Nahatlatch river probably resulted from the reaction of thermal silicate solutions with the small magnesium content of the limestone.

In the adit on Gisby claim the mineral composition of the talcose belt is less certain. The rocks are here greatly sheared and slickensided and a slaty structure has been developed across both the talcose rocks and the adjoining argillaceous sediments that lie between the talc belt and the face of the adit. On the other flank of the talcose belt is a dyke of diorite 33 feet wide. The original composition of the talcose belt was probably not very different from that of a belt of sediments that outcrop in a bluff on the adjoining Madge claim about 700 feet to the northwest of the adit and in line with the general trend of the formations. This less altered rock is a moderately coarse calcareous sediment composed chiefly of a carbonate, quartz, and an isotropic mineral resembling garnet but largely altered to greenish chlorite. A specimen of this rock was found by M. F. Connor, of the Geological Survey, to be composed of 27·66 per cent soluble and 72·34 per cent insoluble materials. An analysis of the soluble and insoluble matter gave the following approximate composition (assuming that the bases in the solute formed carbonates in the rock).

		Percentage
Soluble..	$CaCO_3$	19·2
	$FeCO_3$	7·3
	$MgCO_3$	2·5
Insoluble...	SiO_2	32·00
Iron and aluminum oxides in about equal proportions		27·12
	CaO	1·94
	MgO	7·61
	Cr	0·04±
Loss on ignition....................................		3·34

The presence of chromium and of what appears to be garnets implies the influence of thermal magmatic solutions on the original sedimentary materials. The development of magnesia and iron-rich silicates at the probable expense, in part, of an originally greater proportion of calcium carbonate in the metamorphosed sediment is suggested by the reversed order of abundance of magnesia as compared with lime in the soluble and insoluble materials. The more altered phase of this rock shows a considerable percentage of talc, and, where subjected to much shearing and impregnation by thermal magnesia-rich solutions accompanying the intrusion of the adjacent diorite and the much larger batholithic intrusives of the period, might easily pass over into a talcose rock such as that encountered in the adit on Gisby claim.

Equipment and Production

A mill has recently been installed near the portal of the adit on Gisby claim and is capable of handling about one ton of talc per hour. It is equipped with two jaw crushers, a Raymond pulverizer, and a set of screens running to 200 mesh. Silica is also crushed in this mill to about the size of chicken grit, for which use it finds a ready market. Up to date the only talc treated has been obtained from the Gisby claim. Recently a short aerial tram, operated by a 6-horsepower gas engine, was constructed from the portal of the talc tunnel on Salmon River claim to a hoist at the end of the wagon road. Treatment of this talc at the mill will shortly be commenced.

Shipment to date (1923) has included several hundred tons of silica and less than 100 tons of talc. The latter has been marketed on the coast for an average of $20 a ton. The freight rates to Vancouver are $4.40 a ton of talc and $2.35 a ton of silica.

Economic Possibilities

The property includes large deposits of silica and talc and is most conveniently situated. There is, further, little doubt that a ready market will be found on the coast for both talc and silica products. The chief factors attendant upon the successful operation of the property would, therefore, seem to be an efficient management and a good grade, and consequent marketable value, of talc in the larger deposits outcropping on Salmon

River and Laura claims. Except for the relatively small band or lens of high-grade talc intersected by the adit on Gisby claim, all the talcose bodies on the property contain a relatively high percentage of impurities which, unless some refining process be adopted, will doubtless preclude the use of the talc for purposes requiring a high-grade product. The large body of talcose rock intersected by the lower adit on Salmon River claim is characteristic of the lower grade talcose rocks so abundantly represented on this property. This talcose belt has been shown by an approximate analysis to contain an average of between 55 and 60 per cent talc. The remainder of the rock is composed chiefly of a ferruginous magnesite containing about 15 per cent iron carbonate and between 2 and 3 per cent lime (calcium carbonate). Except for its relatively high percentage of magnesia as compared with lime, the composition of this rock is somewhat analogous to that of the so-called Rochester 'grit' which is mined in the state of Vermont and has been used successfully for certain commercial purposes[1] such as the manufacture of newspaper, wrapping paper, wall paper, mortar, plaster, and various grades of roofing paper. The high percentage of magnesia in the carbonate would probably render it particularly suitable for those purposes where refractory qualities and resistance to weather conditions are desirable. The magnesite in the talc deposits might itself be of commercial value if some economic method of separating it from the associated talc could be devised.

(5) COQUIHALLA DISTRICT

On Coquihalla river, 15 miles above Hope, there is an irregular, northwesterly-trending band of serpentinized greenstone from one-quarter to one mile wide which extends diagonally across and beyond Coquihalla map-area and, hence, has a length of at least 13 miles. This serpentine, in places, especially along its margin, is traversed by zones of minute talc veins. These zones are generally only a few inches wide and the individual veinlets less than one-eighth of an inch wide. The deposits are, therefore, not commercially important. They suggest, however, that more extensive deposits of talc may be associated with the serpentine of this district[2].

Greenwood Mining Division

(6) WHITE'S CAMP, AT HEAD OF KOOMOOS CREEK

An occurrence of soapstone in serpentine at White's camp in the Boundary Creek district is described by R. W. Brock as follows:

"None of the serpentine seen was sufficiently massive to be useful as an ornamental stone. In White's camp a very pure soapstone occurs, which, near transportation and a market, would have an economic value."[3]

"Serpentines are not uncommon in this area. At a few points, as at the head of Koomoos creek, they are fibrous in places, but usually they

[1] Jacobs, E. C.: "Rept. of the Vermont State Geologist", 1913–1914, pp. 384–429; 1915–1916, pp. 232–280.
[2] Cairnes, C. E.: Geol. Surv., Canada, Mem. 139, p. 35 (1924); and personal communication.
[3] Geol. Surv., Canada, Sum. Rept. 1902, p. 133.

are massive. At one point at the head of this creek they become an almost pure soapstone; the outline of the original crystals, which occasionally can be detected, shows that the serpentine is formed from an alteration of basic igneous rocks. These rocks were intrusive in the greenstone and older rocks, sometimes producing contact metamorphism. These serpentines are classed with the Upper Palæozoic found to the west, having similar characteristics and the same relationship."[1]

The dimensions of the deposit are not stated, but it lies several miles by road from the nearest point on the Phoenix branch of the Great Northern railway and unless it is very extensive or of exceptional quality, it cannot be worked profitably under present market conditions.

Revelstoke Mining Division

(7) ILLECILLEWAET DISTRICT

In the Annual Report of the Geological Survey for 1902-03, it is stated that "a pale greyish-greenish white, sub-translucent steatite has been found at the Nith mine, Illecillewaet river, nearly opposite Illecillewaet station, on the line of the Canadian Pacific railway,"[2] and in the Annual Report for 1894, that a specimen of steatite with dolomite from near Ross peak, 6 miles east of Illecillewaet, was presented to the Mineralogical Division of the Geological Survey by Mr. Walter Scott, through H. M. Ami.[3]

During the field season of 1921 M. F. Bancroft, of the Geological Survey, examined an occurrence of talc in a prospect opening 15 feet long which had been excavated in the north side of a cut on the Canadian Pacific railway one-quarter mile west of Illecillewaet station. The deposit occurs in a shear zone in Palæozoic slate and limestone (Laurie formation) and consists of greenish grey talc mingled with pale green actinolite. It is 2 to 4 feet wide and is exposed for the whole length of the opening. The prospector who had opened up the deposit stated that he had found outcrops of talc for a distance of 2,000 feet.

It is probable, therefore, that deposits of talc are common in this district.

Lardeau Mining Division

Numerous bands of serpentinized basic igneous rocks up to one-quarter of a mile wide and 20 miles long occur in association with the Palæozoic sediments of Lardeau district. These have been transformed to talc in places, but up to the present development work has been attempted on only one group of claims.

[1] Geol. Surv., Canada, Map No. 838, marginal note.
[2] Hoffmann, G. C.: "Chemical Contributions to the Geology of Canada"; Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R, p. 25 (1895).
[3] Geol. Surv., Canada, Ann. Rept., vol. VII, p. 101 A (1896).

(8) ASBESTOS GROUP[1]

These claims are situated east of Columbia river, 1½ miles in a direct line from Sidmouth station on the Canadian Pacific railway, 3 miles north of Arrowhead. They have been staked on a mass of serpentine 800 to 1,000 feet wide and ¼ mile long, which has been more or less transformed to talc throughout its width. The largest zone of talc observed occupies the bottom of a pit 20 feet wide, 50 feet long, and up to 6 feet deep. The material from this pit is a variegated greenish-grey talc schist remarkably similar to the talc from the Eagle claim, on Vancouver island. Under the microscope it is seen to consist of coarse grains of carbonate (probably magnesite)[2], granular magnetite, and fine, micaceous talc. This talc is too dark to be ground for use as talcum powder or other purposes for which a white colour is essential, but should be satisfactory for the manufacture of roofing material or other products in which exceptional purity is not important. It would be especially useful in those materials where refractory qualities are required.

Front Lake Mining Division

(9) SILVER CUP MOUNTAIN

A specimen of pale grey-green, micaceous talc said to have been obtained on Silver Cup mountain, to the northeast of Trout lake, was given M. F. Bancroft, of the Geological Survey, by a prospector. Mr. Bancroft also observed several outcrops of rusty talc schist in this locality.

Windermere Mining Division

(10) MOUNT WHYMPER OR SILVER MOON CLAIM

Previous Descriptions. Allan, J. A.: Second Annual Report on the Mineral Resources of Alberta, 1920, pp. 122–24.
Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 18.

This property is situated on the east slope of mount Whymper, about 25 miles west of Banff and 11 miles southwest of Castle station on the Canadian Pacific railway. It lies about 750 feet above the new Windermere highway and a few miles west of the interprovincial boundary between Alberta and British Columbia.

The talc occurs in four irregular masses or lenses enclosed in grey, flat-lying dolomite of Lower Cambrian age. Except for some pockets of fibrous talc, the talc is a massive, dense, greenish grey variety, much fractured, so that unbroken masses more than 2 feet in diameter would be difficult to obtain. According to Spence, the deposits all occur at about the same horizon in the dolomite, are from 15 to 20 feet wide, and have a maximum extent vertically of 75 feet. The principal minerals asso-

[1] Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1921, pt. A, p. 112.
[2] A specimen of the talc when treated with strong hydrochloric acid did not effervesce. *See also* Geol. Surv., Canada, Sum. Rept. 1921, pt. A, p. 112.

ciated with the talc are quartz and dolomite. Chemical analyses of the talc are as follows:

—	I	II	III
Silica	61·52	64·06	62·91
Ferrous oxide	0·66 }	....	1·68
Ferric oxide	0·24 }		
Alumina	....	2·10	
Lime	0·10	....	
Magnesia	32·63	30·13	31·12
Carbon dioxide	0·07	....	
Soda	....	1·78	1·17
Water above 105°C	4·39	1·41	1·53

I. A sample of selected material free from quartz and dolomite, analysed in Mines Branch laboratory. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1912, p. 18.
II. Analysis by Industrial Laboratory, University of Alberta. Allan, J. A.: Second Annual Report on the Mineral Resources of Alberta, 1920, p. 123.
III. Analysis furnished by the owner. Allan, J. A.: Second Annual Report on the Mineral Resources of Alberta, 1920, p. 123.

The analyses show that, except for the dolomite and quartz, the deposits consist of pure talc.

Since the Mount Whymper deposits are associated with dolomite and no other magnesian rocks occur nearby, it is most probable that they have been formed from the dolomite by reaction with siliceous emanations from igneous intrusives underlying the region at depth. That such igneous intrusives underlie the region is indicated by: (1) the presence of intrusive masses of nepheline syenite and related rocks in the Ice River district only 20 miles to the west[1]; (2) the occurrence of "pockety deposits of galena, chalcopyrite, and other sulphides in that part of the Rocky mountains"; and (3) the marmorized condition of the Palæozoic limestone in places in the district.[2]

NORTH WEST TERRITORIES

RAE RIVER

So far as known to the writer, the only recorded occurrence of talc or soapstone in the North West Territories is a deposit of soapstone on Rae river, near Coronation gulf. Dr. John Rae ascended this river about 20 miles in 1849, and among the limestone and quartz rocks discovered "asparagus-stone or apatite, thin beds of soapstone, and some nephrite or jade."[3] It is uncertain that this material actually contains talc, since the name soapstone may have been used by Dr. Rae to designate any soft rock possessing some slip.

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[1] Allan, J. A.: Geol. Surv., Canada, Mem. 55.
[2] Information contained in letter to the writer by J. A. Allan.
[3] Richardson, Sir John: "Journal of a Boat Voyage Through Rupert's Land"; vol. 1, p. 312 (1851).

PORT EPWORTH

At Port Epworth near the mouth of Tree river, in Coronation gulf, there is granite that "holds inclusions of talc-chlorite schist, which the Eskimos quarry for pots and lamps."[1]

COMMITTEE BAY AND BAFFIN ISLAND

Soapstone is a common article of trade for manufacture into pots and lamps among the Eskimos living on Committee bay and in the southeastern part of Baffin island. "It is found in a few places only and very rarely in pieces large enough for the manufacture of the articles named. Among the places visited by the natives for the purpose of obtaining it may be mentioned Kautaq, east of Naujateling; Qeqertelung, near the former place, Qarmaqdjuin (Exeter bay); and Committee bay. The visitors come from every part of the country, the soapstone being dug or "traded" from the rocks by depositing some trifles in exchange."[2]

ONTARIO

Patricia District

FAVOURABLE LAKE

Talc and hydro-mica schists associated with "chloritic and altered hornblende rocks" were observed on Favourable lake, near the head of Severn river, by A. P. Low. Mr. Low makes no statement regarding the extent or character, of the talc schist seen.[3]

Kenora District

NORTH SHORE OF SHOAL LAKE

Material on the north shore of Shoal lake, approximating soapstone in composition, is described by A. C. Lawson as follows:

"A specimen from the north shore of Shoal lake, which was apparently free from ferruginous and siliceous matter, and of a grey colour and finely granular texture, presenting the physical and chemical character of a limestone by the ordinary tests, was found to contain 68·6 per cent of insoluble material, probably magnesian schists, which would cause it to approximate to soapstone in composition, although its hardness was much higher than that of the latter rock. Such a stone is, of course, totally unfit for the purpose of lime-making."[4]

[1] O'Neill, J. J.: Canadian Arctic Expedition, vol. XI, Geol. and Geog., pt. A, p. 21 (1924).
Jenness, D.: Canadian Arctic Expedition, vol. XII, Copper Eskimos, pp. 53–54 (1922).
[2] Boas, Frank: Ann. Rept. Bur. of Eth., vol. VI, Washington, p. 469 (1885).
[3] "Lake Winnipeg and Hudson Bay"; Geol. Surv., Canada, Ann. Rept., vol. II, pt. F, p. 17 (1887).
[4] "Report on the Geology of the Lake of the Woods Region"; Geol. Surv., Canada, Ann. Rept., vol. I, pt. CC, p. 146 (1886).

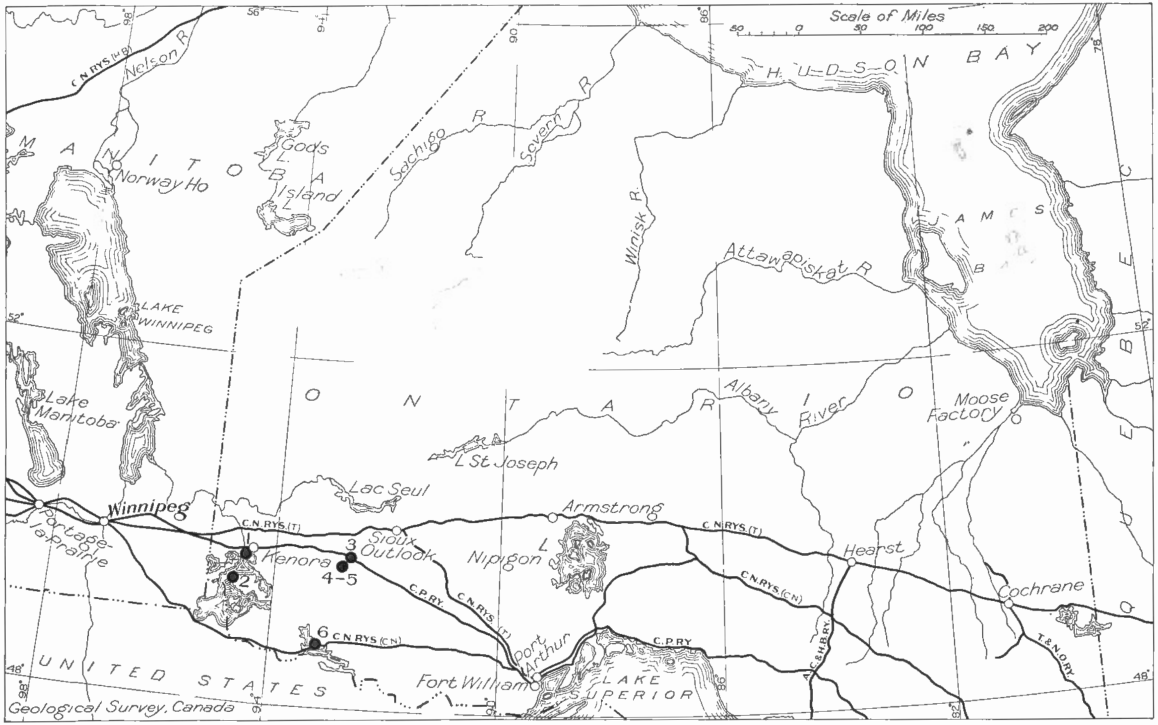

Figure 6. Index map showing location of talc and soapstone deposits in western Ontario: 1, Islands in Lake of the Woods near Kenora; 2, Narrows south of French portage, Lake of the Woods; 3, Wabigoon; 4, Trap lake; 5, Mile lake; 6, Rock Island bay, Rainy lake.

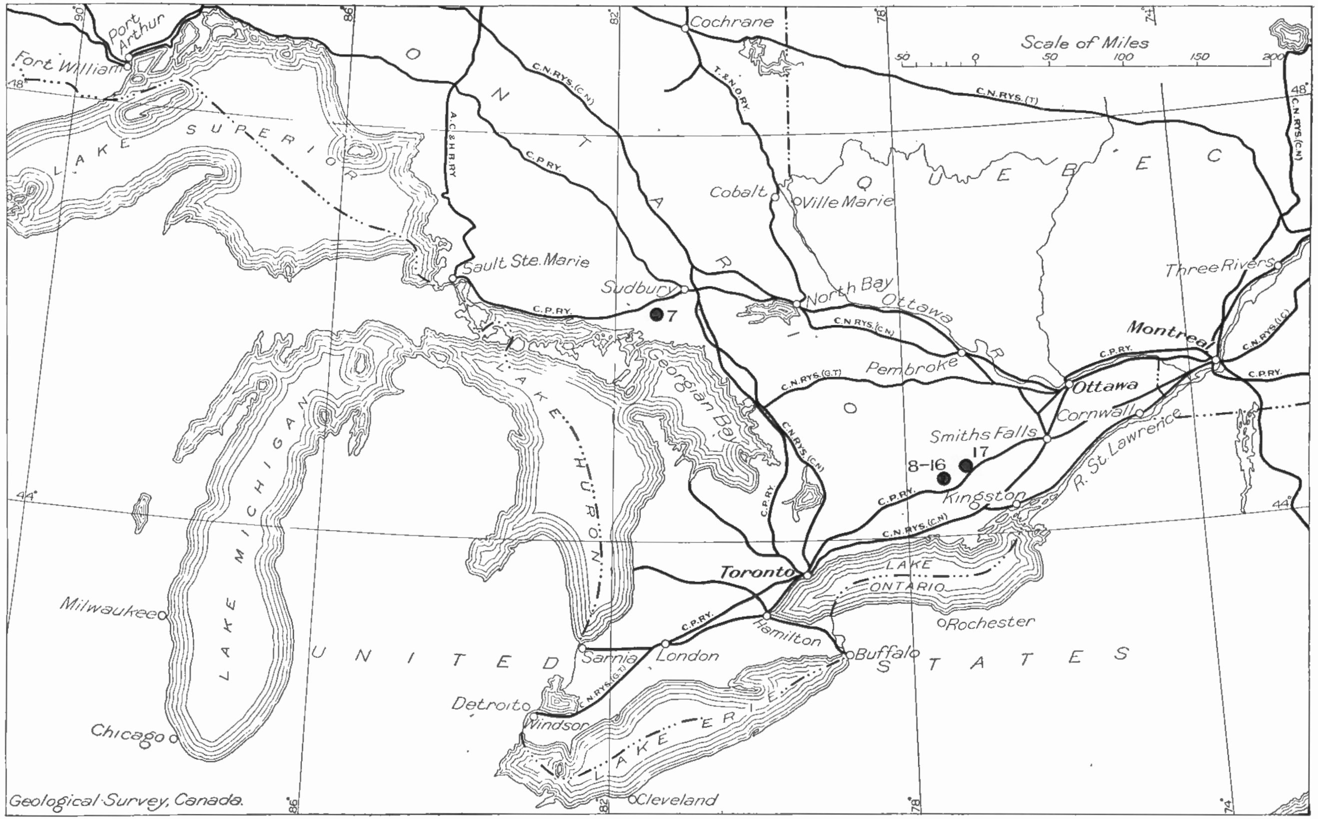

Figure 7. Index map showing location of talc and soapstone deposits in southeastern Ontario. (*See* page 56 for locality names.)

Explanation of Figure 7

7.	Panache lake	
8.	Hastings co., Madoc tp., cons. IV and V, lots 20 and 21	8–16
9.	" " " " con. XI, lot 15	
10.	" " Huntingdon tp., con. XIV, lot 14	
11.	" " " " con. XIV, lot 15, $W\frac{1}{2}$	
12.	" " " " con. XIV, lot 15, $E\frac{1}{2}$	
13.	" " " " con. XIV, lot 16	
14.	" " Grimsthorpe tp., con. V, lot 9	
15.	" " Elzevir tp., con. II, lots 10 and 11	
16.	" " " " con. VI, lot 5	
17.	Lennox and Addington co., Kaladar tp., con. V, lot 2	

(1, 2) LAKE OF THE WOODS

Occurrences of both talc and soapstone on Lake of the Woods are mentioned by Lawson in his description of the geology of that district:

"Pure talc, of pearly, whitish-green, foliated aspect, occurs in small segregations in some of the softer green schists of the islands of the lake, and some handsome specimens have been brought into Rat Portage (Kenora), said to be from an island 2 miles south of the town. Although this pure talc is sometimes ground and used as a lubricant or polisher, it is doubtful if it occurs in sufficient quantities on the Lake of the Woods to be of economic value. The less pure, grey-coloured granular variety of talc, known as soapstone, or steatite, is, however, more abundant, and forms at least one extensive deposit which constitutes the rock on both sides of the canoe channel, $1\frac{3}{4}$ miles southwest of French portage, for a distance of a hundred yards or more. This place has long been resorted to by the Indians for material for their pipes. The rock is soft, sectile, and frequently free from grit, taking a moderately fine polish with ease; it presents excellent facilities for quarrying, and would require no intermediate transport from the quarry to the barges. It lies within a few hundred yards of the regular tug channel through the lake, and will doubtless be of considerable value as the nearest source of supply of furnace linings, fire-stones, slabs, etc., when those commodities come into demand in Manitoba and the west."[1]

"Impure serpentines or soapstones occur in a few localities, most characteristically, however, on the narrows to the south of French portage. The soapstone or pipestone of Pipestone point is simply a soft, decomposed, or steatitic variety of the green hornblendic schists, and is not used by the Indians for making their pipes."[2]

In 1915 shipments of schist similar to that on Pipestone point were made from an unpatented claim situated on Pipestone portage about $3\frac{1}{2}$ miles east of Pipestone point, to the Dryden Timber and Power Company for lining smelting furnaces[3], but proved unsatisfactory for the purpose.

[1] Geol. Surv., Canada, Ann. Rept., vol. I, pp. 148–9 (1886).
[2] Geol. Surv., Canada, Ann. Rept., vol. I, pt. CC, p. 49 (1886).
[3] Ann. Rept., Ontario Bureau of Mines, vol. XXV, p. 67 (1916).

(3, 4, 5) WABIGOON LAKE AND VICINITY

By J. F. Wright

Previous Description. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 35-38.

The increasing demand for soapstone in Canada and the high cost of the imported material has stimulated prospecting and re-examination of various known occurrences of this material in northwestern Ontario, with the result that recently several fairly large deposits of apparently marketable soapstone have been opened in the vicinity of Wabigoon lake, just south of the Canadian Pacific railway. In view of the possible economic importance of these deposits, three days in May and five days in October, 1923, were spent studying the geology in their vicinity. Acknowledgment is made to Messrs. E. G. and Lorrain Pidgeon of Wabigoon for many courtesies extended during these visits.

Location and Development

An outcrop of soapstone near the centre of a peninsula in Wabigoon lake about $1\frac{1}{2}$ miles west of Wabigoon station has been known for a number of years, but the possible economic value of the deposit was not recognized until 1921, when Mr. E. G. Pidgeon bought this property and had the rock tested. The soapstone outcrops on the top and west slope of a hill about 50 feet higher than Wabigoon lake and about 1,500 feet southwest of the Canadian Pacific railway. The location is ideal for quarrying and transportation.

In 1921 Mr. Pidgeon had considerable stripping done to determine the surface extent of the deposit and quarried several cubic feet of the soapstone for test purposes. In 1922 he sold a half interest in the property to H. H. Sutherland of Toronto, and the Wabigoon Soapstone Company, Limited, was organized. No development work has been done on the property since 1921.

In August, 1923, Mr. Lorrain Pidgeon observed outcrops of soapstone on the west end of the first large island that is seen on entering Trap lake from the northeast, and staked two claims, Nos. K1181 and K1194. This point had been used as a picnic ground for years and people had carved their names in the soft rock. The Trap Lake deposit is about 8 miles southwest of the Wabigoon deposit and about 9 miles south of Dryden on the Canadian Pacific railway. The small river flowing from Trap lake north through Mile lake to Contact bay, Wabigoon lake, is navigable by a small steamer or gasoline boat, hence the deposit is well located with respect to transportation; the rough quarried soapstone can be loaded directly on barges and towed either to Dryden or to Wabigoon and prepared for the market or loaded directly on freight cars.

In September, 1923, a company called the Thermo-Stone Quarries, Limited, with headquarters in Toronto, was incorporated to quarry and to market this soapstone. Some stripping was done and soapstone was proved to extend beneath the drift, over the whole island on which the original discovery was made. Several cubic feet of soapstone were sawn out with a cross-cut saw and shipped for test purposes. These tests are reported to show the soapstone to be of high-grade quality. In the spring of 1924 the Wabigoon Soapstone Company and the Thermo-Stone Quarries, Limited, were amalgamated, but no attempt has yet been made to develop either of these properties. Since the Trap Lake deposit was staked two other outcrops of soapstone have been discovered, one near the south shore and the other on the north shore of Mile lake, about $\frac{3}{4}$ and $1\frac{1}{2}$ miles respectively, north of the original discovery. Not enough work has yet been done on either of these outcrops to prove the value or size of the deposits.

Geology

The country immediately north of Wabigoon lake is gently rolling and is characterized by glacial drift ridges and stratified lake clays, with few

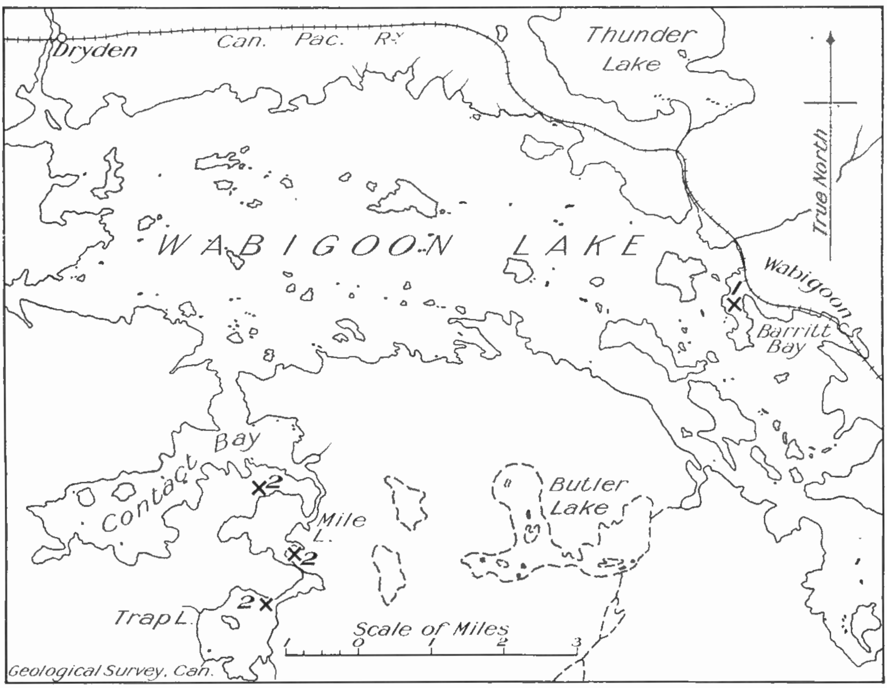

Figure 8. Index map showing location of Wabigoon soapstone deposit (1), and Trap Lake soapstone deposits (2), Kenora district, Ontario.

bedrock outcrops. In contrast, the country to the south of the lake, and especially to the southwest, is rocky and many of the hills rise over 200 feet above the lake. Highly metamorphosed early Precambrian (Keewatin) lavas and sediments are the most abundant rocks exposed, but there are small areas of later basic and acidic intrusives.[1] These rocks form the following groups:

(1) Post-glacial stratified lake clay, glacial terminal and ground moraine boulder clay, and gravel.

(2) Late Precambrian granitic intrusives consisting of pink granite, aplite, and pegmatite, and outcropping as small bosses and dykes in the vicinity of Wabigoon lake, but as very large masses a few miles to the north and southwest of the lake.

(3) Intrusives ranging from amphibole gabbro to syenite in composition and outcropping as dykes and boss-shaped masses. This group cuts the lavas and sediments of group (4) and is possibly older than the intrusives of group (2). The soapstone is a metamorphosed phase of these intrusives.

(4) Early Precambrian (Keewatin) lavas and sediments. Volcanic rocks, ranging in composition from acidic to basic and with interbedded pyroclastics and tuffs, are abundant. A thick sedimentary series of biotite and hornblende schists outcrops north of Wabigoon lake, but the age relations of this series with the lavas to the south are not known. However, the general southward dip and the areal distribution of the sediments suggest that they underlie the volcanic series, and, therefore, are older.

Wabigoon Claim No. HW 133

This claim is 1½ miles west of Wabigoon station and includes most of the long peninsula forming the west shore of Barritt bay (Figure 8). Sand and clay cover most of the surface, but bedrock outcrops along the shore and at the soapstone workings. Pillow lava ranging from trachyte to andesite outcrops along the shore about 350 feet southwest of the soapstone outcrop. Some of the coarse-grained basic rocks towards the south end of the peninsula, that have been included in the volcanic series, may be intrusive gabbro, but this could not be proved. At the south end of the peninsula and on the nearby islands the lavas are more acidic and two pyroclastic beds were noted.

The lavas are intruded by medium to coarse-grained, slightly porphyritic rocks ranging in composition from gabbro to syenite. The coarseness of grain, the texture, and the inclusion of black andesite lava in the syenite outcrop about 200 feet southeast of the soapstone deposit proves the intrusive relations of these rocks. The long axis of this intrusive mass is northwest-southeast, and the known length is approximately 2,000 feet. The dip, as nearly as can be determined, is vertical. The following rock-types are exposed along a section at right angles to the strike and crossing the soapstone outcrop from the northeast:

0–150 feet.	Slightly schistose, medium-grained, light grey, syenitic rock.
150–225 "	Massive, slightly porphyritic, medium-grained, dark grey, dioritic rock.
225–275 "	Massive, coarse-grained, light green, gabbroic rock.
275–310 "	Massive, dark greenish grey soapstone exposed about 400 feet along the strike.
310–410 "	Massive, medium to coarse-grained, light grey, syenitic rock.
410–485 "	Mixed soapstone and gabbroic rock, with soapstone predominating, exposed about 300 feet along the strike.

[1] *See* Manitou Lake sheet, No. 720, Geol. Surv., Canada, by William McInnes; and Thomson, Ellis: Ann. Rept., Ont. Bureau of Mines, vol. XXVI, pp. 163-189.

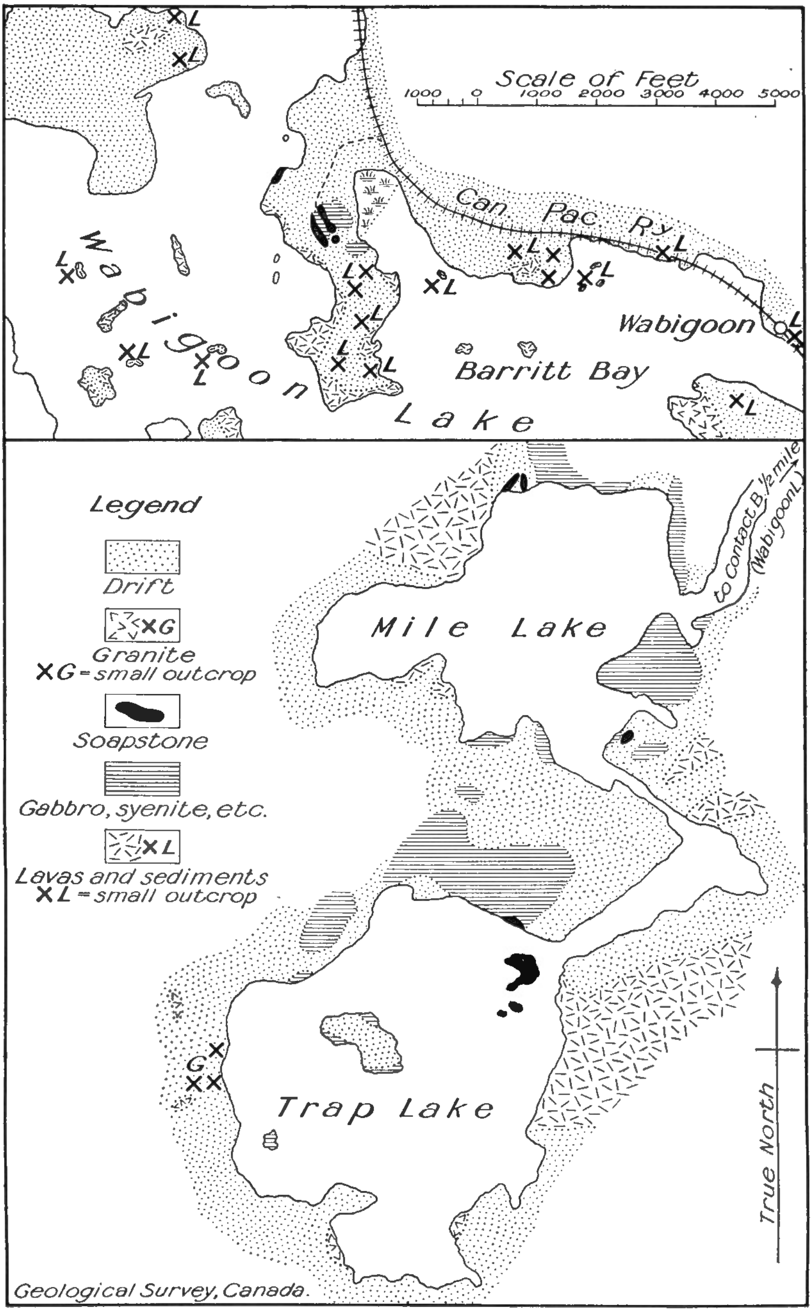

Figure 9. Wabigoon and Trap Lake soapstone deposits, Kenora district, Ontario.

The contact between what is called syenite and diorite, or diorite and gabbro, is apparently transitional, but the contact between what is called gabbro and the soapstone is fairly sharp and can be fixed within a foot or two. All these rock types have been much altered and microscopic study gives little idea of the character of the original rock. Thin sections of the syenitic rock when studied under the microscope were found to consist of a twinned plagioclase, near andesine in composition, but partly decomposed to dark grey kaolinic material, and a few irregular areas of fresh orthoclase; hornblende forms 18 to 20 per cent of the thin sections, and there is considerable chlorite and some epidote. In the thin sections of sheared phases of this rock, from near the northeast edge of the exposure, the feldspars are badly decomposed and indeterminable, there is considerable quartz, some biotite, and a great abundance of chlorite and epidote. Thin sections of the darker dioritic phases contain considerably more of the deep green, highly pleochroic hornblende than do the lighter syenitic phases. The coarser grained gabbroic phases contain abundant hornblende, chlorite, talc, serpentine, and a small amount of basic plagioclase largely altered to zoisite and epidote. Good quality soapstone is seen to consist of a felty aggregate of talc, with small amounts of dolomite, chlorite, and magnetite; poorer quality soapstone contains, besides talc, considerable dolomite in large bunches or nests, calcite, abundant magnetite, chlorite, and in most cases a little serpentine. The six thin sections of soapstone studied were very similar and gave no clue to what may have been the composition of the rock from which the soapstone was derived.

Two bands of soapstone, the south one about 25 feet wide, and the north one about 75 feet wide, separated by about 100 feet of syenitic rock, outcrop along the lake shore about 700 feet northwest of the main soapstone outcrop, and possibly represent the continuation of the basic intrusive and soapstone in this direction. Here both the syenitic rock and soapstone are dense and fine grained. A thin section from the south side of the soapstone band consists of serpentine, talc, chlorite, and magnetite. The serpentine occurs in aggregates of fibres or as parallel fibres at right angles to cracks partly filled with magnetite. Olivine evidently was the abundant primary mineral of this rock. This bluish, massive serpentine rock contains large masses of greenish grey soapstone, which evidently originated from it.

Some outcrops of the basic intrusives that contain the soapstone are badly jointed, but no regular and continuous well-developed jointing system could be determined. The joints are all short, branching, and not parallel as they commonly are when they originate from regional deformation. In places the soapstone is divided by joints into small, irregular blocks. The better developed joint-planes are slickensided and the soapstone is foliated a few inches on each side of the joint-plane. When struck by a hammer, some of the apparently joint-free soapstone from the surface breaks along small cracks stained by yellow iron oxide. These joints are possibly due to weathering, but many of them are probably due to change in volume of the basic rock during the metamorphism to soapstone, in which case the irregular jointing will continue to depth. There are quite large areas apparently free fron joints, but in quarrying the mass as a whole there will be considerable waste due to the complex jointing.

The following table gives chemical analyses of soapstone from the Wabigoon deposit and, for comparison, the Virginia Alberene stone and three types of basic igneous rock closely resembling soapstone in chemical composition.

—	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	41·94	51·44	37·10	40·91	51·29	42·10
Al_2O_3	7·57	4·79	4·53	5·00	3·52	3·28
Fe_2O_3	2·05	3·68	4·57	4·64	1·82	8·27
FeO	7·71	7·24	6·58	7·97	6·00	2·13
CaO	3·42	....	4·20	4·41	13·88	3·77
MgO	25·39	26·43	27·37	30·82	21·06	30·65
Na_2O	....	....	....	0·58	0·30 }	1·90
K_2O	....	....	....	0·36	0·16 }	
CO_2	5·09	0·11	10·45	....	.... }	7·73
H_2O	6·71	6·56	5·46	4·56	1·20 }	

(1) Wabigoon stone, representative of material of northern 35-foot body. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 36.
(2) Wabigoon stone, 18-inch band of soapstone bordering northern body. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 36.
(3) Virginia Alberene stone. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 36.
(4) Amphibole peridotite. Average of seven analyses. Daly, R. A.: "Igneous Rocks and Their Origin", 1914, p. 29.
(5) Pyroxenite of sub-alkaline series. Average of ten samples. Daly, R. A.: "Igneous Rocks and Their Origin", 1914, p. 30.
(6) Altered mica-hornblende-picrite. Judd, J. W.: "Older Peridotites of Scotland"; Quart. Jour. Geol. Soc., vol. XLI, p. 404 (1885).

All chemical analyses of soapstone are uniformly low in alumina and silica and high in magnesia. Alumina is generally accepted as one of the most stable elements under metamorphic conditions, hence, unless the formation of soapstone involves subtraction of alumina and addition of magnesia, the original rock must have contained a large per cent of magnesium-rich, aluminum-poor silicates, such as olivine, enstatite, or augite. It is estimated, from a detailed microscopic study of six thin sections of Wabigoon soapstone, that talc forms from 50 to 75 per cent of the rock, chlorite from 10 to 30 per cent, dolomite from 2 to 20 per cent, serpentine from 0 to 12 per cent, and magnetite from 2 to 3 per cent. The flaky and fibrous character of talc, chlorite, and serpentine makes it difficult, however, to determine the percentages of these minerals in a rock by microscopic examination and any figures of percentages must be regarded as approximate. From the two chemical analyses of the soapstone it may be calculated that it contains from 50 to 65 per cent talc, if all the magnesia is used to form talc and dolomite. However, this leaves little silica to form chlorite and serpentine, which the microscopic study shows to be present. The high per cent of water also suggests that there must be considerable serpentine in the rock. Some of the silica and magnesia assigned to the talc in the above estimate must belong to the chlorite and serpentine, and, therefore, the percentage of talc as calculated from the two chemical analyses of the Wabigoon soapstone should be greater than the per cent estimated from the microscopic study. Since this is not the case, the samples analysed must have been of lower grade than the thin sections studied, or the estimated percentages of talc in the thin sections are too high.

Trap Lake Claims, Nos. K1194 and K1181

(Figure 9)

East of Trap lake the rocks are quartz porphyry, trachyte felsite, and sericite schists, with some fragmental pyroclastic material. These rocks represent metamorphosed acid lava flows and volcanic material. They are intruded by a large mass of granite to the west of Trap lake, and by a lens-shaped area of basic rock, which outcrops from the north side of Trap lake to a short distance beyond the north shore of Mile lake. Here, as at Wabigoon, the soapstone is associated with basic intrusives and the islands at the entrance of Trap lake from the north are entirely soapstone. Massive, coarse-grained, black hornblende gabbro outcrops on the side and top of the high hill north of the outlet of Trap lake. The surface of the gabbro outcropping on the east end of the large island west of the soapstone island weathers rough due to large, angular, and rounded lumps of hard, medium-grained gabbro in a black, fairly soft, fine-grained matrix. Mr. Thomson mentions and illustrates this rock on page 179 of his report. This peculiar type of gabbro and the gabbro on the hill north of the soapstone island are intruded by a number of white to slightly pink aplite dykes. These dykes have sharp contacts with the gabbro, are lens-shaped, are not over 2 feet wide, and cannot be traced over 15 feet along the strike. They may represent aplite dykes from the large granite mass immediately to the west, but it is more probable, as suggested by Thomson (page 180) that they represent acidic material concentrated from the gabbro magma during the late stage of its history.

The soapstone from the west end of the large soapstone island when examined under the microscope is seen to consist of bunches or nests of scaly talc surrounded or nearly surrounded by chlorite and possibly some serpentine. The soft, fine-grained, light greenish-grey, soapstone from the east end of this island consists almost entirely of talc, with minor bits of chlorite, magnetite, and dolomite. In the harder variety the chlorite and other minerals evidently act as a cementing material between the lumps of talc.

Massive soapstone outcrops on both the small islands which lie about 150 and 200 feet south of the south end of the large island. There is also an outcrop of soapstone about 30 feet long and 10 feet wide, on the main shore 550 feet north of the soapstone island. The contact between soapstone and basic rock to the north is fairly sharp, but the soapstone near the contact is hard. However, 5 feet south of the contact the material is typical, soft, greenish grey soapstone. Under the microscope a thin section of this rock along the basic rock and soapstone contact consists of talc, hornblende, serpentine, chlorite, with some epidote and magnetite. A thin section of gabbro from about 10 feet north of the contact contains some labradorite feldspar largely altered to zoisite and epidote, and abundant hornblende. This outcrop proves that the soapstone originated from the basic igneous rocks, but it is not certain whether the mineralogical composition of the rock from which the soapstone originated was the same as that of the comparatively unaltered hornblende gabbro nearby.

The soapstone on the large island is broken by fairly continuous joint-planes, along which there has been some movement, as is indicated by the slickensided surfaces and the slight schistosity of the soapstone along the joint-plane. Some of these joint-planes are filled with veins of white, flaky talc. As far as can be determined from the few exposures this soapstone is not jointed into small blocks, but the joints are 4 or 5 feet apart and are continuous. The outcrop on the east end of the soapstone island shows blocks of soapstone 6 to 8 feet square without sign of joint or crack. One or two outcrops were quite badly fractured and schistified, and, both here and at Wabigoon, there will be quite a per cent of waste material due to this fracturing.

Shortly after the Trap Lake deposit was staked two more outcrops of soapstone were discovered on Mile lake, which is one-half mile north of Trap lake. The first outcrop discovered was near the southeast corner of Mile lake and about 100 feet from the shore. As exposed by the trenching, completed before October, 1923, the soapstone outcrops as a lens-shaped mass about 30 feet wide and 50 feet long. This soapstone is mixed with hard, basic rock, but is of fairly good quality. It is greyish, medium-grained, and somewhat schistified and jointed. The intermixed basic rock will interfere with quarrying, but there is evidently quite a tonnage of fairly marketable material exposed at these workings.

The last soapstone outcrop discovered is directly north across Mile lake from the outcrop just described. No work had been done on this outcrop previous to October, 1923, and little is known about the deposit. The soapstone outcropping on the shore of the lake is massive and free from jointing. There are two outcrops back from the shore about 100 feet, and, here, the rock is slightly schistified. The soapstone apparently is of excellent quality, as the specimens broken from the surface with a hammer stood the temperature tests well.

Origin

Field and microscopic evidence indicate that the Wabigoon and Trap Lake soapstone deposits are similar in origin. The microscopic and chemical analyses indicate that the soapstone originated by the metamorphism of a basic type of igneous intrusive; but no trace of the minerals of this original rock or their texture was recognized in the thin sections examined. The chemical analyses of the Wabigoon soapstone suggest, however, that the original rock may have been similar to amphibole peridotite in composition, and an amphibole-rich gabbro outcrops adjacent to the soapstone both at Wabigoon and Trap lake. The abundant hornblende of this gabbro may be secondary after augite or some other pyroxene, though no evidence suggesting this was noted in any of the thin sections examined. It is doubtful whether the labradorite-rich hornblende gabbro outcropping on the hill north of the soapstone outcrop on Trap lake would alter to soapstone. Since the soapstone always outcrops along the edge or near the edge of the gabbro mass it is very probable that there were segregations of ferromagnesian-rich minerals at these places.

Rocks rich in magnesian minerals have been described from many localities as the original source of talc and soapstone, but the exact conditions under which the alteration took place are not well known. It is generally stated that the most favourable conditions for the formation of talc or soapstone seem to be a limited supply of water—not over rich in CO_2—circulating through a magnesia-rich rock when it is under dynamic stress; but it has been stated that surface waters under static conditions will also alter magnesia-rich minerals to talc.[1] If the Wabigoon and Trap Lake soapstone was formed by surface waters it was in pre-Glacial time, because the surface outcrops of soapstone are glacially polished and striated. In this area glacial erosion removed all the pre-Glacial weathered material. Also, the formation of talc in the Wabigoon and Trap Lake soapstone is closely associated in time with the formation of serpentine in the same rock, and serpentinization is considered a deep-seated process. At Wabigoon and Trap lake all the known evidence favours deep-seated conditions instead of surface conditions for the metamorphism of the basic intrusives into soapstone.

The talc of most large deposits is described as formed by chemical reactions between ascending hot solutions and magnesian silicates. In the case of the Wabigoon and Trap Lake deposit those solutions could have come either fron the granite magma, which probably intruded the gabbros, or from within the basic magma itself. If the solutions accompanied the intrusion of the granite, which outcrops in both cases some distance from the soapstone, they would be silica-rich and would have added silica to the rock, but chemical analyses of the soapstone show that it is silica poor. It seems more probable that the chemical reactions producing the soapstone were caused by residual solutions from within the gabbro magma, and that the alteration took place during the cooling of the magma. The few aplite dykes described cutting the gabbro, and thought to represent end phases of the basic magma, show that there were residual solutions within this magma.

Economic Possibilities

Soapstone blocks are in demand for lining the furnaces in the recovery system of Kraft pulp and paper mills, and, at present, a large percentage of the soapstone blocks used in such paper mills in Canada are imported from the Alberene deposits, Virginia. Reports of tests on blocks of the Wabigoon and Trap Lake soapstone indicate that it is as good, if not better, for this purpose than the Alberene stone. Both the Wabigoon

[1] Lindgren: "Mineral Deposits"; 2nd Edition, p. 394.

and Trap Lake deposits are well located with respect to rail transportation. The quarrying site at Wabigoon is good, but at Trap Lake water may give some trouble in deep quarrying, since the soapstone outcrops on an island and in no place is over 10 feet above the high-water level of the lake. Due to the complex jointing, there will be considerable waste material in quarrying. As far as is known the joints cutting the Trap Lake soapstone are fairly wide-spaced and the rock is massive and uniform, except for a slight variation in hardness from east to west. There is no information about the depth to which the soapstone may extend, but if the alteration took place under deep-seated conditions, as is believed to be the case, it may be expected to extend to considerable depth. The soapstone may change slightly in quality with depth, but there is no reason to believe that it will be either more or less jointed or schistified than it is at the surface. The size of the outcrop and the reported results of tests on blocks of the material sawed from the surface, indicate that there is available at these two localities a considerable tonnage of marketable soapstone.

Rainy River District

(6) PIPESTONE LAKE AND ROCK ISLAND BAY

Occurrences of soapstone in these localities are described by A. P. Coleman[1] as follows:

"There are several non-metallic minerals which will in all probability be of value at some time. Soapstone or steatite of fair quality is found at several points in the Keewatin schists, e.g., at Rock Island bay in Watten township, and near the northern end of Pipestone lake. Up to the present this material has been used only by the Indians for making pipes, which are often very ornamental. The mineral is pale greenish grey, fine grained, and shows scales of talc somewhat mixed with magnetite and dolomite. Little cubes of iron pyrites occur in some specimens. Pure foliated talc has not been observed in the region."

BUTTERMILK LAKE

Soapstone was observed in 1925 by T. L. Tanton on the west shore of Buttermilk lake, 14 miles west of Atikokan and about 4 miles northwest of Elizabeth station on the Canadian National railway. It occurs in zones up to 25 feet wide and 100 feet long in an altered basic igneous rock. It is schistose and includes crumpled dykes of aplite up to 6 inches wide, lying along its planes of schistosity.

Cochrane District

MATTAGAMI RIVER, NEAR MUSKOOTA BRANCH

Robert Bell[2] describes an occurrence of steatite on Mattagami river as follows: "On the Mattagami river, thirty chains below the junction of

[1] Coleman, A. P.: Ann. Rept., Ont. Bureau of Mines, vol. IV, p. 76 (1899).
[2] Geol. Surv., Canada, Rept. of Prog. 1875-76, p. 312; Ann. Rept., Ont. Bureau of Mines, vol. I, p. 81 (1891).

the Muskoota branch, there is an exposure of massive, grey, semi-crystalline steatitic rock, holding grains of specular iron and cut by small veins of whitish bitter-spar." It is uncertain whether steatite was used by Bell to describe a rock containing talc or merely a soft rock of talc-like character, but the association of dolomite with the steatite suggests that the rock actually contains talc, and, in that case, an extensive deposit of soapstone may be present in this locality.

Sudbury District

May Township

Mr. A. Dreany, president of the Spanish River Talc and Nickel Company, wrote Mr. Archibald Blue, of the Ontario Bureau of Mines, in 1896[1] that his company were soon to commence active mining operations on their talc property in the southeastern corner of May township. He stated that a shaft had been sunk 40 feet on the deposit and the vein, which was 2 feet wide at the top of the shaft, had widened to 11 feet in its bottom. About 75 tons of talc was then on the dump. Apparently the work proposed by Mr. Dreany was never undertaken, and since that time the property has never been examined by any of the officers of either the Department of Mines of Ontario, the Geological Survey, or Mines Branch, but according to information given W. H. Collins, the deposit is not talc, but a soft (probably sericitic) schist.

(7) PANACHE LAKE

"A vein-like body of soapstone is reported to occur on the north-east shore of Panache lake, not far east of the largest island. The material, which is exposed at the water's edge, is 2 or 3 feet wide and consists of soft, grey-green soapstone, locally used for making pencils for marking on stone, etc. The country rock on each side is Huronian quartzite."[2]

McKim Township

FROOD MINE

A. P. Coleman[3] in his report on the Sudbury Nickel region states: "The Frood mine, or No. 3, belonging to the Canadian Copper Company . . . . has been opened up by two large open pits and a shaft, and the ore is irregular in its occurrence and greatly mixed with rock matter, the large dump showing chiefly norite and greywacke, but also blocks of actinolite and talc, no doubt secondary products." Since Coleman makes no further reference to the mineral, it is probable that this occurrence is only of mineralogical interest.

[1] Ann. Rept., Ont. Bureau of Mines, vol. VI, p. 278 (1896).
[2] Collins, W. H.: personal communication.
[3] Ann. Rept., Ont. Bureau of Mines, vol. XIV, pt. III, p. 57 (1905).

Timiskaming District

WEST SHORE OF LAKE TIMISKAMING, ABOUT 4 MILES SOUTH OF MONTREAL RIVER

A. E. Barlow[1] with reference to the occurrence of talc in this region, says: "This mineral, usually a decomposition product of basic pyroxenic or hornblendic rocks, is not very commonly met with, but specimens were obtained of tolerably pure material from the west shore of Lake Timiskaming, about 4 miles south of the Montreal river." No additional information is given regarding the extent of the deposit, but the use of the word "specimens" seems to indicate that the occurrence is not commercially important.

Hastings County

Madoc Township

(8) CONCESSIONS IV AND V, LOTS 20 AND 21—ELDORADO

Previous Descriptions. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 31–2.

Location and History

This property lies 1½ miles northwest of Eldorado station on the Trenton-Maynooth branch of the Canadian National railway and adjacent to the east bank of Moira river. The buildings and principal mine workings are situated at the northwest corner of lot 20, concession V, Madoc township, but the mass of talc-dolomite schist which constitutes the deposit extends into lot 21, concession V, and lots 20 and 21, concession IV. Talc is said to have been discovered in this locality about the year 1908. Mining operations were not undertaken, however, until 1911, when William Hungerford purchased the mining rights to lot 20, concession V, from G. D. Gordon, the owner of the lot, and organized the Eldorado Talc and Silica Company to develop the deposit and build a mill. This company carried on operations until the end of 1913. In March, 1914, reorganization occurred and a new company known as Eldorite, Limited, took over the property and continued operations intermittently to September, 1916, when the mine and mill once more became idle. In February, 1919, a third company, the Eldorado Mining and Milling Company, acquired the property, but in November, 1920, operations were once more discontinued, and, since that time, have not been resumed.

Rock Formations

The bedrocks outcropping near the Eldorado deposit belong mainly to three groups: (1) dolomite, limestone-dolomite, and limestone belonging to the Grenville-Hastings series; (2) dykes of granite, intrusive in the Grenville-

[1] Geol. Surv., Canada, Ann. Rept., vol. X, p. 159 (1899).

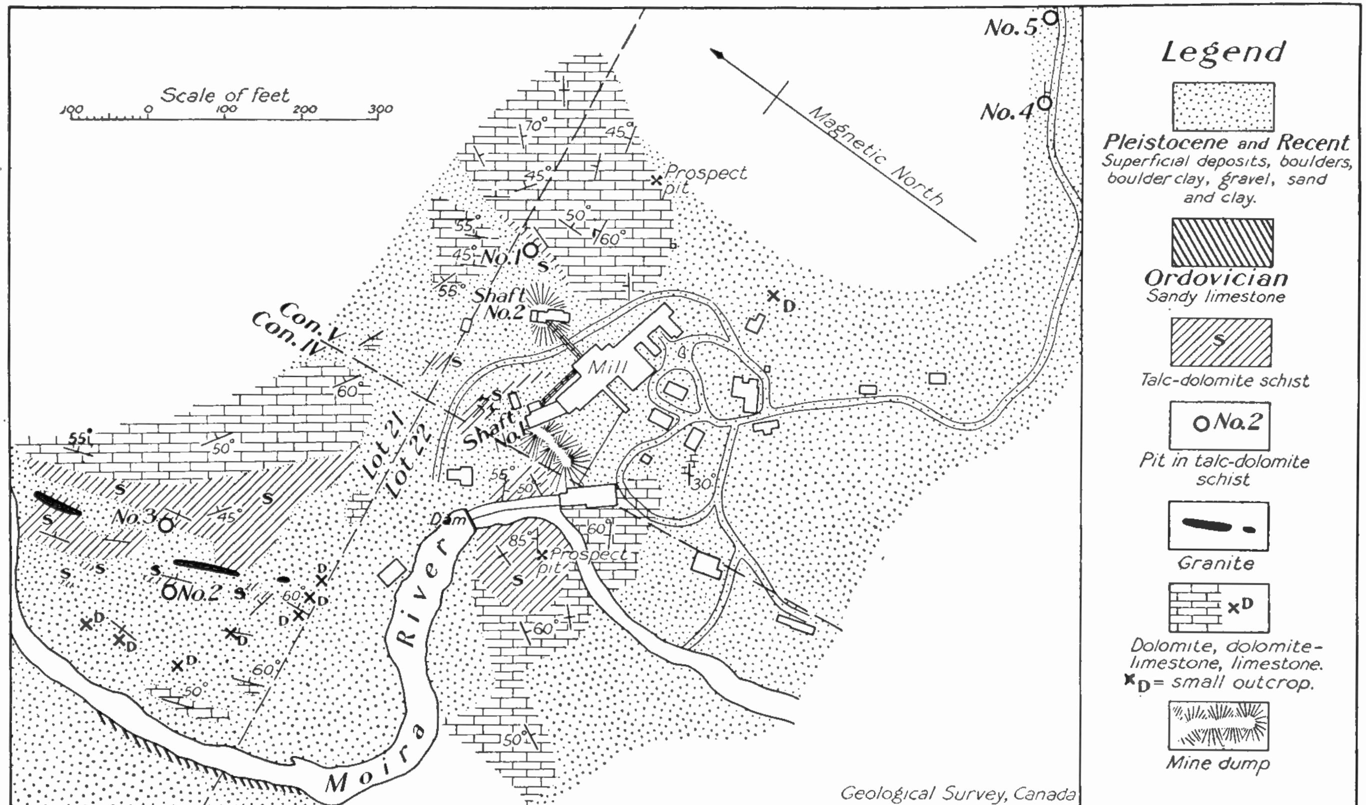

Figure 10. Talc-dolomite schist deposit, Eldorado property, lots 20 and 21, concessions IV and V, Madoc township, Hastings county, Ontario.

Hastings series; and (3) flat-bedded, sandy limestone of Palæozoic age. The dolomite of the Grenville-Hastings series is the dominant rock associated with the deposit, however (Figure 10). It is a white, cream-white, or pale pink, medium-grained, glistening rock of beautiful appearance, which weathers to a rusty-brown or buff colour (Plate III). It is generally characterized by banding or prominent partings or foliation, but locally may be quite massive. It usually contains numerous irregular aggregates, bands, lenses, or veinlets of quartz which in places constitute over half of the rock. The dolomite in the outcrop situated 100 feet north of No. 2 shaft (Figure 10) under the microscope was found to consist of granular dolomite and quartz intersected here and there by linear zones of micaceous talc. This relationship of the talc indicates that it has either been introduced into, or developed in, the dolomite and quartz along planes of fracture and is, therefore, not an original constituent of the rock. The mineral composition of this thin section was determined by A. H. Bell, using the planimeter method, and was found to be: talc 3·9 per cent, quartz 32·2 per cent, and dolomite 63·9 per cent. The limestone and limestone-dolomite of the Grenville-Hastings series outcrop in extensive areas in the region adjoining the Eldorado deposit, but were observed in only two localities close to the deposit—in the second ridge of dolomite northeast of the zone of talc-dolomite schist on lot 21, concession V, Madoc township, and in a zone in the area of dolomite outcropping west of Moira river, on lot 20, concession IV. The rock in the first locality is a dark grey type which, unlike the normal dolomite, effervesces to a considerable extent when treated with cold, strong, hydrochloric acid, and evidently contains some calcium carbonate as well as dolomite. It may, therefore, be called a limestone-dolomite. The rock in the second locality is also a grey type which appears brownish grey on its weathered surface, but effervesces freely when treated with strong hydrochloric acid, and is presumably limestone.

The dykes of granite that intrude the Grenville-Hastings series were observed in association with the Eldorado deposit only in lot 21, concession IV. Here, two separate northwesterly-trending masses, which may, however, be detached portions of the same dyke, are exposed, the northern of which is 10 feet wide and outcrops for 75 feet, and the southern 5 to 8 feet wide and outcrops for 150 feet. The granite composing the southern mass consists of phenocrysts of plagioclase having the optical properties of oligoclase enclosed in a fine, granular matrix of quartz, orthoclase, microcline, and biotite.

The sandy Palæozoic limestone can be seen along the west bank and in the bottom of Moira River channel, on lot 21, concession IV, when the water in the river is low. It consists of flat beds of grey to greenish grey limestone from 2 to 4 inches thick, in which numerous, coarse, angular grains of quartz and feldspar are included. The exposed thickness of the formation is about 1 foot.

Rock Structure

The principal structural feature exhibited by the rocks with which the Eldorado talc-dolomite schist deposit is associated are those resulting from deformation. Thus the Grenville dolomite, when examined under the microscope, is seen to be traversed by fracture zones filled with talc and the talc itself in some cases has been crumpled and broken (Figure 11). The dolomite, limestone-dolomite, and limestone, have also been highly folded into pitching-anticlines and synclines. This feature is especially

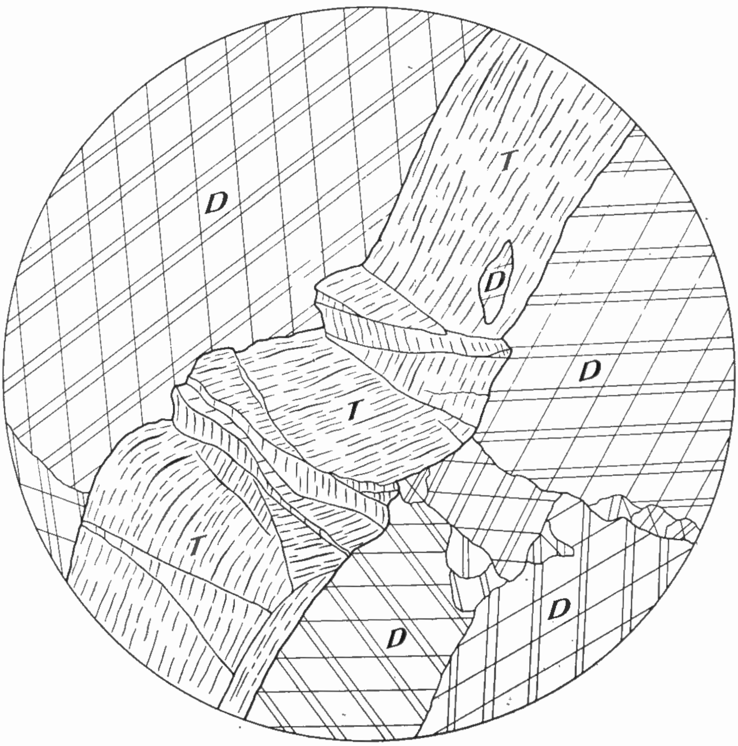

Figure 11. Camera-lucida drawing of thin section of dolomite occurring in lot 20, concession VI, Madoc township. D =dolomite, T =a flake of talc crumpled and transformed into minute foliæ. Magnification 13 diameters.

well shown in the outcrops of dolomite lying to the northeast of No. 2 shaft and in the talc-dolomite schist exposed on both sides of Moira river below the mill-dam. The trend of the folding in the Grenville sediments adjacent to the deposit is northeasterly at its southeast end and northwesterly at its northwest end.

General Character of Deposit

The principal mass of talc-dolomite schist exposed in the Eldorado property is that outcropping near the main workings at the northwest corner of lot 20, concession V, Madoc township, and extending westward and northward into the adjacent parts of lots 20 and 21, concession IV, and lot 21, concession V. A grey talc-dolomite schist is also exposed farther to the south on lot 20, concession V, in two pits (Nos. 4 and 5 (Figure 10)) adjoining the north side of the road leading to the mine.

The main mass of schist is not well exposed near No. 1 and No. 2 shafts, but can be seen in the underground workings, in the face of the pit (No. 1) that has been sunk about 100 feet east of shaft No. 2, and in pits (Nos.

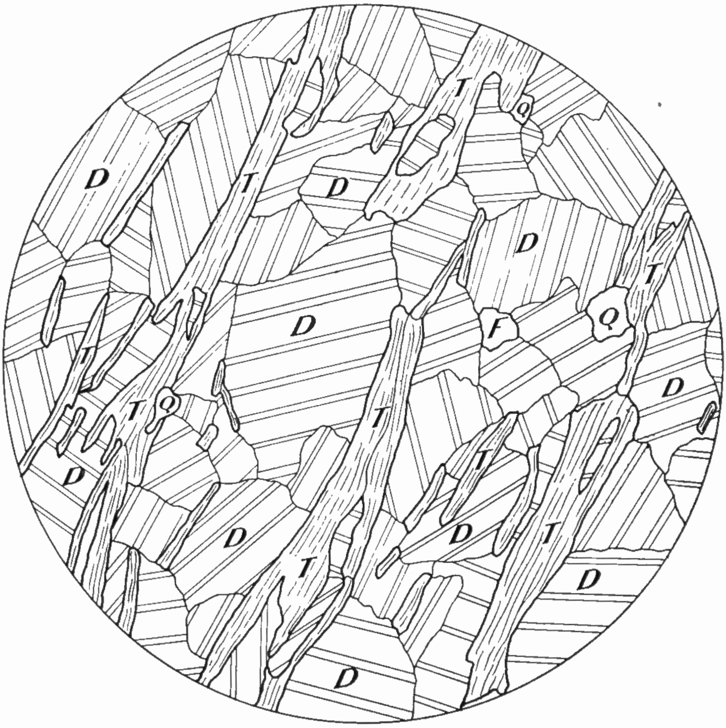

Figure 12. Camera-lucida drawing of thin section of talc-dolomite schist occurring in lots 20 and 21, concessions IV and V, Madoc township. T =talc, D =dolomite, Q =quartz, F =feldspar. Magnification 6·5 diameters.

2 and 3) and outcrops on lot 21, concession V. In all of these localities it is generally a fine-grained, cream-white, snow-white to pale grey schist which differs from the ordinary dolomite chiefly in its highly foliated character and in the greater abundance of glistening flakes of talc that it contains.

The only variations from the normal type of talc-dolomite schist observed in the deposit were some fragments of fine pink schist lying in the dumps from No. 1 and No. 2 shafts, which, when examined under the microscope, were seen to consist of parallel rods of tremolite, grains of quartz and feldspar elongated parallel to the foliation of the schist, a few, large, scattered grains of carbonate (presumably dolomite), and a few small cubes of pyrite. This rock, except for the presence of tremolite, is not greatly different in composition or texture from the dyke of granite associated with the schist, so that it probably belongs to a dyke of granite that has been converted into tremolite schist by the deformation to which it has been subjected.

A number of representative specimens of the talc-dolomite schist were examined under the microscope and were all found to consist of granular dolomite, a few scattered grains of quartz, and orthoclase, and zones of micaceous talc (Figure 12). In some sections the talc is deformed and at such points has been converted into minute folia (Figure 11), but elsewhere it occurs in large, clear flakes up to a millimetre and more in diameter.

The grey talc-dolomite schist exposed in pits Nos. 4 and 5 is a dark grey, graphitic schist exhibiting large flakes of talc here and there on its cleavage faces. The rock has been everywhere much deformed, and, in places, has been minutely crumpled, so that its cleavage surfaces exhibit fine, alternating ridges and depressions resembling the surface of a washboard (washboard structure). This rock, when examined microscopically, was found to consist of numerous, parallel, rod-like crystals of tremolite, grains of dolomite and quartz elongated parallel the foliation of the schist, large flakes of talc, fine specks of graphite distributed in aggregates and zones, and a few scattered cubes of pyrite. Its grey colour is due entirely to the graphite which, although present chiefly in aggregates and zones, occurs in fine specks fairly well disseminated throughout the whole rock. It was from this grey, tremolitic talc-dolomite schist that the special product known as "gratalc" was prepared by the Eldorado Mining and Milling Company, Limited.

Quantitative determinations of the mineralogical composition of six thin sections of the talc-dolomite schist by the planimeter method are included in the following table.[1]

—	I	II	III	IV	V	VI	Average
Quartz	0·5	2·7 }	7·0	1·9	1·4	2·2	2·7
Plagioclase	0·7	.... }					
Dolomite	45·5	90·1	81·0	79·1	78·9	89·1	77·3
Talc	53·4	7·2	12·2	19·0	19·4	8·7	20·0
Sulphides	....	....	....	....	0·3	....	
Total	100·1	100·0	100·2	100·0	100·0	100·0	100·0

The average of these determinations shows the schist to contain 20 per cent of talc.

[1] Determinations made by A. H. Bell.

In order to check these determinations, average samples of the talc-dolomite schist, piled in the No. 1 and No. 2 shaft houses, and of the graphitic tremolite-talc schist in pits Nos. 3 and 4, were submitted to the Mineralogical Division of the Geological Survey for partial analyses, the results of which are as follows:

—		I	II
Soluble	$CaCO_3$	34·93	17·34
	$MgCO_3$	33·00	19·98
	Fe_2O_3, Al_2O_3	0·65	1·90
	H_2O+ (above 110°C.)	1·28	2·15
	H_2O- (below 110°C.)	0·10	0·30
Insoluble		30·50	58·50
		100·46	100·17
Analyses of Insoluble Residue			
	SiO_2	68·51	69·96
	$Al_2O_3+Fe_2O_3$	2·07	3·90
	CaO	0·47	2·00
	MgO	23·31	16·39
	K_2O+Na_2O	1·59	4·18
	H_2O+	4·05	3·57
		100·00	100·00

I. Average sample of talc-dolomite schist in main deposit.[1]
II. Average sample of graphitic tremolite talc-dolomite schist in pits Nos. 4 and 5.[1]

In connexion with the analyses of the talc-dolomite schist (No. I) it may be noted: (1) that microscopic examination of six thin sections of this rock showed dolomite and talc to be the only magnesia-bearing minerals present and, since dolomite is soluble and talc insoluble, it may be assumed that the magnesia present in the insoluble residue is derived entirely from the talc; and (2) that, since pure talc contains 31·7 per cent of magnesia, it may be calculated that the 23·31 per cent of magnesia in the insoluble residue is equivalent to 22·4 per cent of talc in the talc-dolomite schist. Since the sample taken for analysis represented an average of many tons of the schist, whereas the thin sections examined represented an average of only six specimens, it is probable that the 22·4 per cent calculated from the analyses is more nearly correct than the 20 per cent obtained from the thin sections examined.

In the case of the graphitic tremolite-talc-dolomite schist (analysis No. II), tremolite, another magnesia-bearing insoluble mineral, is present. It cannot be assumed, therefore, that all the magnesia found in the insoluble residue was derived from talc. However, if all the magnesia were in talc, the graphitic tremolitic schist would contain 28·7 per cent of that mineral. It can be concluded, therefore, that the graphitic schist cannot carry more, and probably carries considerably less, than 28·7 per cent talc.

[1] Analyses by M. F. Connor.

Form and Extent of Deposit

Owing to the great complexity in the structure of the talc-dolomite schist deposit, its poorly exposed condition, and the inaccessibility of the underground workings when the writer examined the property in 1921, the form of the deposit as a whole could not be positively determined ; but, at some points at least, its structure is fairly evident. Thus, on lot 21, concession IV, the schist evidently occurs in a northwesterly-trending belt about 150 feet wide, dipping northeastward conformably with the adjoining dolomite. Near pit No. 1, at the extreme east end of the mass, on the other hand, the schist forms an anticline pitching northeastward. The abrupt change in the structural trend of the dolomite adjoining the deposit from northwesterly at the western end of the deposit to northeasterly at its southern part, also indicates that it occurs at the crest of a fold, so that it is probable that the mass is, in the main, anticlinal in form and pitches eastward.

The approximate superficial extent of the talc-dolomite schist, as indicated by the outcrops shown in Figure 10, is 120,000 square feet, but all of this area cannot be classified as talc schist of the quality found in the workings in lot 20, concession V, for in places, notably on the top of the hill in lot 21, concession IV, highly quartzose masses occur in the schist. Nevertheless, even if one-fourth of the total area of talc-dolomite schist shown in Figure 10 be deducted as too low in talc content to be classified as talc schist, nearly 1,500,000 tons of schist would still be present on the property above the depth of 200 feet[1] to which the underground workings have been sunk.

The grey, graphitic talc-tremolite-dolomite schist is exposed only in the faces of pits 4 and 5, where it can be seen for a width of 20 feet at right angles to the strike. It is probable, therefore, since the strike of the schist in both pits is about parallel to the road, that there is a continuous zone of this material 20 feet or more wide extending from pit No. 4 to pit No. 5, a distance of over 100 feet.

Origin

The origin of the talc deposits of Madoc district is discussed at considerable length in Chapter III. It need, therefore, be merely stated here that from the evidence there presented it is concluded that the Eldorado deposit was formed by reaction with the dolomite of siliceous emanations from intrusive granite. That emanations from the granite penetrated the dolomite in a most intimate manner is indicated not only by the occurrence of the talc in the dolomite as previously described, but by the presence of feldspar intimately disseminated through the dolomite and by the occurrence in places of numerous quartz veins cutting the dolomite (Plate III).

Development Work and Equipment

Except for a few small prospect pits (Nos. 1 to 5), none of which is more than 10 feet deep, all the development work in the Eldorado property

[1] Assuming 12 cubic feet of schist=1 ton.

has been performed from two shafts about 210 feet apart; No. 1 inclined 75 degrees to the west (north 80 degrees west, magnetic) and No. 2 inclined 75 degrees to the northwest (north 30 degrees west, magnetic). These shafts are connected at a depth of 65 feet by a succession of large openings up to 60 feet in diameter formed in mining the talc-dolomite schist (Figure 13). At 200 feet the shafts are connected by a drift, which has been extended 30 feet to the southwest of shaft No. 1 and 160 feet to the northeast of shaft No. 2. At the time the property closed down in 1920 no mining had been attempted at this level except that performed in driving the drift and crosscuts as shown in Figure 13.

The equipment on the property when the mine was last operated included two mills of the air-flotation type, one for treating the white

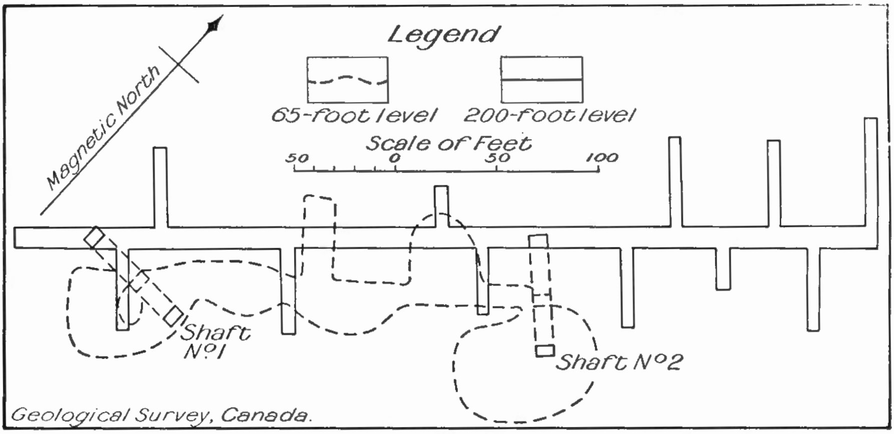

Figure 13. Plan of 65 and 200-foot levels, Eldorado mine, lot 20, concession VI, Madoc township, Hastings county, Ontario.

talc-dolomite schist and the other for the graphitic schist ("gratalc"); engine and boilers; a waterpower plant on Moira river; camp buildings and all the machinery necessary for operating on the scale of about 50 tons a day. Since closing down, a part of the machinery in the mill has been removed.

Economic Possibilities

Three possible ways of operation may be considered in endeavouring to determine the future commercial possibilities of the Eldorado talc-dolomite schist. (1) Recovery of the talc by concentration. All operations up to the present seem to have been carried on with the object of recovering as much as possible of the talc and disposing of the ground residue, consisting mainly of dolomite, as a by-product. If it be assumed that practically all the talc contained in the schist can be recovered by concentration nearly 5 tons of schist would have to be mined and milled for every ton of talc produced. Since the highest price paid for ground talc at Madoc is about $15 per ton, the maximum return that could be obtained would be $3 for every ton of schist mined. This would be increased, of course, by whatever sum might be obtained for the ground dolomite residue, but so far as known to the writer there is at present no market for such a by-product.

(2) Disposal of the talc-dolomite schist in ground form without concentration. It may be possible that the schist could be ground for use in the manufacture of roofing paper. It contains at least 20 per cent of talc and the dolomite is itself remarkably resistant to weathering agencies, as shown by the way in which it stands up in ridges wherever it occurs in Madoc district. Experimental tests would be required to determine its serviceability for this or similar purposes, but if it can be used in this way there is an immense quantity of the material available which could be mined and ground very cheaply.

(3) Possible discovery of a zone or zones of high-grade talc in the talc-dolomite schist. It is also possible that a zone or zones of pure talc sufficiently large to be workable are present within the talc-dolomite schist, although none was observed either in the surface openings or in the underground workings. Whether they are present in other parts of the mass can be determined only by diamond drilling or other development work. If the deposit should prove workable in the manner outlined under (2), any such zone or zones that might be present would be discovered in the ordinary course of mining operations.

CONCESSION V, LOT II, SEYMOUR MINE

Small quantities of steatite, "an earthy variety of talc," were observed by Harrington in specimens from the Seymour iron mine.[1] The occurrence is evidently only of mineralogical interest.

(9) CONCESSION XI, LOT 15

A zone of impure talc-dolomite schist 5 feet wide is exposed in a prospect pit 10 feet square and 5 feet deep on the slope of a rocky ridge situated a few hundred feet east of the farm house on this lot. The foliation in the schist is uniform along the east wall of the opening, but elsewhere is irregular. This deposit, like those in Elzevir township to the eastward, is an alteration zone in the greenstone lava flows of the Grenville series that form an extended area along the boundary between Madoc and Elzevir townships. The continuation of the zone to the south is drift covered, but it is absent in a bare outcrop lying transversely across the strike of the zone 200 feet to the north.

[1] Harrington, B. J.: "Notes on the Iron Ores of Canada and Their Development"; Geol. Surv., Canada, Rept. of Prog. 1872-74, pp. 204-5.

Mayo Township

CONCESSION X

Specimens of fine, compact, white to pale grey talc were shown the writer by Mr. Donald Henderson, of Madoc, which he stated he had obtained from a deposit on the Baker and Wannamaker lot, near Hartsmere, concession X (A of some maps), Mayo township. The talc occurs in a zone up to 18 inches wide on the margin of a diorite dyke and can be seen at intervals for 200 feet.

Huntingdon Township

(10) HENDERSON MINE

Previous Descriptions. DeKalb, C. D.: "Mines of Eastern Ontario"; Ann. Rept., Ont. Bureau of Mines, vol. X, p. 130 (1901).

Miller, W. G., and Knight, C. W.: "The Precambrian Geology of Southeastern Ontario"; Ann. Rept., Ont. Bureau of Mines, vol. XXII, pt. II, pp. 113–114 (1914).

Ladoo, R. B.: "Talc Mining at Madoc, Ontario"; Reports of Investigations U.S. Bureau of Mines, Sept., 1920.

Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 25–31.

The most extensive deposit of talc so far discovered in Madoc district occurs in lot 14, concession XIV, Huntingdon township, the property of Henderson Mines, Limited. It is situated less than one-quarter mile east of Madoc village, on the southeast slope and beneath a rock knob that stands up prominently near the north shore of Moira lake. The distance from the mine to Madoc station, the terminus of the Belleville-Madoc branch of the Canadian National railway, is 1½ miles in a direct line or 2 miles by road.

The discovery of talc in this locality is said to have been made about forty-five years ago by a member of the Henderson family while ploughing, but no attempt was made to open up the deposit until 1896. In that year Jas. E. Harrison purchased the mining rights to the property (subject to royalty) from Christopher Henderson, and sold these rights to the A. H. Robbins Mining Company, of New York, which, under Harrison's management, immediately commenced mining operations on the deposit. Harrison continued mining and shipping talc from 1896 to 1900, taking out about 200 tons of talc a year during this period. During 1901 the property was idle, but in 1902 Christopher Henderson, by arrangement with the A. H. Robbins Mining Company, reopened the mine and operated it until June, 1904, when it was once more closed down. In March, 1905, Cross and Wellington of Madoc, by contract with the A. H. Robbins Mining Company, took over the operation of the mine, and, with the exception of the winters of 1906 and 1907, operated the property continuously to 1918 when the George H. Gillespie Company, of Madoc, purchased the interests of the A. H. Robbins Mining Company, and Cross and Wellington, in the property, and formed a new company known as Henderson Mines, Limited, which has continued operations since that time.

Geology

The rocks with which the talc deposit is associated belong to three groups: (1) metamorphosed sediments of Precambrian age belonging to

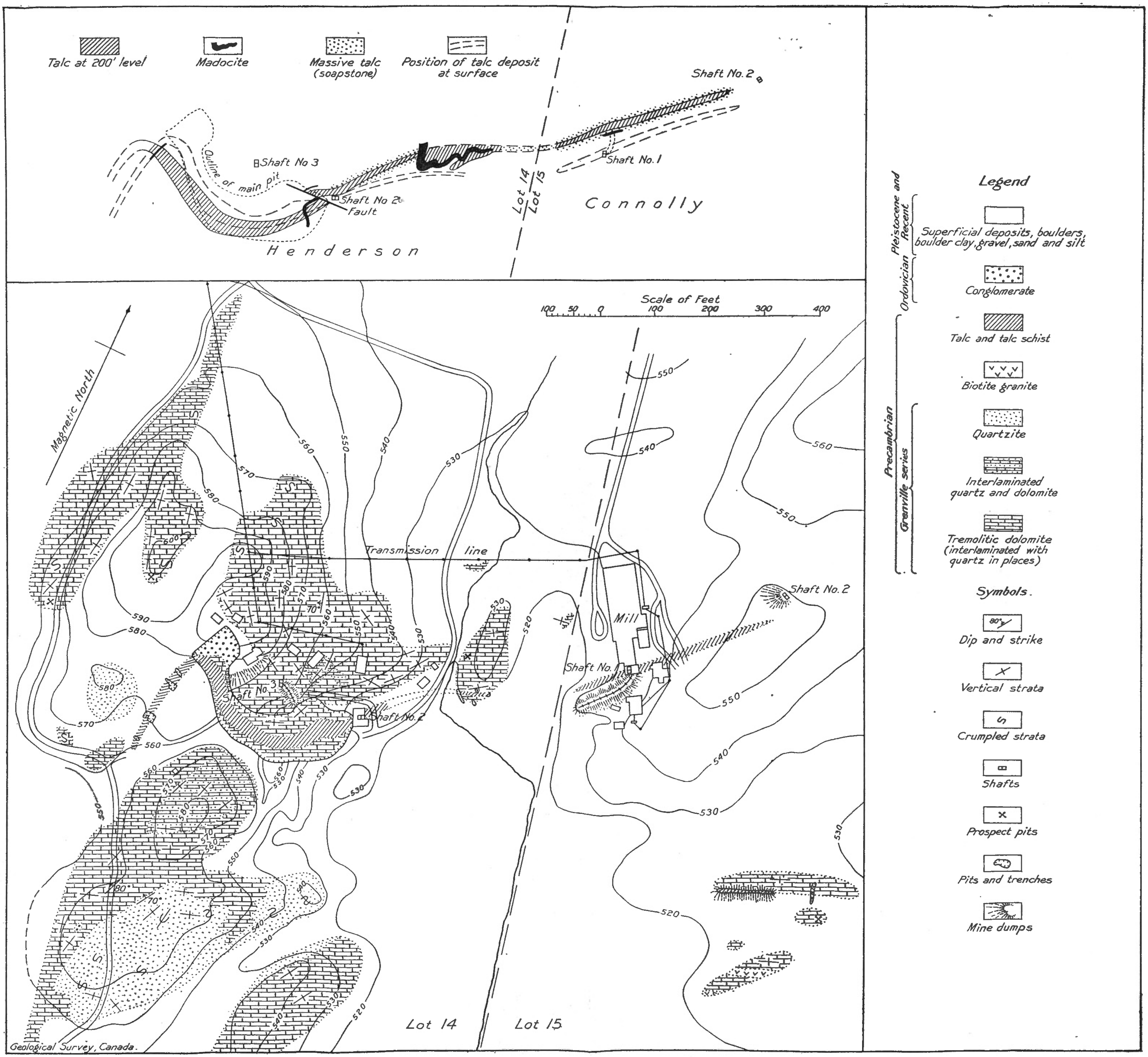

Figure 14. Talc deposits, lots 14 and 15 concession XIV, Huntingdon township, Hastings county, Ontario.

the Grenville-Hastings series; (2) dykes of madocite, a rock composed mainly of brown tourmaline, which have not been observed at the surface but have been cut in the underground workings; and (3) remnants of basal Palæozoic conglomerate resting unconformably on the Grenville-Hastings sediments.

Grenville-Hastings Series

The sediments belonging to the Grenville-Hastings series exposed near the talc deposit (Figure 14) consist of: (1) tremolitic dolomite; (2) interlaminated quartz and tremolitic dolomite; and (3) quartzite. The areas of these subdivisions are not fully shown in Figure 14, however, for numerous masses of interlaminated quartz and dolomite, and quartzite only a few feet in diameter, which are too small to be shown on this scale, occur here and there in the tremolitic dolomite. It is probable that these masses were originally parts of continuous beds which have been crumpled or broken into their present form.

Tremolitic Dolomite. The tremolitic dolomite is a grey to buff weathering rock consisting almost entirely of tremolite and dolomite that outcrops extensively in a northeasterly trending belt adjoining the Henderson and Connolly talc mines. The tremolite occurs partly as scattered, rod-like crystals or aggregates of crystals, and partly in solid masses or bands. Owing to the insolubility of tremolite relative to dolomite these masses and bands form prominent knobs and ridges on the weathered surface of the rock (Plate V). Where freshly broken the tremolitic dolomite is a blue-grey to snow-white rock in which the presence of the tremolite is revealed merely by the reflections from its cleavage surfaces. The various phases of the tremolitic dolomite examined under the microscope were found to consist, for the most part, either of granular dolomite, or of rods of tremolite scattered through a dolomite matrix. In a thin section of a specimen of tremolite collected from the dump of the new (No. 3) shaft the tremolite was observed to be traversed by fine, irregular fractures filled with talc, a relationship indicating that the talc is an alteration product of the tremolite. In another thin section from a tremolitic aggregate in the limestone, however, the aggregate was found to consist of large, frayed out flakes of talc enclosed in a tremolite matrix, a relationship suggesting that the talc is an original constituent of the rock. A specimen of the tremolitic dolomite from the Henderson mine, collected by Miller and Knight, was found on partial analysis to have the following composition.[1]

It seems evident from this analysis that the tremolitic dolomite in places at least contains some calcite, and may, therefore, be more properly described as a limestone-dolomite.

—	Per cent		Per cent	
CaO	29·29	equivalent to	dolomite	71·52
MgO	15·53		calcite	16·97
CO_2	43·67			
Insoluble	4·62			

[1]Miller, W. G., and Knight, C. W.: "The Precambrian Geology of Southeastern Ontario"; Ann. Rept., Ont. Bureau of Mines, vol. XXII, pt. II, p. 63 (1914).

On the dump from the No. 3 shaft the tremolitic dolomite is seen in dark grey and white phases, the grey phase occurring as inclusions within the white (Plate VIII). Partial analyses of samples of these were made by G. P. Connell, of the Mines Branch, with the following result.

—	Grey phase	White phase
	Per cent	Per cent
CaO	31·21	25·15
MgO	21·60	15·70
Insoluble residue	0·60	23·04

In both of these samples the ratio of magnesia to lime is about that of dolomite. The only difference between them, other than their colour, therefore, is the large proportion of insoluble tremolite in the white phase. This brecciation, accompanied by the development of tremolite, occurred in the wall-rock adjoining the talc deposit and probably took place when the talc deposit was being formed.

Interlaminated Quartz and Tremolitic Dolomite. This member of the Grenville-Hastings series consists of irregular zones of quartz from $\frac{1}{32}$ to $\frac{1}{4}$ of an inch wide, alternating with similar zones of tremolitic dolomite. On the weathered surface of the rock the quartz (Plate IV) forms an irregular prominence, whereas the tremolitic dolomite underlies depressions. Thin sections examined under the microscope were found to consist of grains of quartz averaging about 0·25 mm. in diameter, in which irregular zones of granular dolomite and fine rods of tremolite were included. This interlaminated quartz and tremolitic dolomite was thought at one time to be of organic origin and was named along with other similar structures in the Grenville sediments *Eozoon canadense.*[1] In this case, however, the so-called Eozoon is probably finely interstratified quartz and dolomite in which the lamination owing to recrystallization and deformation has become somewhat irregular.

Quartzite. The quartzite exposed on the Henderson property occurs chiefly on the wooded rocky knob that lies a few hundred feet to the south of the main pit (Figure 14). It consists of white quartz in beds from $\frac{1}{2}$-inch to 3 inches in width and has been crumpled into S-shaped folds (Plate IX).

Madocite. The talc deposit on the Henderson property is intersected at a number of points in the underground workings by dykes of a fine-grained, dark rock consisting chiefly of fine, needle-like crystals of black tourmaline. The dykes range in width from 2 feet to 20 feet and have been greatly crumpled (Figure 15). They generally have a zone of fine amber mica along their margin, the foliation in which lies parallel to the

[1] Logan, W. E.: "On the Occurrence of Organic Remains in the Laurentian Rocks of Canada"; Quart. Jour., Geol. Soc., Lond., vol. 2, pp. 45-50 (1865); Can. Nat., vol. 2, pp. 92-99 (1865); Am. Jour. Sci., vol. 37, pp. 272-3 (1864). "On New Specimens of Eozoon," Can. Nat., vol. 3, pp. 306-311 (1868).
Dawson, J. W.: "On the Structure of Certain Organic Remains in the Laurentian Limestones of Canada"; Quart. Jour. Geol. Soc., Lond., vol. 21, pp. 51-59 (1865); Can. Nat., vol. 2, pp. 99-111 (1865). "On Eozoon Canadense," Can. Nat., vol. 3, pp. 312-321 (1868).

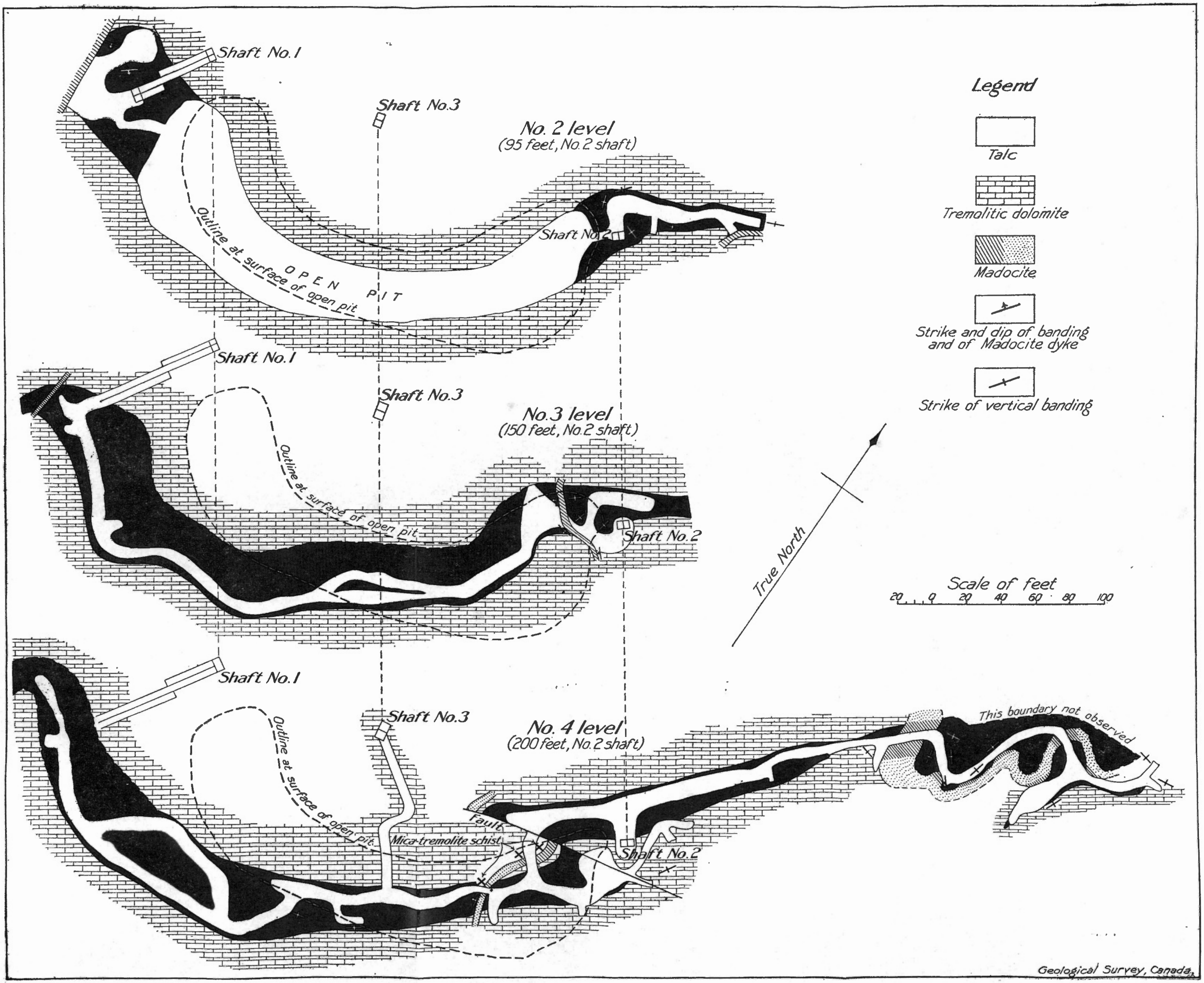

Figure 15. Plans of Nos. 2, 3, and 4 levels, Henderson mine, Huntingdon township, Hastings county, Ontario.

wall of the dyke. When examined under the microscope the rock was seen to consist chiefly of zoned crystals of deep brown tourmaline, the interspaces between which are filled with colourless tremolite. The only other constituent observed is pyrite, which occurs here and there in cubes and irregular grains. The mineralogical composition of this rock differs somewhat from any similar rock that has been previously described, but most closely resembles a rock found as boulders near the village of Luxullian, in Cornwall, England, and hence known as luxullianite.[1] It differs from the luxullianite of Cornwall in that it contains, in addition to brown tourmaline, tremolite and pyrite, whereas the additional constituents in luxullianite are quartz, orthoclase feldspar, and acicular blue tourmaline.[2] Because of its unusual character it has been given a new name—madocite.

Palæozoic Conglomerate. This rock is exposed near the Henderson mine in two localities (Figure 14). The larger area, that situated at the north end of the main pit (near the former site of the No. 1 shaft) was laid bare in 1922 by stripping operations. Prior to this there was an outcrop about 100 feet southwest of the new opening, but this is now covered by a dump of earth. The smaller area is a small remnant a few feet in diameter that outcrops about 500 feet southwest of the main pit. The conglomerate consists of angular pebbles of quartz in a matrix of calcareous sandstone or sandy limestone, and occurs as a thin veneer generally not over a few feet thick resting on the Precambrian. This relationship shows that its outcrops are basal remnants of the Palæozoic sediments which at one time covered the whole region, but which have since been removed by erosion.

Structural Features

The rocks associated with the Henderson talc deposit have been intricately folded, a feature that is especially well shown in the outcrops of tremolitic dolomite that lie to the north and northwest of the main pit, in the quartzite composing the southern part of the ridge southwest of the main pit, and in the madocite dykes exposed in the underground workings. In the tremolitic dolomite the beds and the bands of tremolite which lie parallel to the beds and which stand up conspicuously on the weathered surface have been crumpled into small, S-shaped folds, which in turn are superimposed on the limbs of still larger folds of the same type (Figure 14). In the quartzite the beds, which are well developed, are folded in the same intricate manner as the tremolitic dolomite (Plate IX). The madocite dykes appear to have been intruded partly parallel and partly transverse to the bedding of the dolomite and evidently before the dolomite was deformed, for they have been intensely crumpled (Figure 15). It may be mentioned in this connexion that the talc was also deformed (Plate X) as explained in the description of the deposit that follows.

[1] Pisani, M. F.: Compte Rendu, vol. 59, p. 913 (1864).
Flett, J. S.: Mems. of the Geol. Surv. of Great Britain, No. 347, p. 66 (1890).
[2] Bonney, T. G.: "On the Microscopic Structure of Luxullianite"; Min. Mag., vol. I, pp. 214–221 (1877).

General Character

The deposit consists for the most part of snow-white, cream-white, or pale grey, flaky to micaceous talc, but in places—especially along the walls and at the extremities of the mass—the talc is massive and deep grey, or even resinous brown. The principal impurities are lenticular aggregates of calcite and dolomite, scattered crystals of pyrite, and a few prismatic crystals of tremolite. The flakes of talc range in size from mere specks to sheets ½-inch or more in diameter in the more micaceous varieties. The pyrite crystals are generally small, but here and there individuals up to ¾ inch in diameter are present; they are most abundant in the massive, grey phases of the deposit.

Examination of the talc under the microscope shows it to be composed of two main varieties, a fine, fibrous type in which the individual fibres are not more than 1 mm. long, and a coarse, micaceous type consisting of plates ½-inch or more in diameter. The fine, massive, grey talc consists entirely either of a felt of fine, fibrous talc, or of frayed-out flakes of talc included in a matrix of fine, fibrous talc. The coarse, flaky to micaceous phases of the talc consist chiefly of frayed-out flakes having a roughly parallel arrangement, but in some sections transverse crystals up to ¼ mm. in diameter and 1 mm. or more in length are present. Many of these are partly transformed into the fine, fibrous type of talc, the foliation trending either obliquely or transverse to the longer direction of the crystal. The talc in all these sections is much bent and broken and has evidently been subjected to intense deformation.

Analyses of Talc, Henderson Mine

—	I	II	III	IV
SiO	52·02	53·92		
Al_2O_3	2·00	0·32		
Fe_2O_3	0·18	none		
FeO		0·36		
CaO	6·01	5·02		
MgO	27·83	29·63		
CO_2	7·34	5·51	9·61	4·92
H_2O+	4·20	5·05		
H_2O-	0·24			
Total	99·82	99·81		

I. Ground talc from Henderson mine. Analysis given the writer by George H. Gillespie.
II. Crude talc from Henderson mine. Sample collected by H. S. Spence. Analysis by A. Sadler, Mines Branch.
III. Determination of carbon dioxide in ground talc from Henderson mine. Analysis by A. Sadler, Mines Branch.
IV. Determination of carbon dioxide in a selected specimen of crude talc, Henderson mine. Analysis by A. Sadler, Mines Branch.

It is evident from analyses I and II that the principal impurities in the talc are a fraction of a per cent of iron resulting from the presence of pyrite, and calcite shown in the analyses by lime and carbon dioxide. With the exception of the calcite the talc is practically pure. The carbon dioxide was determined in samples III and IV for the purpose of ascertaining whether by sorting the crude talc a pure product could be obtained, but the presence of 4·92 per cent of carbon dioxide in the selected specimen indicates that the calcite is too intimately mingled with the talc to be eliminated by cobbing. Some purchasers object to the presence of calcite (calcium carbonate) in ground talc, but it is doubtful whether it is really as objectionable for most of the purposes for which ground talc is used as seems to be assumed. In the manufacture of toilet preparations, for example, the calcite in the Madoc talc is pure white, chemically inert, and not very hard, so that it is objectionable only because it lacks the soft, foliated character of the talc. That the Madoc talc, despite the calcite that it contains, makes a fair quality of talcum powder, is shown by the large amounts that have been consumed for this purpose for many years. However, to meet the objection to the presence of calcite, separation tests have been carried on in the laboratories of the School of Mines, Queens University, Kingston, Ontario, and a process evolved that it is believed will remove the calcite at a cost that is not commercially prohibitive. It is proposed to construct an experimental mill at Madoc with a capacity of 5 tons a day, for the purpose of perfecting this process. If it is found commercially practicable to remove the calcite, the product that would result would probably be superior, not only in purity but in most of the other qualities that make talc useful, to that produced anywhere else in the world.

Form, Extent, and Origin

The Henderson talc deposit, wherever its relationships are exposed, conforms to the structure of the enclosing tremolitic dolomite and hence, since the dolomite has been intensely crumpled, the talc mass has been similarly deformed. At the surface it has a form somewhat resembling an interrogation mark lying with its top to the west (Figure 14 and Plate X). Down to 200 feet, the depth to which the property has been developed, the deposit dips toward the south at its west end and toward the north at its east end, so that it has roughly the form of the blades of a propellor (Figure 14). At the 200-foot level, the deposit is interrupted about 50 feet west of No. 2 shaft by an overthrust fault, and at its east end is much crumpled as shown by the crenulations in the madocite dyke (Figure 15). The fault, which has an horizontal displacement of about 50 feet at the 200-foot level, appears to fade out rapidly upwards and in the upper levels and at the surface is indicated merely by an open fold.

The boundaries fixed for talc deposits of the Henderson type vary to some extent according to the type of material that is classed as talc, for in places, especially on the margins of the deposit, there is material which is not white and flaky and which is not regarded as a part of the deposit, but which when examined under the microscope is seen to consist entirely of talc. The known length of the deposit measured in a straight line is about 700 feet, but following its crenulations, about 900 feet. Its width ranges from a few feet to 65 feet. Its average width for its whole length is about 30 feet. The deposit has so far been proved to extend to a depth of 200 feet, but, since it is of deep-seated origin, it probably continues to considerably greater depth.

The origin of the deposit is discussed at considerable length in Chapter III. It is believed to have been formed by the silication of the dolomite through the action of solutions emanating from the Moira batholith of granite that outcrops on the north shore of Moira lake a few hundred feet to the south, and that the openings now occupied by the madocite dykes were probably the channels along which these emanations ascended from the granite.

Economic Possibilities

There are four factors involved in a discussion of the economic possibilities of the Henderson property: (1) the reserves of talc remaining above the 200-foot level, (2) the possible reserves of talc below the 200-foot level, (3) the possibility of discovering an extension of the deposit to the westward, and (4) the possibility of finding other deposits on the property.

(1) In the main pit the talc mass has been almost entirely removed down to the 200-foot level, except near No. 2 and No. 1 shafts (now caved in at the surface) and east and west of these points where a large part of the talc remains.

(2) No talc has yet (September, 1924) been mined below the 200-foot level, but the deposit down to this point has not changed in extent or character, and since, as pointed out in Chapter III, it is closely associated with the madocite dykes, there is no apparent geological reason why the talc should not extend to the same depth as the madocite. It is probable, therefore, that the factor limiting operations at depth will not be the depletion of the deposit but the increase in cost of mining.

(3) The talc exposed in the pits opened in 1922 at the extreme west end of the talc mass is an impure phase, but it is uncertain whether this material lies on the direct continuation of the deposit or on its margin, so that it has not yet been positively determined that the end of the talc mass on the west has been reached. If it continues westward the structure in the outcrops of the dolomite at this point indicates that it will curve around to the northwest following roughly the contour of the hill.

(4) It is possible, of course, that talc masses or zones separate from the main mass are present in the property, especially beneath drift-covered depressions, but with the exception of a few zones less than an inch in width no other deposits have so far been found. The existence of other extensive deposits can be determined only by development work, and so long as the main mass remains undepleted such exploration would scarcely be justified.

(11) CONCESSION XIV, LOT 15, WEST HALF, CONNOLLY MINE

Previous Descriptions. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 30–31.

This property adjoins the Henderson on the east (Figure 14). The main deposit, which is evidently the continuation of that on the Henderson, did not outcrop and was discovered by Donald Henderson and Chesley Pitt in 1911 by sinking pits in the drift to bedrock. In 1912 Henderson and Pitt sold their option to Henry Hungerford, who, on behalf of the Hungerford Syndicate, carried on development work from the autumn of 1912 to the spring of 1913. During this time a shaft was sunk 65 feet and drifts projected along the deposit 45 feet to the southwest and 25 feet to the northeast. The mine then remained idle until May, 1915, when it was acquired by the Anglo-American Talc Corporation, and since that time it has been practically in continuous operation. In 1921 the Asbestos Pulp Company became the owners of the property.

Geology

The bedrock near the main deposit is completely covered by glacial drift. Information regarding the rocks on the property is, therefore, confined to that obtained from outlying outcrops and from the rocks cut in the underground workings. The rocks so far discovered include dolomite and tremolitic dolomite belonging to the Grenville-Hastings series, granite and madocite.

There are four localities on the property in which the rocks of the Grenville-Hastings series can be seen: the dump from the No. 1 shaft, the dump from No. 2 shaft, several outcrops near pit No. 1, and a rock area near pit No. 2 at the east line of the property (not shown in Figure 14). The material in the dump from No. 1 shaft is that derived from the south and north crosscuts (Figure 16). It consists mainly of white, tremolitic dolomite, which in places passes into a rock almost entirely composed of acicular crystals of tremolite ranging from minute needles to rods ½-inch or more in diameter and in colour from white or pale grey to yellow-green or honey-yellow (Plate XIII). Other less common rocks are masses of fine amber mica containing pyrite, and a black or grey, graphitic tremolite-dolomite. The rock in the dump from No. 2 shaft is mainly a cream-white, light grey or dark grey, banded dolomite stained red in places. This red coloration as seen in the shaft occurs adjacent to a fracture zone filled with greenish-grey gouge in which numerous red or pink scalenohedral crystals of calcite are embedded. The dolomite in the other outcrops on the property is a buff or rusty weathering grey to cream-white or pink variety in which zones of rusty tremolitic schist are included in places.

The granite is a fine-grained pink variety which occurs in twoi rregular, broken, and poorly defined zones to the south of pit No. 1 (Figure 14). At the east margin of the larger zone some irregular aggregates and veins of quartz up to 6 inches wide are exposed in a small prospect pit. A specimen of quartz carrying gold was shown the writer by Mr. Connolly, which he stated was obtained from this opening, but an average sample of the quartz assayed by A. Sadler, of the Mines Branch, contained no gold. These granite zones are evidently connected with the large batholith outcropping in the islands and on the north shore of Moira lake, a few hundred feet to the south.

Madocite was observed in the Connolly property on the third level at the entrance to the south crosscut, and at the fourth level on the east wall of the crosscut connecting the shaft with the talc deposit. Specimens of those collected from the rock dump when examined under the microscope were found to contain an abundance of brown tourmaline, but the tremolite seen in the dykes on the Henderson is replaced by phlogopite and carbonate. In two of them, plagioclase having the optical properties of albite was present. Since tremolite and phlogopite are minerals of the contact metamorphic type, whereas tourmaline, albite, and pyrite are minerals that normally belong to igneous rocks, it seems probable that the mineralogical composition of the madocite varies according to the amount of dolomite wall-rock it has absorbed, the tourmaline, albite, and pyrite being original constituents and the tremolite and phlogopite being reaction products with the wall-rock.

Character and Origin of Deposits

There are three talc deposits in the Connolly property, that on which the main workings occur and those exposed in pits Nos. 1 and 2. The main deposit is a lenticular mass about 400 feet long and from 5 to 25 feet wide. Its average width is about 15 feet. It dips about 75 degrees to the north. Like that on the Henderson, it consists chiefly of white, flaky talc schist, with hard, grey talc in places along its margin. Except for masses near the No. 1 shaft, and west of the No. 1 shaft, most of the talc has been mined down to the third level (188 feet), and mining is now being carried on from the fourth level (248 feet). Pits 1 and 2, in which the other deposits occur, are prospect openings, the former about 100 feet long, 10 feet wide, and 8 feet deep, and the latter 10 feet square and 10 feet deep. The deposit in pit No. 1 is a grey talc schist (Figure 14). The bottom of the pit is now partly hidden by debris, but, judging from the width of the opening, the schist zone is from 2 to 8 feet wide and extends nearly the whole length of the pit. The deposit in pit No. 2 (not shown in Figure 14) is a grey to green talc-tremolite schist dipping 80 degrees to the north. It is 3 feet wide in the east face of the pit. The wall-rock is dolomite traversed by thin seams of talc.

The talc deposits on the Connolly property, as explained more fully in Chapter III, are believed to have been formed by the interaction of siliceous emanations derived from the Moira batholith of granite which lies a few hundred feet south of the deposit with the dolomite. It is also probable in the case of the main deposit that the opening now occupied by madocite was the main channel along which these emanations ascended.

Equipment and Development

The equipment on the property includes a mill for grinding the talc, compressors, motors, hoists, boilers, a hoist house, a compressor house, a boiler house, an office, and all the necessary equipment for carrying on mining operations on the scale of 25 tons a day. The development work performed up to September, 1923, includes prospect pits Nos. 1 and 2, and two shafts, No. 1, 248 feet and No. 2 about 220 feet deep. From level No. 3 a crosscut has been driven 130 feet to the south and from the sublevel between levels 2 and 3 a crosscut 219 feet to the north (Figure 16).

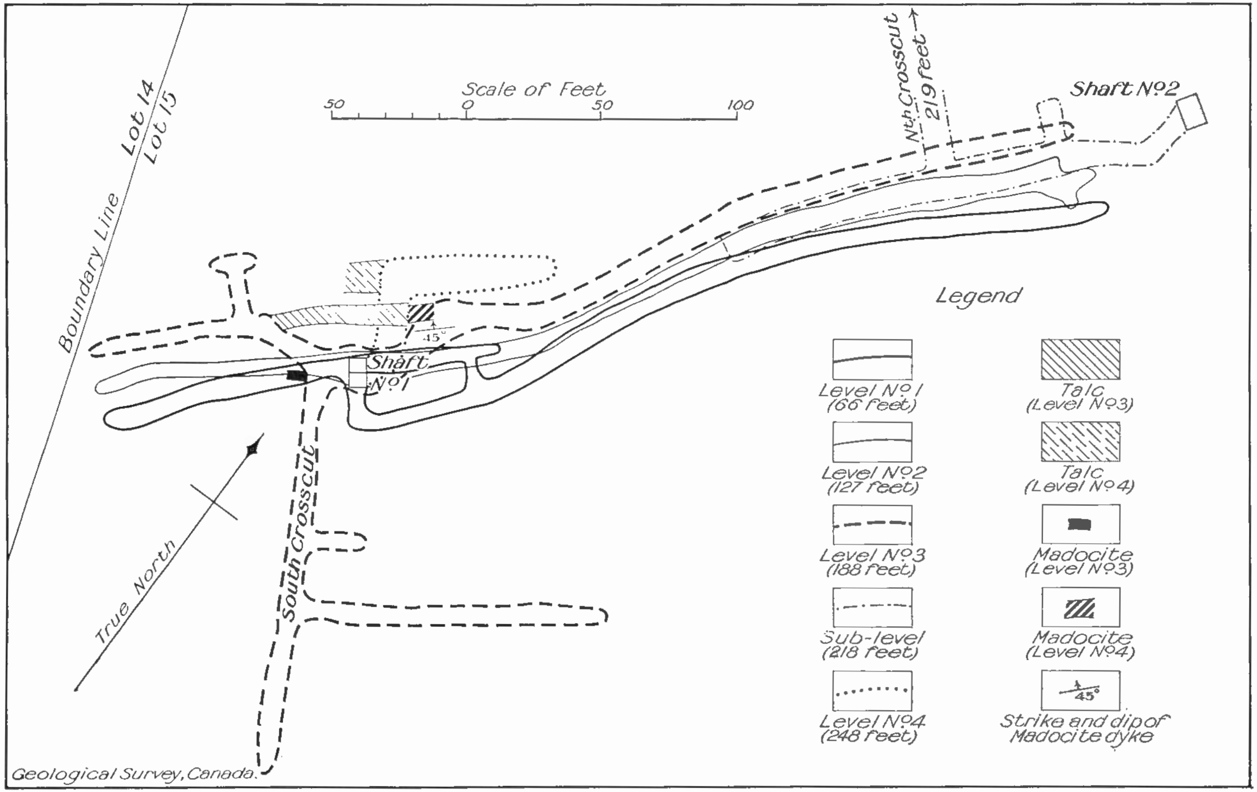

Figure 16. Plan of workings, Connolly mine, west half of lot 15, concession XIV, Huntingdon township, Hastings county, Ontario.

Economic Possibilities

As in the case of the Henderson property there are three obvious ways in which operations on the Connolly property might be continued: (1) to search for other zones of talc that may parallel the main deposit, (2) to search for a possible continuation of the main deposit to the eastward, and (3) to continue development of the main deposit at depth.

There are no outcrops on the property north of the main deposit, and the nearest outcrops to the south are those near pit No. 1 (*See* Figure 14). The only parallel deposit exposed at the surface, therefore, is that in pit No. 1. This deposit, however, is dark coloured and impure and not comparable to the talc of the main deposit. It might be used for the manufacture of low-grade talc, provided a market for material of this class were available. Since the bedrock surface elsewhere is deeply covered, the most practicable method of exploration is by diamond drilling or by crosscutting from the main workings. It is said that some diamond-drill holes were put down to the northwest of pit No. 1 several years ago, but the writer has no information regarding the material cut in these holes. In 1922, a crosscut was driven 130 feet south from the No. 1 shaft. In this some leads of flaky talc schist up to 6 inches wide and some zones of hard talc several feet wide were cut (Figure 16). During the winter of 1922-23, a crosscut was driven 219 feet north from the 218-foot sublevel. This was not accessible when the writer examined the property in 1923. It was stated, however, that a zone of grey talc 5 feet wide was cut, but no workable leads of high-grade talc were found. These crosscuts indicate that there are no extensive parallel zones of high-grade talc adjacent to the main deposit.

It is shown in Figure 14 that the talc deposits in the Henderson and Connolly properties lie almost in line with one another and only 60 feet apart. It seems certain, therefore, that they are parts of a single zone of talc. It may be possible that other parts of the zone occur on the Connolly to the east of the main lens. If such a deposit is present it probably lies to the south rather than to the north of the main deposit, for the folds and the fault in the western part of the zone all tend to bend or displace the deposit to the south of the points where its normal northeasterly trend would carry it. The occurrence of talc schist in pit No. 2 and in the openings on the east half of the lot to the southeast of the Connolly lot also lends some support to this possibility.

The main deposit on the Connolly has been followed to a depth of 248 feet and at this point has a width of 16 feet. There is, therefore, no indication that the deposit is changing in character or decreasing in extent down to the limit of the present workings. Furthermore, since the deposit as shown in Chapter III is associated with madocite dykes, there is no evident reason why it should not continue to the same depth as the madocite, so that except for some unforeseen accidental interruption, it is probable that the depth to which mining is carried on the deposit will be fixed by the cost of operations rather than the working out of the deposit.

(12) CONCESSION XIV, LOT 15, EAST HALF

This half-lot adjoins the Connolly property on the east and is owned by the Asbestos Pulp Company, to which the Connolly now belongs. There are two openings in the property, an old pit lying 40 feet northeast of the No. 2 pit on the Connolly and a new shaft 45 feet deep sunk in 1922 by the Asbestos Pulp Company. The first pit is 15 feet long by 10 feet wide and 25 feet deep, in which a zone of cream-white to grey talc schist 2 to 5 feet wide is exposed along the southeast wall. The schist zone trends north 40 degrees east magnetic and dips 75 degrees northwest. The wall-rock is dolomite similar to that seen on the Henderson and Connolly properties. The cream-white phase of the schist zone, except for small lenses of dolomite, is composed of high-grade flake talc, but this constitutes a very small part of the deposits, the greater part of the zone consisting of grey, hard, impure talc with flake talc developed only on the foliation planes.

The new shaft is situated about 140 feet east of the west boundary of the lot and 100 feet east of the old pit. It has been put down on a zone or zones of talc schist which lie about 15 feet southeast of, and parallel to, the talc schist zone in the old pit. This deposit consists chiefly of alternating zones of white, flaky, micaceous talc and white or grey dolomite. A few thin zones of grey to green talc schists are also present. The zones of white talc range from a few inches to 2 or even 3 feet in width, but contain numerous inclusions of dolomite up to a foot or more in diameter. The most persistent zone lies along the southeast wall of the shaft. The dolomite is traversed by numerous seams of talc. A northwesterly trending vertical fissure in which grey or smoke-coloured crystals of calcite encrusted with pyrite were observed extends diagonally down the north and south walls of the shaft. The talc zone as exposed in the shaft is too much broken and contains too many inclusions to be workable. The presence of high-grade talc similar to that composing the main deposits on the Henderson and Connolly properties indicates, however, that a more extensive deposit free from inclusions may be present on the continuation of the zone or nearby.

(13) CONCESSION XIV, LOT 16

Previous Descriptions. Ann. Rept., Ont. Bureau of Mines, vol. XIX, pt. 1, pp. 155–6 (1919).
Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 51.

Prospecting operations were carried on in this lot by the International Pulp Company, of Gouverneur, New York, from August, 1917, to July, 1919. Three shafts were sunk, No. 1, a few hundred feet south of the buildings on the Arthur Pitt farm, No. 2 close to the west boundary of the lot and about 700 feet from its northwest corner, and No. 3 on the Chesley Pitt farm about 70 feet northeast of shaft No. 1. There are no rock outcrops near any of these shafts and they are now, with the exception of No. 3, completely filled with water, so that the writer's observations consisted chiefly in examining the materials on the rock dumps adjoining the shafts.

Shaft No. 1 is inclined about 70 degrees to the west and is 50 feet deep. A drift extends 80 feet northeast from the bottom of the shaft, and a crosscut 50 feet southeast from a point in the drift 30 feet from the shaft. The rock on the dump consists of grey to rusty brown mica schist, dolomite, limestone, massive talc, and siliceous talc schist. The mica schist occurred in the shaft, the dolomite and limestone in the drift, and the talc and talc schist in the crosscut.[1]

Shaft No. 2 is said to be 60 feet deep. From its bottom a crosscut extends 100 feet north and drifts for about 10 feet to the east and west. The rocks on the dump consist chiefly of fine, dark grey, talcose, tremolitic schist and a light grey, tremolitic dolomite. The minerals observed were arsenopyrite in numerous, fine, rod-like crystals embedded in tremolitic schist and a coarse, micaceous porphyry, pyrrhotite, pyrite, fine phlogopite (amber mica), quartz, and tremolite in radial aggregates. Fragments of coarse, white to grey, talc schist, some of which is similar to that in the main zone in the Henderson and Connolly properties, were seen in the dumps, but the amount of this material is small.

Shaft No. 3 is about 25 feet deep, with a drift 5 feet towards the northeast at its bottom. The material exposed in the shaft and on the dump is a grey to white talc schist containing lenticular inclusions of quartz. It resembles the talc schist seen on the dump of shaft No. 1 and is presumably the continuation of the same zone. It strikes north 70 degrees east magnetic. According to Mr. Chesley Pitt, two diamond-drill holes, one 70 feet deep and inclined 60 degrees to the north, and the other 60 feet deep, and inclined 60 degrees to the south, were put down from a point about 35 feet south of shaft No. 3. The writer has no information regarding the material cut in these holes.

Grimsthorpe Township

(14) CONCESSION V, LOT 9

Previous Descriptions. Adams, F. D., and Barlow, A. E.: Geol. Surv., Canada, Mem. 6, p. 369 (1910).

This deposit is situated about one-half mile northwest of an abandoned log road that follows Black river and Indian creek diagonally across the southeast corner of Grimsthorpe township. It lies 5 miles northeast of Lingham's flat and 11 miles northeast of Cooper post office. The deposit is a vertical northwesterly trending vein of translucent lamellar talc (Plate XIV) 10 to 14 inches wide, exposed in the bottom of an opening 1 to 4 feet wide and 3 feet deep that has been excavated in the front of a southeastward-facing rock scarp 12 feet high. Except for an aggregate of coarsely crystalline dolomite in the middle of the vein at one point, the deposit consists entirely of talc, the foliæ of which, in places, extend the whole width of the vein. The rock cut by the vein is a fine-grained, hard, greenish grey type which under the microscope is seen to consist almost entirely of serpentine and scattered aggregates of carbonate.

[1] Information given by Mr. Chesley Pitt.

Three hundred feet northeast of this occurrence a second pit 2 to 4 feet wide and 1 to 3 feet deep has been opened up in the same rock face in a zone of fibrous actinolite 2 to 4 inches wide that cuts transversely across a zone of coarse, pale green amphibolite. The amphibolite zone has an exposed width of 5 feet, trends north 70 degrees east, and dips 70 degrees southeast.

This deposit, although, as exposed, of too small extent to be workable, is of interest because it consists of the foliated variety of talc that generally occurs in veins cutting soapstone or less pure deposits of talc; because it contains nickel, and because of its exceptional purity as shown by the following analysis.[1]

	Per cent
SiO_2	60·45
Al_2O_3	0·27
Fe_2O_3	0·78
FeO	2·04
NiO	0·50
CaO	0·16
MgO	29·84
H_2O at 100°C	0·32
H_2O above 100°C	5·42
	99·78

It is probable that this talc is related in origin either to the serpentine in which it occurs or to a related highly magnesian rock underlying the depression to the southeast of the deposit. In most localities where talc of this type is associated with serpentine, the serpentine has been transformed to soapstone where the vein occurs, but in this case the soapstone is absent, so that the talc has apparently been formed directly from the serpentine. It is possible, however, that soapstone underlies the depression to the southeast of the deposit and the vein has been derived from this source. If this be the case, the vein probably widens towards the southeast.

Elzevir Township

CONCESSION I, LOT 27, AND CONCESSION II, LOT 13

The occurrence of talc in these two lots is mentioned in the early reports of the Geological Survey.[2] The writer did not see any deposits of talc in them, but since they are occupied either entirely or in part by Grenville volcanics, it is probable that the material referred to is similar to that seen in association with the altered volcanics in other localities.

(15) CONCESSION III, LOT 10

Near the middle of this lot a lenticular mass of soapstone 120 by 160 feet in area was observed by F. L. Finley, who assisted the writer in 1922 and 1923. The rock presents a peculiar pitted appearance on its weathered surface, probably due to the easy solubility of the dolomite that it contains.

[1] Wait, F. G.: Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R (1896).

[2] "Catalogue of Some of the Economic Minerals and Deposits of Canada"; Geol. Surv., Canada, Rept. of Prog. 1849-50, p. 110. "Geology of Canada, 1863," p. 469.

(15) CONCESSION III, LOT 11

About 100 feet from the southeast corner of this lot a small opening, 5 feet square and 2 feet deep, has been made in a zone of irregularly foliated talcose dolomite 15 to 20 feet wide and having an exposed length of 150 feet. The strike of the zone is north 70 degrees west magnetic and the dip 60 degrees southwest. Another outcrop of the same material occurs on the road side 100 feet to the northwest, so that the zone is at least several hundred feet long. This deposit is an alteration zone in greenstone lava flows of the Grenville series and has probably originated, as explained more fully in Chapter III, through the metamorphic action of the intrusive batholith of granite that occurs about ½ mile to the northeastward.

(16) CONCESSION VI, LOT 5; CONCESSION VII, LOTS 4 AND 5

The deposits in these lots (Figure 17) lie near one another, are similar in character and origin, and can, therefore, be described together. They consist chiefly of zones of talc-dolomite schist in altered basic lava flows belonging to the Grenville series. They lie in an embayment in the contact of the greenstone with an extensive batholithic mass of intrusive granite. Their abundance at this point suggests that the transformation of the basic lavas to talc and dolomite was brought about by the metamorphic action of this intrusive. The deposits were originally opened by Joseph James, of Actinolite (formerly Bridgewater) in 1883, for use in the manufacture of roofing material, and were worked by him at intervals from that time to 1908, when they were purchased by the Actinolite Mining Company, Limited. A grinding mill was built at Actinolite by the new owners, but this, except for a few weeks each year, has been idle since that time. The material from these deposits has been generally described as actinolite, but talc is by far the most abundant constituent.

Concession VI, Lot 5. There are three pits in this lot, all of which are in a rock mass situated at its east end about 700 feet north of the Flinton road. A small creek adjoins the outcrop on the south. Pit No. 1 is an irregular opening 20 feet long, 15 feet wide, and 5 to 15 feet deep. Pit No. 2 is 25 feet long, 20 feet wide, and 10 feet deep; and pit No. 3, 25 feet long, 5 feet wide, and 5 feet deep. The rock exposed in each of these is talc-dolomite schist. All exposures in the ridge, 50 feet wide, in which the pits occur, consist of this material.

Concession VII, Lot 4. There are three openings in this lot, all at its west end, and 600 to 700 feet south of the Flinton road. The greenstone exposed next the deposits is a fine-grained variety which under the microscope was seen to consist almost entirely of serpentine. The main pit (No. 1, Figure 17) is an east-west trending opening 120 feet long, 50 feet wide, and 5 to 20 feet deep, extending diagonally across a northeasterly-trending rock ridge.

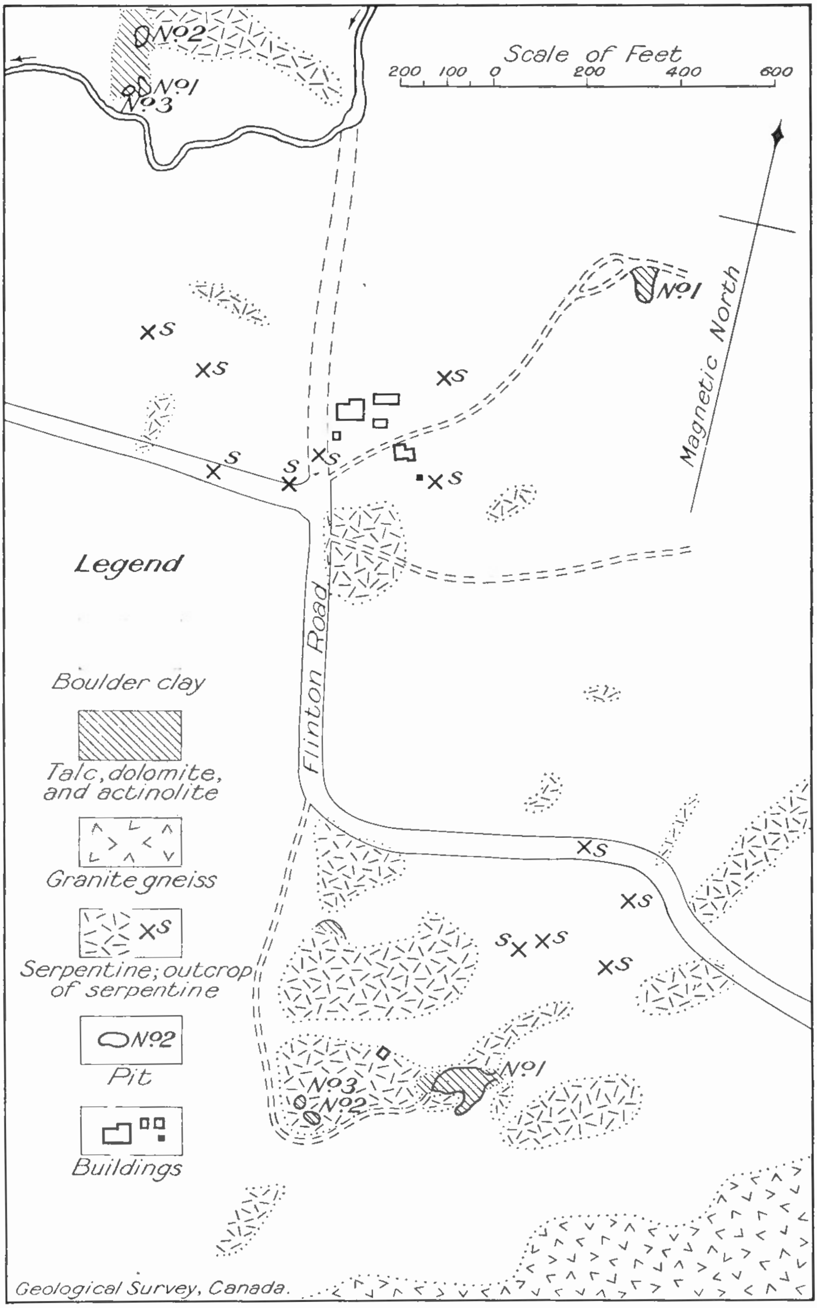

Figure 17. Talc deposits, lots 4 and 5, concessions VI and VII, Elzevir township, Hastings county, Ontario.

Most of the pit is now filled with water and all that can be seen of the deposit is a zone about 10 feet wide at its west end. At this point a carbonated greenstone schist, including zones of coarse flake talc up to 3 inches wide and zones of dolomite up to 6 inches wide, is exposed. The main mass of the deposit, as indicated by the scattered fragments thrown out in blasting, is talc-dolomite schist which under the microscope is seen to consist of talc, carbonate—presumably dolomite—serpentine, and disseminated grains of magnetite. Some pieces of this material are cut by veins of lamellar talc up to 4 inches wide. About 300 feet west of the main pit there are two prospect openings: No. 2, an irregular pit 25 feet long, 4 to 15 feet wide, and 10 feet deep; and No. 3, 15 feet long, 10 feet wide, and 5 feet deep. The greenstone is much less altered in these pits than in the main opening.

Concession VII, Lot 5. There is only one pit in this lot, an opening 60 feet long, 25 to 40 feet wide, and 5 to 15 feet deep, in a small, drift-covered knob situated northeast of the farm buildings on the lot and about 800 feet northeast from the corner, on the Flinton road, where it turns south along the line between concessions VI and VII. The rock exposed in the pit is chiefly talc-dolomite schist stained red with iron oxide in places. The strike of the schist is north 10 degrees west magnetic and the dip 60 degrees west. In places, especially on the east face of the pit, actinolite in fibres up to a foot long occurs in veins cutting the schist and in zones along planes of movement. The rock has been much faulted and broken, as shown by the presence of numerous striated and slickensided surfaces on the pit faces.

Lennox and Addington County

(17) Kaladar Township

CONCESSION V, LOT 2

Several prospect pits for talc have been opened in this lot. In one of these, zones of soapstone and talc schist from 1 inch to 1 foot wide, separated by dolomite containing radial aggregates of tremolite, were observed by H. D. Squires, who assisted the writer during the field season of 1924. The pit in which the talc was seen is situated near the west end of the lot and is 12 feet long, 10 feet wide, and 10 feet deep. The total width of talc is 2 feet. The strike of the talc zones and the dolomite is north 28 degrees east and the dip 63 degrees southeast.

Lanark County

Lavant Township

CONCESSION III, LOT 24, EAST HALF

Some prospect pits were opened and a diamond-drill hole 120 feet deep put down in this lot several years ago by T. B. Caldwell, of Perth, in prospecting for talc. The rock on the property, according to H. S. Spence, is a serpentinized dolomite in which little talc is present.[1]

[1] "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 32–33.

Leeds County

RIDEAU LAKE, GRINDSTONE ISLAND

There is a pit on this island, 150 feet long, 50 to 80 feet wide, and 18 to 20 feet deep, in serpentinized pyroxenic limestone. This material has been described as talc, but it consists almost entirely of fine, massive, green serpentine. It was worked at intervals from about 1885 to 1889. The serpentine was shipped by scow to Montreal, where it was ground for use in the manufacture of roofing material.

QUEBEC

Témiscamingue County

The occurrence of steatite on an island in Quinze river, and on the east and west shores of lake Opasatika, is mentioned by W. McOuat,[1] but these are merely zones of soft chlorite schist in the altered volcanics of the Abitibi group (Keewatin).[2]

Ungava

A number of localities in Ungava, or New Quebec, where soapstone or steatite occur, are mentioned by Bell and Low. It is uncertain, however, whether these occurrences contain talc. The principal data regarding each deposit are as follows:

Locality	Character of deposit	Reference
Mosquito bay, east coast of Hudson bay	Grey soapstone used by Indians. Locality not seen	Geol. Surv., Canada, Rept. of Prog. 1877–78, pt. C, pp. 23–24
Vicinity of Skynner cove, Nickvale inlet, Labrador coast	"A kind of soapstone" used by Eskimo for making pots	Geol. Surv., Canada, Rept. of Prog. 1882–4, pt. DD, p. 15
Koksoak river, 13 miles below inlet of Larch river	Light, pearly schist containing mica and steatite, 35 feet thick	Low, A. P.: Geol. Surv., Canada, Ann. Rept., vol. IX, pt. L, p. 35 (1898)
Kettlestone Knob, east coast Hudson bay	Steatite schist in altered diorite used by Eskimos for lamps and kettles	Low, A. P.: Geol. Surv., Canada, Ann. Rept., vol. XIII, pt. D, p. 55 (1903)

Argenteuil County

Grenville Township

RANGE II, LOT 27

On the north side of the road that follows the north shore of Ottawa river about 1 mile east of Pointe au Chene a pit, 25 feet long, 15 feet wide, and 15 feet deep, has been excavated on the hill-slope in altered crystalline limestone, which has been described as soapstone or steatite.[3] An examination of the deposit showed, however, that it consists of deep green serpentine, pale amber mica, and white or grey pyroxene in masses up to 2 feet in diameter, enclosed in a matrix of dolomite and disseminated grains of serpentine. No talc was seen.

[1] "Report on an Examination of the Country between Lake Temiskaming and Abitibi"; Geol. Surv., Canada, Rept. of Prog. 1872–73, pp. 117, 122, 132.
[2] Wilson, M. E.: "Kewagama Lake Map-area"; Geol. Surv., Canada, Mem. 39, p. 61 (1913).
[3] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. XII, pt. J, p. 37 (1902).

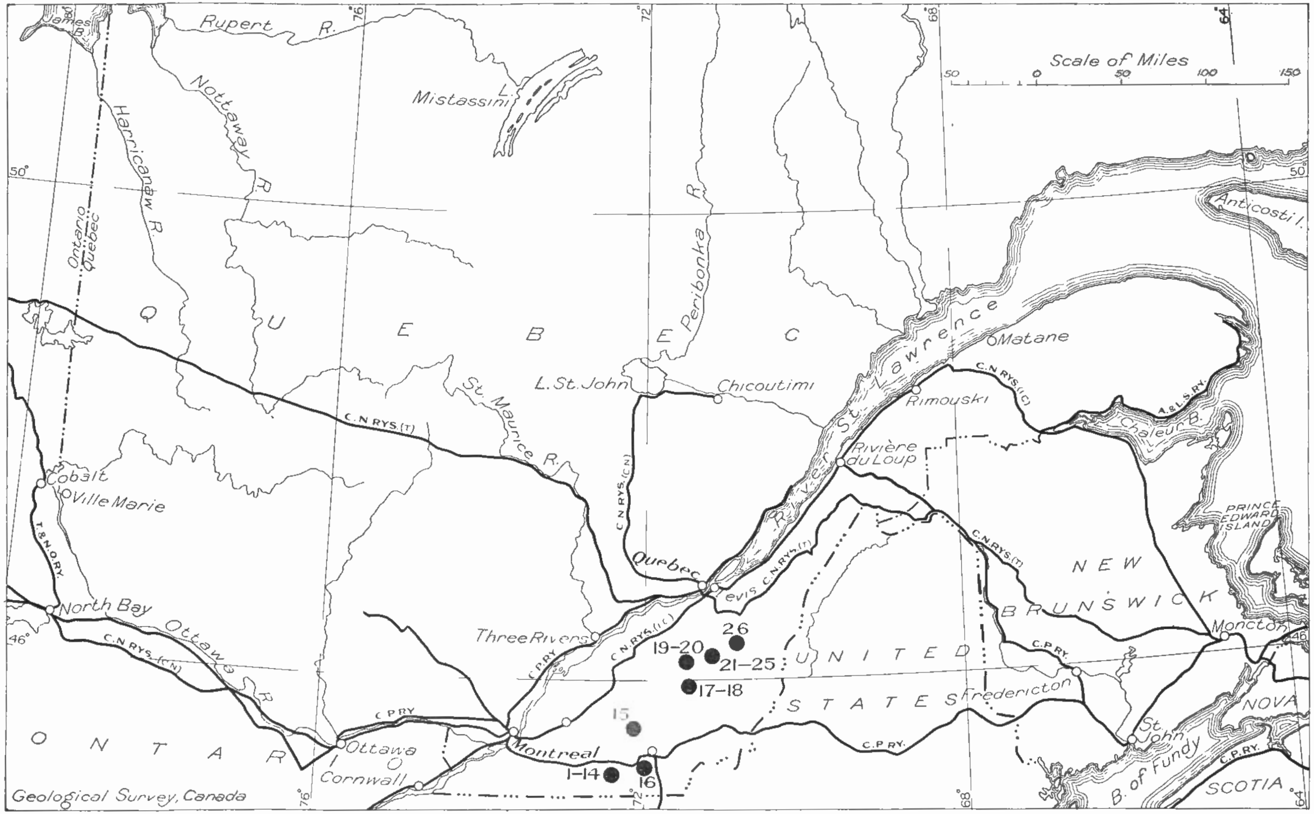

Figure 18. Index map showing location of talc and soapstone deposits in Quebec. For list of localities, see opposite page.

Index

1. Brome co., Sutton tp., range V, lot 10.
2. Brome co., Sutton tp., range VIII, lot 11.
3. Brome co., Sutton tp., range VII, lot 12.
4. Brome co., Brome tp., Knowlton.
5. Brome co., Potton tp., range V, lot 19.
6. Brome co., Potton tp., range V, lot 28.
7. Brome co., Bolton tp., range I, lot 23, John Pibus.
8. Brome co., Bolton tp., range II, lot 26, George Pibus.
9. Brome co., Bolton tp., range II, lot 6.
10. Brome co., Bolton tp., range IV, lot 4.
11. Brome co., Bolton tp., range VI, lot 24.
12. Brome co., Bolton tp., range VI, lot 26.
13. Brome co., Bolton tp., range IX, lot 17.
14. Brome co., Bolton tp., range IX, lot 1.
15. Richmond co., Melbourne tp., range IV, lot 23.
16. Sherbrooke co., Hatley tp., range V, lots 19, 20, and 21.
17. Wolfe co., Ham tp., range I, lots 22 and 25, Nicolet lake.
18. Wolfe co., Wolfestown tp., range II, lot 20, Martel.
19. Megantic co., Ireland tp., range VII, lot 2, Porter.
20. Megantic co., Inverness tp., range I, lot 1, Briggs.
21. Megantic co., Thetford tp., range V, lot 9, Federal Asbestos Company.
22. Megantic co., Thetford tp., range V, lot 7.
23. Megantic co., Thetford tp., range V, lots 5 and 6.
24. Megantic co., Thetford tp., range V, lot 2, Berlin Asbestos Company.
25. Beauce co., Broughton tp., range VII, lot 14, Fraser Asbestos mine.
26. Beauce co., Vaudreuil tp., St. Victor river.

RANGE XII, LOT 15

Talc is found in association with the magnesite deposits in this lot. It occurs chiefly with serpentine filling fractures in the diopside masses, but only in small amounts. The occurrence is, therefore, only of mineralogical interest.

Brome County

Sutton Township

(1) RANGE V, LOT 10

This deposit is exposed in the bed of a brook about ¼ mile east of the road leading south from Sutton on the east side of the west branch of Missisquoi river. It occurs at the extreme south end of an altered serpentine band intercalated in Precambrian schist and phyllite that form the west limb of Sutton Mountain anticline. It consists of two zones of pale greenish grey talc schist 2 feet wide, 15 feet apart, but converging towards the south. Between the schist zones there is a gradual change from the talc schist to massive talc and magnesite and from talc and magnesite to talcose serpentine. The talc and magnesite mixture that forms the greater part of the deposit consists of pale greenish white talc, scattered aggregates of grey magnesite, and disseminated grains of millerite[1] and chromite.

The talc is much lighter in colour than most of the talc found in the Eastern Townships, but the presence of the grey magnesite and the millerite would prevent its use in high-grade talcum powder. No development work has been performed on the deposit, and the amount of the material actually in sight is small. Probably the whole width of about 20 feet exposed could be mined for talc, but this is due to the position of the deposit

[1] Identified by E. Poitevin, Geol. Surv., Canada, Mineralogical Division.

at the end of the serpentine sill. If traced northward it would probably divide into two deposits on either side of the serpentine band, each of which would probably not exceed 10 feet in width. Additional prospecting would be necessary to determine the length of the zones along the strike of the serpentine sill.

The deposit lies only 1 mile east of the Farnham-Newport branch of the Canadian Pacific railway and 3 miles from Sutton station. It is, therefore, fairly well situated for the shipment of the material.

(2) RANGE VIII, LOT 11

Soapstone is exposed in the bed of a creek, southeast of the fair grounds at Sutton village.[1]

(3) RANGE VII, LOT 12

A bed of steatite associated with dolomite mixed with magnesite, pyrite, and small octahedra of chromic iron is stated by Sir William Logan[2] to occur in this lot. The present owner of the lot could give the writer no information regarding the position of the occurrence.

Brome Township

(4) RANGE IX, KNOWLTON

An impure soapstone at Knowlton was used by the Hon. Mr. Knowlton "mixed with a considerable quantity of brown spar, as a paving for his kitchen".[3] The occurrence was not seen by the writer.

RANGE VIII, LOT 2

A very little talc occurs in this lot in slickensided fractures exposed on the broken margin of a steep scarp of serpentine.

Potton Township

(5) RANGE V, LOT 19

It is stated in the "Geology of Canada, 1863"[4], that "a workable bed of soapstone is met with on lot 20 of the fifth range of Potton." The only deposit of talc near this locality known to the inhabitants of the district occurs on lot 19 a few hundred feet south of lot 20 and it is almost certain that this is the occurrence referred to. It is situated near the middle of the lot and about 1,000 feet west of the Missisquoi river road. No pits have been excavated on the deposit, but in 1920 a number of diagonal diamond-drill holes were put down for the purpose of intersecting the talc at depth by the Talc Development Company of Canada, Limited, an organization associated with the Eastern Talc Company of Vermont.

[1] Information given the writer by Mr. L. E. Clark.
[2] "Geology of Canada, 1863," p. 797.
[3] "Geology of Canada, 1846-47," pp. 86-87.
[4] "Geology of Canada, 1863," p. 797.

The talc is associated with a nearly vertical north-south trending band of serpentine about 200 feet wide. On the west contact of the serpentine band platy talc schist is exposed in the bed of a stream that has eroded a channel for itself in the soft talc. The width of the schist zone is about 4 feet, of which 2 feet is light grey in colour. The east contact of the serpentine band is not exposed, but a zone of rusty soapstone up to 20 feet wide occurs along the margin of the outcrop, indicating that the contact is nearby. Under the microscope serpentine from the middle of the band was seen to contain scattered aggregates of talc, and here and there a grain of chromite. A small proportion of talc is, therefore, present even in the interior of the serpentine sill.

The following analyses of talc from Potton township are given on page 470 in the "Geology of Canada, 1863."

—	I	II
Silica	59·50	51·60
Ferric oxide	4·50	7·38
Alumina	0·40	3·50
Magnesia	29·15	22·36
Nickel oxide	trace	trace
Lime	....	11·25
Volatile	4·40	3·60
Total	97·95	99·59

It is probable that these are analyses of the talc from this property, since it is the only deposit of talc mentioned in the report. The first, except for the presence of iron oxide, has the composition of almost pure talc; the second contains lime silicate in addition to talc.

An estimate of the value of a talc deposit of this class must be based on: (1) the quality of the talc; (2) the extent of the deposit; and (3) the transportation facilities or in most cases the distance to the nearest railway station. In the case of this deposit the talc has a grey colour and is, therefore, of second-grade quality. Some of the soapstone might be used as blocks, but this cannot be determined until the deposit is opened up. Since the writer has no information regarding the results of the diamond-drilling operations of the Talc Development Company of Canada and the talc zones are not exposed for more than 100 feet along the strike of the serpentine band, it is not possible to estimate definitely the extent of the deposit. The diamond-drill holes were evidently put down for the purpose of intersecting the talc zone on the west contact of the serpentine, since they were started in the serpentine and inclined to the west. It is possible, however, that a more extensive talc schist zone is present on the east contact. As exposed the talc schist zone on the west margin is too narrow to be of much value. The deposit is only 1½ miles from Travor Road station on the North Troy-Windsor Mills branch of the Canadian Pacific railway.

(6) RANGE V, LOT 28

This deposit is situated on a northeast-facing hill-slope about 1½ miles west of South Bolton village. The principal opening in the deposit is a pit 9 feet long, 5 to 8 feet wide, and 2 to 3 feet deep, in which there is exposed in succession from east to west 2 feet of grey, talcose, hard schist, 2 feet of soft, pale grey, platy talc schist, 4 feet of broken talcose serpentine, and 1 foot of massive serpentine. The strike of the schist is north 10 degrees east magnetic and the dip 70 degrees east. The only other opening in the property is a small excavation situated 20 feet south of the main pit, in which 2 feet of soft talc schist is exposed. The serpentine observed on the west wall of the large pit continues as an outcrop for 20 feet to the westward.

From the preceding description it may be inferred that in this locality there is a north-south trending zone of talc schist and soapstone 8 feet wide lying on the east margin of a serpentine band. The material is of the character that might be used for those purposes in which colour is unimportant, but it is probably too much broken for use as soapstone blocks. The known length of the deposit is only 20 feet, but the width indicates that a zone of considerable length may be present. The nearest railway station, South Bolton, on the Newport-Windsor Mills Branch of the Canadian Pacific railway is only 2 miles away.

Bolton Township

(7) RANGE I, LOT 23—JOHN PIBUS

This deposit is situated about 5 miles southeast of Knowlton, on the Sutton-Drummondville branch of the Canadian Pacific railway. It was discovered by Leonard Greer in 1911. Greer sank some prospect pits at that time and the following year (1912) an option was taken on the property by L. N. Benjamin, who carried on prospecting operations from August, 1912, to September, 1913, with an average of about six men. Since that time, no further work has been performed on the deposit and the ownership has reverted to Mr. Pibus.[1]

The talc deposit lies on the east margin of a belt of serpentine intercalated in the complex of schist and impure crystalline limestone that forms the west limb of the Sutton Mountain anticline. The width of the serpentine band was not determined, but an exposure 40 feet wide occurs about 100 feet northwest of the prospect openings. The openings in the deposit include a shaft said to be 28 feet deep, an adit in the hill-side 140 feet long, and several trenches and prospect pits. The adit has caved in and the shaft and most of the prospect pits are now filled with debris. Talc was observed in place in only one pit, an east-west trending opening 50 feet long, 10 feet wide, and 10 feet deep, situated 50 feet south of the shaft. Here a vertical zone of platy-grey talc schist 10 feet wide is exposed. The schist strikes north 40 degrees east magnetic. It is adjoined on the west by a greenstone, which was not examined under the microscope but

[1] Information given the writer by Mr. Pibus.

which is probably serpentine. Mr. Pibus stated that in the adit, except for masses of hard rock up to 2 to 3 feet wide here and there, talc was exposed continuously the whole of its length of 140 feet. The material on the dump from the adit is a light grey soapstone which under the microscope is seen to consist almost entirely of micaceous talc.

It is not possible to make a definite statement regarding the possibilities of this deposit on the basis of the information outlined above. The talc seen in the dump from the adit would be satisfactory for most purposes where a white colour is not essential. The contact of the serpentine band continues for at least several hundred feet to the northeast, so that an extensive deposit of talc may be present. The cost of transportation to Knowlton station is not prohibitive, the distance being 5 miles downgrade.

(8) RANGE II, LOT 26—GEORGE PIBUS

Previous Descriptions. Ells, R. W.: "Report on Mineral Resources of Quebec"; Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 153 (1891).

Harvie, R.: "Geology of Orford Map-Area, Quebec"; Geol. Surv., Canada, Sum. Rept. 1911, p. 292.

Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 40–41.

This deposit is situated about 1,000 feet southeast of the road from South Bolton to Knowlton and at the southeast corner of the lot. It is 6 miles from Knowlton on the Sutton-Drummondville branch of the Canadian Pacific railway and 4½ miles from South Bolton on the North Troy-Windsor Mills branch of the Canadian Pacific railway.

The rocks where the deposit occurs are mica schists, phyllites, and quartzites which, according to the Eastern Townships map (No. 511), are of Precambrian age and lie almost at the crest of the Sutton Mountain anticline.

Only two pits were observed in the property: one 12 feet long, 10 feet wide, and 8 to 20 feet deep, situated below a woodroad on the wooded slope of a creek valley; and the other 10 feet long, 5 feet wide, and 3 to 15 feet deep, situated in the creek bed in the bottom of the valley a few hundred feet east of the first opening.

In the first pit a zone of platy, cream-white talc schist 10 feet wide is exposed. It strikes north 70 degrees east magnetic and dips 90 degrees. It is adjoined on the northwest by slickensided chlorite schist and on the southeast by massive serpentine. In the second pit pale green serpentine cut by seams and veinlets of talc up to ½ inch wide is exposed. The quantity of talc present is unimportant, but the presence of the serpentine is of interest since it indicates that the talc schist in the first pit occurs on the margin of a serpentine band that continues to the eastward for at least several hundred feet.

Since the zone of talc 10 feet wide in this property is exposed in a single pit the amount of talc known to be present is small; but it is one of the few deposits of high-grade talc in the Eastern Townships and the width of the zone indicates that an extensive deposit may be present. It would be necessary to trace the zone along the strike to determine its length before its future possibilities can be determined. The cost of transporting the talc to either Knowlton or South Bolton, distances of 6 and 4½ miles, respectively, over a good road and downgrade, would not be too great a handicap in working a deposit of this quality, provided it is sufficiently extensive.

The following analysis of a sample of the talc indicates that it is pure talc except for the presence of grains of magnetite.[1]

Silica	59·78
Ferrous oxide	3·96
Ferric oxide	0·44
Alumina	1·82
Lime	0·02
Magnesia	29·23
Carbon dioxide	0·02
Water above 105°C	4·79
	100·06

(9) RANGE II, LOT 6

The deposit in this property was not examined by the writer, but is described on page 797 of the "Geology of Canada, 1863," as follows:

"On the sixth lot of the second range of Bolton is a band of soapstone, which occupies a breadth of about thirty yards, and is limited on the southeast by a bed of dark green serpentine a foot in thickness, to which succeed nacreous clay slates. The steatite is more or less mixed with crystals of bitter spar (magnesite) which to the northwest side predominate; so that the rock passes into dolomite which is bounded by slates similar to those in the opposite side of the band."

This description suggests a deposit similar to that in lot 10, range V, Sutton township, where a narrow band of serpentine has apparently been almost completely transformed to talc and dolomite.

(10) RANGE IV, LOT 4

An association of talc and steatite with serpentine, on this lot, is described in the "Geology of Canada, 1863," page 797, as follows: "On the fourth lot of the fourth range of Bolton, the belt of magnesian rocks is represented by a breadth of about twenty-five yards of steatite holding bitter spar (magnesite) and intermingled with patches of dolomite, while about 300 yards to the northeastward, on the slate, it passes into a bed of dark green, slaty serpentine, containing asbestos with grains of chromic and magnetic iron. This is bounded on the northwest by a bed of steatite and beyond this is a bed of actinolite, mingled with asbestos and talc, the whole occupying a breadth of 50 yards."

(11) RANGE 6, LOT 24

Previous Descriptions. "Geology of Canada, 1863", pp. 797.

This deposit is situated on the west slope of the Missisquoi River valley, about 1 mile above South Bolton village, and 1½ miles northwest of South Bolton station, on the North Troy-Windsor Mills branch of the

[1] Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 40.

Canadian Pacific railway. It is now entirely overgrown and difficult to find. It can be most easily reached by way of an old log road that follows the creek valley a few hundred feet to the south of the deposit. Three hundred tons of soapstone having a value of $1,800 were shipped from the property by Slack and Whitney in 1871.[1]

The talc lies on the eastern limb of the Sutton Mountain anticline and is associated with phyllite, mica schist, epidote-hornblende schist, and chlorite schist which are shown on the Eastern Townships map (No. 571) as Precambrian in age. They strike north 20 degrees east magnetic and dip to the east. The character and relationships of the deposit, which was probably better exposed when he made his examination than at present, are described by Logan as follows: "A locality which furnishes a steatite of superior quality is on the twenty-fourth lot of the sixth range of Bolton. Here it is associated with chlorite and with dolomite. Resting upon a band of the latter is a layer of about 3 feet of impure steatite, overlaid by 4 feet of dolomite. This is followed by a layer of a few feet of chlorite, to which succeed about 5 feet of steatite; the upper 2 feet of which are very pure and compact, and furnish large blocks free from flaws. The bed of steatite, however, appears here, as in some other places, to have a lenticular shape, thinning out and being replaced by chlorite rock."[2]

At present the deposit is exposed in two parallel north-south trending pits united at their south end. The western of these openings is about 60 feet long, 25 feet wide, and 5 feet deep; the eastern 160 feet long, 10 to 25 feet wide, and 5 to 15 feet deep. The bottom of the west pit is buried in debris, but a zone of impure talc schist (steatite of Logan) 4 to 5 feet wide and dipping to the east is exposed along its east face. The bottom of the east pit is exposed only in spots, but is apparently underlain by a zone of dark grey to pale grey or green talc schist 10 to 15 feet wide. This schist contains numerous crystals of carbonate in rusty weathering zones. It is lightest in colour and most free from impurities along the east face. Between the two pits there is a rock ridge about 10 feet wide, the west half of which is composed of buff-coloured dolomite and the east of schist. The strike of the deposits is north 20 degrees east magnetic and the dip about 50 degrees east.

These talc schist zones are distinguished from most of the talc deposits of the Eastern Townships in that they are not associated with sills of serpentinized basic igneous rocks. It may be possible, however, that they have been derived from small sills that have been so completely transformed that their original character cannot now be recognized. The bedrock is not exposed near the pits, but serpentine sills and masses are exceedingly abundant in the district and almost certainly occur nearby.

There are present in this property, as indicated in the preceding description, two zones of talc schist, the larger of which is probably at least 150 feet long and 5 to 15 feet wide. If it be assumed, therefore, that the deposit descends to only 50 feet, there would be several thousand tons

[1] Robb, Chas.: Geol. Surv., Canada, Rept. of Prog. 1871-72, p. 148.
[2] "Geology of Canada, 1863," p. 797.

of talc present. This talc, however, is grey and contains a considerable percentage of carbonate and is, therefore, of low grade. The rock is not now exposed at the ends of the pit, but it is possible that, as suggested by Logan, the deposit is lenticular, and in that case it is not much more extensive at the surface than as shown in the pits. A small amount of development work on the continuation of the talc schist zone to the north and south would determine this. If the deposits do not extend farther along the strike they are not sufficiently large to warrant the erection of a grinding mill except in conjunction with other deposits, of which there are several in the neighbouring district.

(12) RANGE VI, LOT 26

A high ridge of serpentine bordered in places by a more or less talcose zone extends diagonally across the northwest end of lots 25 and 26, range VI, Bolton township. Near the northwest corner of lot 26, and on the northwest margin of the serpentine ridge there is a pit 15 feet long, 8 feet wide, and 3 to 5 feet deep, said to have been excavated by Nathan Banfield about 1876. The material exposed in this pit is dark green soapstone in which minute crystals and grains of magnetite are disseminated. Under the microscope it was found to consist almost entirely of fine, micaceous talc in which some brownish green chlorite is included. The contact zone near the pit is not exposed, and hence no information regarding the extent of the deposit outside the pit was obtained; but the serpentine ridge is continuous across the whole width of the lot, so that the talcose zone may extend a considerable distance. The material composing the deposit is too dark to be used for high-grade talc, but might be useful either as low-grade talc or as soapstone. The mining rights to this lot belong to W. J. Pike, of Montreal.

(13) RANGE 9, LOT 17

Previous Descriptions. "Geology of Canada, 1863", pp. 797-8.
Ells, R. W.: "Report on the Mineral Resources of the Province of Quebec"; Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 152 (1891).

The talc deposit on this lot adjoins the east side of the road that follows the shore of the east bay of lake Nick. It occurs as a zone 20 feet wide on the margin of a steep scarp of serpentine and consists chiefly of talc and magnesite in which grains of pyrite are disseminated. It is intersected by numerous minute fractures filled with talc and at one point by an irregular vein of quartz and carbonate up to 3 feet wide. The exposed length of the deposit is about 200 feet and the exposed width 20 feet. Its actual length and width cannot be determined. The only prospect work performed on the property is a small amount of blasting along the face of the scarp at its steepest point.

The material in the deposit is too dark in colour and contains too much magnesite to be used in high-grade talcum powder or for most of the purposes for which the slip of the talc is essential. It might be useful in the manufacture of roofing material or similar products in which grey talc is used. The mass of serpentine with which the deposit is associated continues for several thousand feet both to the north and southeast, so that the deposit is probably large enough to be worked if a market for the material be available. It is 2 miles in a straight line or 3½ miles by road to the nearest railway station, Bolton Centre.

(14) RANGE IX, LOT 1

A band of soapstone 16 paces wide, associated with serpentine, occurs in a cutting on the Canadian Pacific railway a short distance west of Orford Pond[1].

Richmond County

Melbourne Township

(15) RANGE IV, LOT 23

About 200 tons of soapstone was mined on this lot in 1918 and 1920 by the Canada Paper Company, of Windsor Mills, Quebec, from a zone of massive, grey-green soapstone 1 foot wide. The deposit is owned by the new Rockland Slate Company and lies about 1 mile from Kingsbury station, on the Orford Mountain branch of the Canadian Pacific railway.[2]

Stanstead County

Stanstead Township

RANGE IX, LOT 13

"A soft and apparently decomposing talcose slate, which exhibits parallel vertical layers of greyish-white and ochre-yellow colours; the latter being due to hydrated peroxide of iron. This talcose rock has been employed mixed with oil for painting houses."[3]

Sherbrooke County

Hatley Township

(16) RANGE V, LOTS 19, 20, AND 21

Soapstone "of excellent quality" occurs in "areas of considerable extent" in these lots, according to R. W. Ells.[4] No attempt has been made so far to develop the occurrence.

Wolfe County

Ham Township

(17) RANGE I, LOTS 22 AND 25 (OLD NUMBERING 43-44 AND 49-50)

Soapstone is stated to occur in these lots near the south slope of Nicolet lake, both by Ells and Dresser.[5] No information regarding the

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[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. VII, pt. J, p. 62 (1896).
[2] Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 44.
[3] "Geology of Canada, 1863," p. 767.
[4] "Report on the Geology of a Portion of the Eastern Townships"; Geol. Surv., Canada, Ann. Rept., vol. II, pt. J, p. 67 (1887); "Report on the Mineral Resources of Quebec"; Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 152 (1891).
[5] Ells, R. W.: "Report on the Geology of a Portion of the Eastern Townships of Quebec"; Geol. Surv., Canada, Ann. Rept., vol. II, pt. J, pp. 42 and 67 (1887).
Dresser, J. A.: "Preliminary Report on the Serpentine and Associated Rocks of Southern Quebec"; Geol. Surv., Canada, Mem. 22, p. 96 (1913).

character or relationship of the deposit is given, but a serpentine mass is shown to occupy the basin of Nicolet lake on the map that accompanies Dresser's memoir, so that this deposit, as in the case of most of the deposits in the Eastern Townships, probably lies on the margin of the serpentine.

Wolfestown Township

(18) RANGE II, LOT 20

Previous Descriptions. Ells, R. W.: "Report on the Geology of a Portion of the Eastern Townships"; Geol. Surv., Canada, Ann. Rept., vol. II, pt. J, p. 67 (1887).
Obalski, J.: "Mines and Minerals of Quebec", 1889–90, p. 111.
Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 44–45.

This deposit is situated on the bank of White river, a few hundred feet south of Martel's mill at Belmina. The property was originally owned by Calvin Carter and was sold by him to Fenwick and Sclater of Montreal, who formed the Wolfestown Mining Company, to develop the deposit.[1] One hundred and twenty tons of soapstone was taken out in 1888 and 150 in 1889, part of which was shipped to Montreal and ground in a Cyclone Pulverizer for use as paint, in lubricant, etc. J. N. Martel[2], of Belmina, is the present owner of the property.

The rocks where the deposit occurs, according to the geological map of the Eastern Townships (No. 571), are Precambrian in age. All that can now be seen of the deposit is an outcrop peeping through caved-in drift near the top of the river bank. The exposed thickness of rock is about 25 feet, of which the lower 6 feet is grey, platy talc schist and the remainder chlorite schist. The rock strikes north 80 degrees east magnetic and dips 50 degrees south. Serpentine is not present in the outcrop, but may be present beneath the drift below the talc schist zone.

The talc is of the average quality found in the Eastern Townships. It is too dark in colour for the best grade of talcum powder and contains the usual inclusions of magnetite. The extent of the deposit, beyond that it is exposed for a width of 5 feet and that its lower part was not seen, is unknown. The property lies about 6 miles from Coleraine station, on the Quebec Central railway.

Megantic County

Ireland Township

(19) CRAIG'S ROAD RANGE (OR RANGE VII), LOT 2

Previous Descriptions. Dresser, J. A.: "Mineral Deposits of the Serpentine Belt of Southern Quebec" Trans. Can. Min. Inst., vol. XII, pp. 177–8 (1909).
"Preliminary Report on the Serpentine and Associated Rocks of Southern Quebec"; Geol. Surv., Canada, Mem. 22, p. 96 (1913).
Wilson, A. W. G.: "Notes on the Occurrence of Talc and Soapstone in Megantic County, Quebec"; Sum. Rept., Mines Branch, Dept. of Mines, Canada, 1909, p. 81.
Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 81.

This property is situated $1\frac{1}{2}$ miles south of Clapham, and nearly 1 mile southeast of the road on the boundary line between Ireland and Halifax

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[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. II, pt. J, p. 67 (1887); vol. IV, pt. K, p. 152 (1891).
[2] Obalski, J.: "Mines and Minerals of Quebec," 1889–90, p. 111.

townships. It lies 10 miles in a straight line or 13 miles by road from Black Lake, the nearest railway station. The only development work on the property was performed by W. J. Porter, of Clapham, about the year 1906, for the Megantic Talc Company, organized by C. V. M. Temple of Toronto.

The rocks exposed on the property consist of mica schist or phyllite in which either intrusive sills or contemporaneous lava flows of serpentinized greenstone are intercalated. They strike a few degrees east of north and dip about 35 degrees east. The talc-bearing zone, which lies along the underside of a greenstone belt, consists of grey to greenish grey talc and dolomite in which aggregates of serpentine and scattered grains of magnetite are included, giving the rock a variegated appearance. The width of the zone on the surface is about 60 feet, but measured at right angles to the dip it would probably not be more than half this amount.

The principal opening in the zone is a northeasterly-trending pit 30 feet long, 20 feet wide, and 5 to 15 feet deep, excavated in the northeast face of a knob of the serpentine band. The rock in this pit is a variegated, light to dark grey, or greenish grey soapstone which is schistose in places and in which masses of harder, less talcose serpentine are included. It includes irregular veins and aggregates of pale green, translucent talc and coarsely crystalline ankerite (ferruginous dolomite). These vary greatly in the proportion of talc and dolomite that they contain, consisting entirely of talc at some points and of dolomite at others. Their maximum width is about 1 foot. The following analysis of a sample of the pale green, micaceous talc[1] shows it to be an exceptionally pure, normal talc containing a small amount of iron to which it probably owes its green colour.

	Per cent
Silica	60·86
Ferrous oxide	1·11
Ferric oxide	0·24
Alumina	0·22
Lime	0·08
Magnesia	32·19
Carbon dioxide	0·09
Water above 105°C	4·50
	99·29

In another locality on the lower margin of the serpentine band, about 500 feet south of the pit just described, there is an opening 10 feet long, 5 feet wide, and 2 feet deep in a bare outcrop in which altered serpentine is exposed for a width of about 60 feet. The rock exposed in this pit is a soapstone like that seen in the first pit, but the veins and aggregates of talc and ankerite are absent.

The high-grade talc on this property is confined to the veins in the principal pit, but this, although of exceptionally high quality, is present only in a few small veins in a single opening and is not commercially important. The value of the property, therefore, consists mainly in the presence of the zone of soapstone in which the veins occur. This is at

[1] Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 42.

least several hundred feet long and probably not less than 30 feet thick measured at right angles to the dip of the serpentine band. This material might be valuable either for cutting into soapstone blocks or as low-grade, ground talc, but the degree of alteration of the serpentine to talc varies from point to point along the margin of the greenstone band, so that additional development work is required to determine the quality of the soapstone throughout the zone as a whole.

Inverness Township

(20) RANGE I, LOT 1

Previous Description. Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 42.

This talc deposit lies on the north side of the road on the boundary between Halifax and Inverness townships and about one-quarter mile northwest of the Inverness-Ireland township line. It also lies about ½ mile south of Clapham post office and 12 miles northwest of Thetford Station on the Quebec Central railway. It is owned by Mrs. R. J. Briggs, of Clapham.

The rocks exposed on the property consist of highly metamorphosed sediments—quartz schist, and phyllite—in which a band of talcose serpentinized greenstone (soapstone), having an exposed width of about 80 feet, is included. The strike of schist and phyllite is northeast and the dip 30 degrees northwest. The talc deposit consists of pale green, micaceous, platy talc schist similar in every respect to that in the George Pibus property in Bolton township. It lies on the upper side of the soapstone and hence trends northeasterly and dips northwest in conformity to the margin of the soapstone band. It is from 2 feet to 6 feet thick and has been laid bare at intervals in prospect pits for 100 feet along its strike. An examination of the talc schist under the microscope showed it to consist of fine, micaceous talc in which a few, small, scattered grains of magnetite partly altered to hematite are included.

The development work consists of nine small prospect pits. These fall into three groups: (1) four pits excavated along the zone of high-grade talc that occurs on the upper side of the soapstone band; (2) five pits in the soapstone band or on its southern margin to the south of the pits of group 1; and (3) a single pit situated 200 feet to the east of the most easterly pit of group 1. This opening is in talc schist dipping northwest, but it is adjoined on the south by phyllite, and, therefore, must lie on the lower rather than the upper side of the soapstone band.

Group	No. of pit[1]	Dimensions of opening	Character of deposit	Wall-rock
	1	14 feet long 1–6 feet wide 3–5 feet deep	Micaceous, platy, pale green talc schist zone, 2 to 3 feet wide. Strike north 80 degrees east magnetic, dip 30 degrees northwest	Quartz schist and phyllite on north, soapstone on south
1	2	3 feet long 1 foot wide 2 feet deep	Micaceous talc schist for full width of opening	Not seen
	3	6 feet long 2 feet wide 3 feet deep	Micaceous talc in bottom	Not seen
	4	10 feet long 5–17 feet wide 7 feet deep	Micaceous, platy, talc schist zone 5 to 6 feet wide. Strike north 70 degrees east, dip 30 degrees northwest	Phyllite on foot-wall
	5	7 feet long 3 feet wide 7 feet deep	Old pit filled with debris, soapstone on dump	Not seen
	6	6 feet long 3 feet wide 8 feet deep	Old pit filled with debris. Soapstone on dump	Not seen
2	7	5 feet by 5 feet 6 feet deep	Grey talc schist in which lenticular masses of soapstone up to 2 feet wide are included. Strike northeast, dip northwest	Talc schist, outcrop of phyllite 5 feet south of pit
	8	5 feet long 3 feet wide 4 feet deep	Soapstone underlain by light grey talc schist	Soapstone on north, talc schist on south
3	9	4 feet long 2 feet wide 3 feet deep	Micaceous, platy, talc schist dipping northwest	Phyllite on foot-wall

[1] Pits of group 1 numbered in the order of their occurrence from west to east, those of group 2 in the order of their occurrence from north to south.

There are two types of material that might be produced from this property: (1) high-grade talc from a zone 2 to 6 feet wide extending along the upper side of a northwestward dipping soapstone band; and (2) low-grade talc or soapstone blocks from the soapstone band. The material of the first class is of excellent quality, but is everywhere covered with glacial drift, and so far pits have been sunk through the drift to the deposit for only 100 feet along its strike. Additional development work both along the continuation of the talc schist zone and on its dip is required, therefore, to determine its value. It is also possible that there is a second zone of high-grade talc on the under side of the soapstone band. Talc schist that has apparently this relationship was seen in pits 8 and 9.

Although the quantity of talc in sight in this property is thus not great, it is known that the narrow sills of talcose serpentinized greenstone which occur intercalated with the mashed sedimentary series of the Eastern Townships of Quebec are generally continuous for hundreds or even thousands of feet. It is possible, therefore, that the zone of high-grade talc schist which has been formed along the margin of one of these sills may also be extensive.

The soapstone band, like the high-grade talc schist, is entirely drift covered, so that information regarding it was obtained mainly from fragments from old pits, lying on the dump. Much additional work would be required, therefore, before its character and extent could be determined.

Thetford Township

(21) RANGE V, LOT 9

About 10 feet of talc is exposed in this lot in a small pit situated a few feet north of the main pit of the Federal Asbestos Company, according to H. S. Spence.[1]

(22) RANGE V, LOT 7

A small opening was made on this lot, by T. Demers, of Thetford, in 1920, from which 100 tons of crude talc are reported to have been shipped to United States.

(23) RANGE V, LOTS 5 AND 6

Previous Descriptions. Dresser, J. A.: "Serpentine Belt of Southern Quebec"; Geol. Surv., Canada, Sum. Rept. 1909, p. 198.

"Preliminary Report on the Serpentine and Associated Rocks of Southern Quebec"; Geol. Surv., Canada, Mem. 22, p. 96 (1913).

Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept of Mines, Canada, 1922, p. 43.

The talc deposits in these lots are situated on the southeast slope of a ridge of serpentine that extends in a northeasterly direction about $\frac{1}{4}$ mile northwest of the main highway from Robertson to East Broughton. A series of pits were excavated along this slope about forty years ago in prospecting for asbestos. In two of these pits, one on lot 6, close to lot 5, and the other on lot 5, 300 feet west of the first pit, zones of soapstone are exposed. In August, 1922, Louis Cyr opened a pit in the first of these zones, and, at the time the writer visited the property in September, three saws were in operation cutting the soapstone into blocks for shipment to the paper mills.

These deposits differ from most of the talc and soapstone deposits of the Eastern Townships in that they occur within the serpentine and not on the margin. The deposit which Mr. Cyr has opened up consists of a zone of variegated pale grey and green, massive to platy, talc schist in which masses and lenses of serpentine up to 3 feet wide are included. The width of the zone is 25 to 30 feet and its exposed length 200 feet. The strike of the deposit is variable, but on the average is about east-west; the dip

[1] "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, pp. 3-4.

is to the south. The second deposit, situated 300 feet to the east, is a zone of grey-green, platy talc schist similar to that in the main deposit. It is 12 feet wide, strikes north 70 degrees west magnetic, and dips 60 degrees south. It is exposed along the strike across a single pit 10 feet wide. The principal data regarding the openings in the property are as follows:

Lot	Pit No.	Dimensions of opening	Character of deposit	Remarks
5 and 6	1	150 feet long, 1 to 30 feet wide, face 5 to 20 feet high	Variegated grey and green soapstone	Pit situated on line between lots 5 and 6
6	2	60 feet long, 15 to 20 feet wide, 10 to 15 feet deep	Massive, much fractured serpentine, except on north face, where schistose soapstone occurs	Old pit 25 feet west of pit No. 1
5	3	30 feet long, 15 feet wide, face 15 feet high	Grey-green soapstone similar to that in main pit, strike north 65 degrees east (magnetic), dip 60 degrees southeast	50 feet east of the east end of main pit
5	4	10 feet long, 6 feet wide, 3 feet deep	The continuation of zone in pit 1	20 feet east of pit No. 2
5	5	30 feet long, 10 feet wide, 20 feet at face	Zone of schistose, grey-green talc, 12 feet wide. Strike north 70 degrees west (magnetic), dip 60 degrees south	About 300 feet east of main pit
5 and 6	Other pits	....	All in serpentine, no talc present	

The talc composing these deposits, except for some inclusions of serpentine in the more massive zones and possibly some pyrite or pyrrhotite, is almost entirely free from impurities. A few bands of cream-white talc occur in places, but in the main the colour is grey or green and far too dark to be used for high-grade talcum powder. An analysis of a sample presumably taken from pit No. 5 is as follows:[1]

	Per cent
Silica	59·66
Ferrous oxide	4·12
Ferric oxide	0·37
Alumina	1·67
Lime	None
Magnesia	29·26
Carbon dioxide	None
Water above 105° C	4·90
	99·98

The presence of 4·12 per cent of iron in this analysis suggests that some pyrite or pyrrhotite may have been present in the sample, and the low silica content is possibly due to the presence of a few grains of serpentine, but otherwise the sample has the composition of normal talc. The material in pit No. 1 is too platy in places for cutting into blocks and

[1] Spence, H.S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 43.

in consequence the proportion of waste in using it for this purpose is large. It is possible that this will disappear to some extent at greater depth.

The full extent of either deposit is not known. The deposit in pits 1 to 4 has a known width of 25 feet and a length of over 200 feet and may continue beneath the drift both to the east and west. The deposit in pit No. 5 is not exposed beyond its walls, but the width of the soapstone in the pit indicates that a zone similar to that in pits 1 to 4 may be present.

The deposits in these lots are about 1 mile from the Quebec Central railway and less than 2 miles from Robertson station, with which it is connected by a good road. They are, therefore, conveniently situated for the shipment of the soapstone produced.

(24) RANGE V, LOT 2

The ridge of serpentine in which talc occurs on lots 5 and 6, range V, Thetford township, continues eastward across lots 4 and 3 to lot 2, where the Berlin Asbestos Company mined asbestos during the years 1909 to 1912. A number of masses of soapstone and sawn slabs of soapstone were observed on the dump from the asbestos pit, indicating that soapstone was associated with the asbestos. The pit, which is 200 feet long and 125 feet wide, is almost completely filled with water. The wall above the water's edge consists of broken serpentine, except on the northwest face where a zone of soapstone occurs. This strikes north 50 degrees east magnetic and dips 45 degrees south and is 20 feet wide. It consists of grey-green talc schist similar in character to the material being mined by Mr. Cyr on lots 5 and 6.

Beauce County

Broughton Township

RANGE XI, LOTS 2 AND 4

Talc is stated by Dresser[1], to occur in range XI, lot 2, and in lot 4 by Ells[2]. On inquiring from the farmers who owned these lots the writer was directed to the southeast side of a ridge of serpentine that extends across the lots a few hundred feet from the road that follows the line between ranges X and XI. The face of this ridge consists of broken serpentine traversed by zones of antigorite, but so far as was observed no talc or soapstone was present at this point.

(25) RANGE VII, LOT 14

Previous Descriptions. Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. V, pt. II, p. 265 (1893).
Dresser, J. A.: Geol. Surv., Canada, Mem. 22, pp. 68 and 96 (1913).

This property is known as the Fraser Asbestos mine and was worked for asbestos about 30 years ago. At that time the asbestos was mined from a zone of especially long fibre developed near the south margin of a serpentine mass, the actual margin of which is marked by a soapstone zone. From 1917 to 1920 asbestos was again mined, on this occasion from an open pit in the serpentine mass. In excavating this pit the

[1] Dresser, J. A.: "Serpentine Belt of Southern Quebec"; Geol Surv., Canada, Sum. Rept. 1909, p. 198.
[2] Ells, R. W.: "Report on the Mineral Resources of the Province of Quebec"; Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 153 (1891).

contact of the serpentine with the adjacent schists was laid bare and part of the old workings exposed, so that the soapstone can now be seen in a mine pillar and on the continuation of the contact westward. In the pillar the talc is exposed horizontally for 10 feet and vertically for about 12 feet. It has a width of about 1 foot at the top of the pillar and 2 feet at the bottom. The strike of the zone is north 5 degrees east magnetic and the dip 50 to 60 degrees south. From the pillar westward the talc is exposed in the face of the pit at intervals for 200 feet. In this distance it is nowhere more than 2 feet wide, of which only 1 foot is pure talc.

The talc is a massive, fine-grained, grey to white variety of exceptional purity. The deposit is probably not sufficiently large to be mined by itself, but it might be worked if asbestos mining were continued on the property.

Vaudreuil Township

(26) ST. VICTOR RIVER

An occurrence of soapstone in this locality is described by B. R. McKay[1] as follows:

"Soapstone occurs on the north side of St. Victor river about 2¾ miles west of the Chaudière. The outcrop is a belt about 30 feet in width forming the northern rim of St. Victor River gorge for a distance of 1,100 feet below the lower falls. The rock occurs as a contact zone between an intrusive dunite and a slaty conglomerate and was evidently derived from the dunite by hydrothermal metamorphism by waters accompanying or closely following the intrusion. Numerous veinlets of magnesium carbonate and fibrous serpentine cut through the dunite and the soapstone. In certain parts of the soapstone large, angular, boulder-like fragments of peridotite occur, the schistose planes of the soapstone wrapping about the inclusions and giving to the rocks a bomb-like structure. The peridotite fragments vary from small nodules, the size of a hen's egg, to masses 8 feet in length. As a rule the fragments lie with their longer axis parallel to the foliation of the soapstone and are arranged in belts as if they were part of larger fragments. These masses were evidently torn from the parent peridotite body during a period of faulting and enclosed in a matrix of soapstone. The peridotite fragments being more competent than the surrounding soapstone were able to withstand the pressure which caused the less competent rock to flow around them. Further evidence of the dynamic stress to which these rocks were subjected is seen in the undulating fault-plane which is traceable for a distance of over 100 feet along the north side of the intrusion.

The deposit on St. Victor river would be serviceable for the manufacture of many of the products referred to above, but the numerous fractures cutting the rock make it unsuitable for cutting into large slabs or blocks."

The interesting feature of this deposit is that, like most of those observed by the writer farther to the west, the soapstone lies on the margin of the basic intrusive mass.

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[1] "Beauceville Map-Area, Quebec"; Geol. Surv., Canada, Mem. 127, p. 87 (1921).

Gaspe County

STE. ANNE RIVER

Veins of light green talc occur in an olivine-bearing rock on this river, west of mount Albert.[1] The deposit is not of commercial importance.

NEW BRUNSWICK

The only localities in New Brunswick where talc or soapstone is reported to occur are at the Narrows on St. John river (1, Figure 19), Lancaster parish, and near Musquash village (2, Figure 19), Musquash parish, St. John county. The description is as follows: "Compact talc or steatite has been observed at several points in small quantities, in connection with the rocks of the Laurentian system, as in the Narrows of the St. John river, near Musquash and elsewhere."[2]

NOVA SCOTIA

Several occurrences of talc in Nova Scotia are mentioned in the reports of the Geological Survey, but most of these are merely mineral localities and not deposits of commercial extent. The information given regarding each deposit is included in the following table:

Locality	Character of deposit	Associated rock	Reference
Antigonish county, brook east of Georgeville	Talc associated with serpentine in quartz vein 13 inches wide	Black slates and flinty sandstones	Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept., vol. II, p. 19 (1887)
Cape Breton island, Inverness county, at Stewartdale on Brigand brook, near Whycocomagh	Light grey, feebly lustrous, sub-transparent steatite	Crystalline limestone	Hoffmann, G. C.: Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R, p. 25 (1895). Geol. Surv., Canada, Rept. of Sect. of Chem. and Min., 1906, p. 17
Cape Breton island, Cape Breton county, road ascending along Benacadie brook	Calcareous talcose rock	Light green, soft, soapy rock and gneiss	Fletcher, Hugh: Geol. Surv., Canada, Rept. of Prog. 1876–77, p. 411
Cape Breton island, Cape Breton county, Garbarus bay, Eagle head	Soapstone in thin layers	Felsite and quartzite	Fletcher, Hugh: Geol. Surv., Canada, Rept. of Prog. 1877–78, pt. F. p. 30
Cape Breton island, Cape Breton county, Kennington Cove, 4 miles west of Louisburg	Specimen of talc		Hoffmann, G. C.: Geol. Surv., Canada, Ann. Rept., vol. VIII, pt. A, p. 119 (1897); vol. IX, pt. A, p. 112 (1898)

[1] Ells, R. W.: Geol. Surv., Canada, Rept. of Prog. 1882–4, pt. F, p. 20.
[2] Bailey, L. W., and Matthews, G. F.: "Preliminary Report on the Geology of New Brunswick"; Geol. Surv., Canada, Rept. of Prog. 1870–71, p. 238.

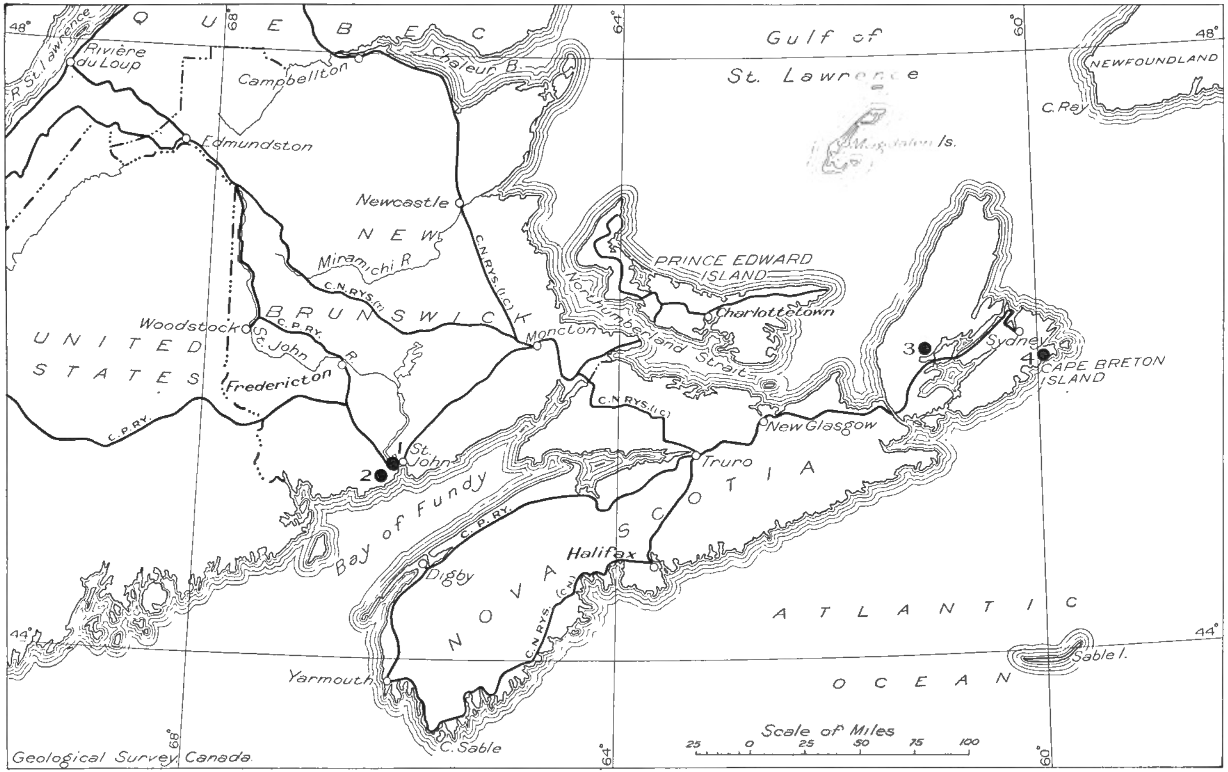

Figure 19. Index map showing location of talc and soapstone deposits in New Brunswick and Nova Scotia: 1, The Narrows, St. John river; 2, Musquash; 3, Whycocomagh; 4, Louisburg.

(3) Inverness County, near Whycocomagh

The only talc deposit in Nova Scotia on which any work has been done is that near Brigand brook, 3 miles from Whycocomagh. A shaft was put down on the side of the road and a small quantity of the material taken out and shipped to Pictou for grinding, in 1896, by R. P. Fraser.[1]

The deposit consists of bands of massive, pure cream-coloured talc up to 12 inches wide, alternating with quartzite, and dipping to the north about 45 degrees. The associated rock is dolomite.[2]

(4) Cape Breton County, near Louisburg

A deposit of sericite schist on the Atlantic coast, to the east of Simon point 4 miles southwest of Louisburg, described by A. O. Hayes, is possibly occurrence No. 5 in the table. It consists of a zone of soft, altered, talc-like schist in a series of stratified volcanic rocks. Samples of the material were submitted to the Mineralogical Division of the Geological Survey and identified as sericite schist. Two shafts 61 and 14 feet deep were put down and crosscuts 43 and 23 feet long, respectively, driven from the bottom of these about the year 1898.[3]

LABRADOR

Soapstone is "found in a number of places in masses large enough for Eskimo lamps" in northern Labrador. "It is doubtful if" it "could be worked profitably."[4]

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1 Piers, Harry: "Economic Minerals of Nova Scotia"; Report of the Dept. of Mines, 1906, p. 50.
2 Spence, H. S.: "Talc and Soapstone in Canada"; Mines Branch, Dept. of Mines, Canada, 1922, p. 23.
3 Hayes, A. O.: Geol. Surv., Canada, Sum. Rept. 1918, pt. F, pp. 18–20.
4 Coleman, A. P.: "Northern Part of Labrador and New Quebec"; Geol. Surv., Canada, Mem. 124, p. 52 (1921).

CHAPTER V

TALC AND SOAPSTONE IN OTHER COUNTRIES

Talc is known to occur in nearly every country of the world in which crystalline schists are found. It is being mined, or has been mined in recent years, in Australia, Austria, Brazil, China, France, Germany (Bavaria), Great Britain, India, Italy, Norway, Spain, United States, and the Union of South Africa, but from the standpoint of the Canadian talc industry the talc and soapstone deposits of importance in other countries are: (1) those of United States, the country where most Canadian talc is marketed; (2) those of Italy and France, from which large quantities of high-grade talc are shipped annually to United States; and (3) those of Germany, Austria, Spain, India, Norway, and the Union of South Africa, all of which might possibly compete with Canadian talc either in United States or in Europe.

UNITED STATES

The talc and soapstone deposits of United States are confined chiefly to the Adirondack region and the belt of Precambrian crystalline schists and metamorphosed early Palæozoic strata that lies within and adjacent to the belt of Appalachian folding. Other deposits occur within the Cordilleran region of the western states, but mining has not been attempted in this territory except in California. The talc deposits of United States belong to the two principal classes (Chapter III): (1) those derived from dolomite by silication, and (2) those formed by the alteration of basic, igneous rocks.

The talc from deposits of the first type is usually white, but with the exception of the California deposits contains too much tremolite or other impurities to have the smoothness or slip necessary for use in toilet preparations. It is used extensively in the manufacture of paper and as filler in paint. The deposits of New York State, California, and part of those of North Carolina and Georgia belong to this class. The New York deposits are by far the most important, their annual output constituting 36 per cent of the total quantity produced in United States and exceeding that of any other state in value.

The talc belonging to the second type of deposit is commonly grey or green and is used either in slabs or blocks as soapstone, or in the ground form for those purposes for which a white colour is not essential. The deposits of Vermont, Virginia, Maryland, and part of those of North Carolina and Georgia belong to this class. Most of the Vermont talc is sold as low-grade talc flour, whereas that of Virginia is manufactured into bricks, etc. (Alberene stone).

By far the greater part of the total production of talc and soapstone of United States is obtained from the three states, New York, Virginia, and Vermont, their annual production constituting 87 per cent of the total production of the country.[1]

New York[2]

The talc deposits of New York state occur in association with limestone and schist of the Grenville series, and with the exception of one deposit near Natural Bridge, Lewis county, all occur in the Gouverneur district, St. Lawrence county. They lie in a zone about 2 miles wide and 10 miles long extending northeasterly from Sylvia lake to and beyond the town of Edwards. The deposits consist for the most part of white, fibrous talc mingled with tremolite and occur in zones, lenses, or irregular masses up to 40 or even 65 feet wide and several hundred feet long. They conform in structure to the enclosing wall-rock and hence trend northeasterly and usually dip 30 to 60 degrees to the northwest. They are believed to have been formed from the tremolitic limestone of the Grenville series through the agency of intrusive granite[3] magmas. The quality of the talc varies according to the degree to which this alteration from tremolite to talc has been carried and "much of the material mined as talc is probably not talc but tremolite or a product of partial alteration as it is often 2 to 3½ in hardness (pure talc is 1) and has little slip."[4] Most of the talc produced in New York state is used in the manufacture of paper and as filler in paint, for which its fibrous character makes it especially useful.

Vermont[5]

The talc deposits of Vermont lie in the southern continuation of the serpentine belt of Quebec. They are similar in character to the Quebec deposits, but occur more commonly as detached lenses that are not so evidently associated with serpentine. The following description is taken chiefly from the accounts of E. C. Jacobs published in the Reports of the Vermont State Geologist.

The talc occurs in lenses which lie here and there in a zone extending throughout nearly the whole length of the state. The rock in which the talc is found is a quartz-sericite schist of low magnesia content and is probably of sedimentary origin. The lenses lie parallel to the foliation of the schist, which usually trends north and south. Most of the deposits

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[1] Sampson, Edward: "Talc and Soapstone"; U.S. Geol. Surv., Mineral Resources, 1922, p. 83. *See* Chapter VI, p. 83.

[2] Sahlen, A.: "The Talc Industry of the Gouverneur District, New York"; Trans. Am. Inst. of Min. and Met., vol. XXI, pp. 583-88 (1893). Mineral Industry, vol. I, pp. 435-38 (1892).

Smyth, C. H., Jr.: "Preliminary Examination of the General and Economic Geology of Four Townships in St. Lawrence and Jefferson Counties, New York"; New York State Mus., Ann. Rept., vol. XLVII, pp. 685-709 (1894). "Report on the Talc Industry of St. Lawrence County, New York"; New York State Mus., Ann. Rept., vol. XLIX-2, pp. 661-71 (1898).

Newland, D. H.: New York State Mus. Bull. No. 223-4. The Mineral Resources of the State of New York, pp. 283-295.

Ladoo, R. B.: "Talc Mining in New York"; U.S. Bureau of Mines, 1920.

[3] Smyth, C. H.: "Genesis of the Zinc Ores of the Edwards District, St. Lawrence County, N.Y."; New York State Mus. Bull. 201, p. 31 (1917).

[4] Ladoo, R. B.: "Talc Mining in New York"; U.S. Bureau of Mines, 1920, p. 2.

[5] Jacobs, E. C.: Reports of the Vermont State Geologist, 1913-14, pp. 332-429; 1915-16, pp. 232-280.

Ladoo, R. B.: "Talc Mining in Vermont"; U.S. Bureau of Mines, 1919.

consist of a central mass of talc and dolomite known as "grit" which merges on either side into a relatively narrow zone of almost pure talc. The almost pure talc is adjoined in turn by a zone of chlorite schist called "blackwall" by the miners. In one deposit, the Moretown, however, the talc zone, as in the case of many of the Quebec deposits, lies on either margin of a serpentine band. In places within the talc and grit chloritic zones or masses similar in appearance to the blackwall (cinder) are present.

The grit is a grey, crystalline material which under the microscope is seen to consist chiefly of talc and dolomite, with serpentine (antigorite variety) and pyrrhotite as less abundant constituents.

The analyses in column I of the following table indicate that the maximum proportion of talc present in the grit is about 37 per cent.[1] The maximum width of the grit is stated by Jacobs to be 190 feet.

——	I	II
SiO_2	23·53	56·69
Al_2O_3	2·45	3·68
Fe_2O_3	....	1·16
FeO	5·26	3·77
Fe (for FeS)	....	0·31
MnO	....	0·26
MgO	28·14	28·13
CaO	10·26	1·57
S	....	0·20
H_2O+	1·40	4·60
Loss on ignition excluding water	29·04	
Total	100·08	100·37

I. Rochester grit, Report of the Vermont State Geologist, 1915–16, p. 265.
II. Rochester talc, Report of the Vermont State Geologist, 1915–16, p. 265.

The high-grade talc of Vermont as distinguished from the grit varies from a soft, translucent variety to a moderately hard, compact, massive type. It ranges in colour from white, through light green and grey-green to dark, mottled green.[2] The principal impurities shown by microscopic examination to be present are serpentine (antigorite variety), dolomite (near the grit), actinolite, and pyrrhotite. These, according to the analyses (column II in the above table), form about 10 per cent of the whole if all the silica is contained in talc.

Virginia[3]

The talc and soapstone deposits of Virginia are confined to the triangular upland area that occupies the central part of the state, the Piedmont plateau. This region is underlain chiefly by a complex of schists, gneisses, granites, slate, quartzite, etc., intruded in places by basic eruptives. The strike of the complex is in general northeast and the dip southeast. The deposits consist almost entirely of grey soapstone and occur in a

[1] If all the silica is contained in talc.
[2] Ladoo, R. B.: "Talc Mining in Vermont," 1919.
[3] Watson, T. L.: "Mineral Resources of Virginia," 1907, pp. 290–96.

northeasterly-trending belt extending from Grayson county on the North Carolina boundary to Fairfax at the north end of the state. The most important quarries are in Nelson and Albermarle counties. The soapstone occurs in zones from 30 to 165 feet wide and conforms to the structure of the adjacent rocks. The deposits are enclosed in altered sediments, quartz mica schist, micaceous sandstone, or quartzite, except in places in Albermarle county where they are associated with an altered basic intrusive. They are believed to have been formed by alteration from basic igneous rocks.[1]

The material is marketed partly in the ground form, but chiefly as sawn or manufactured soapstone (Alberene stone). Most of the soapstone produced in North America is derived from the Virginia deposits.

California[2]

The talc deposits of California occur chiefly in Inyo and San Bernardino counties in the southeastern part of the state. They occur in irregular masses, lenses, or zones up to 12 feet wide enclosed in dolomite or lying on the contact of limestone and intrusive diorite. The talc is slate-grey, pale green, or pure white and contains tremolite as its principal impurity. It is stated by Ladoo that the talc occurring in the two principal properties contains less than 1 per cent lime,[3] but analyses are not given. In the following analyses of California talc cited by Diller it contains 2·60 to 4·28 lime.

——	I	II	III
Silica	60·20	60·88	63·36
Alumina	1·25	0·36	0·46
Ferric iron	2·50	0·10	0·09
Ferrous iron	0·00	0·33	0·30
Magnesia	27·98	28·85	27·60
Lime	2·60	4·28	3·49
Water	5·70	4·50	3·92
	100·23	99·30	99·22

I. Sheep creek, 20 miles northwest of Silver lake, San Bernardino county. Analyst, R. A. Percy.
II. One mile north of Riggs Station, 9 miles north of Silver lake, San Bernardino county. Analyst, R. C. Wells, U.S. Geol. Surv.
III. Seven miles southeast of Riggs Station, San Bernardino county. Analyst, R. C. Wells, U.S. Geol. Surv.

If the lime shown to be present in these samples were contained entirely in tremolite the deposits would contain fiom 20 to 30 per cent tremolite, since normal tremolite contains 13·4 per cent lime. It is

[1] Keith, Arthur: U.S. Geol. Surv., Washington, Folio No. 70, 1901, p. 7.
Diller, J. S.: "Talc and Soapstone"; Mineral Resources of United States, 1915, p. 28.
[2] Diller, J. S.: "Talc and Soapstone"; Mineral Resources of United States, U.S. Geol. Surv., 1913, pp.157-160.
Ladoo, R. B.: "High Grade Talc and the California Talc Industry"; U.S. Bureau of Mines, Reports of Investigations, May, 1921.
Bradley, W. W.: "California Mineral Production for 1920," pp. 140-142.
[3] Diller, J. S.: "Talc and Soapstone"; Mineral Resources of the United States, U.S. Geol. Surv., 1913, pp. 158.

suggested by Diller that the California deposits have been derived from limestone by metamorphism in a manner similar to that outlined by Smyth for the New York deposits.

Pennsylvania and New Jersey[1]

The talc deposits of Pennsylvania and New Jersey are associated with crystalline limestone in the belt of Precambrian rocks that extends diagonally from Pennsylvania across the northwestern part of New Jersey. The principal deposits occur near Easton, Pennsylvania, and Phillipsburg, New Jersey. They consist of mixtures of magnesia or lime-magnesia silicate minerals, tremolite, phlogopite, serpentine, or talc—usually associated with dolomite or limestone. They are believed to have been formed by the metamorphic action of intrusive granite and pegmatite on crystalline limestone or dolomite. The material is sold partly in the ground form as mineral pulp or low-grade talc and partly as rock for decorative purposes.

North Carolina[2]

The talc and soapstone deposits of North Carolina are found almost exclusively within the belt of Appalachian folding that extends acoss the western part of the state. They are of two classes: (1) lenticular masses and sheets of talc in blue and white Cambrian (Cherokee) marble; and (2) lenticular masses of soapstone and talc associated with dunite and other basic intrusives. The deposits of the first type occur in lenticular masses up to 50 feet wide and 200 feet long enclosed in the Cherokee marble. The presence of tremolite and other lime-magnesia silicates in the deposits and their association with dolomite suggest that they have been formed from the dolomite by metamorphism. The deposits of the second class—the soapstone type—are believed to be derived from dunite or other basic intrusives with which they are associated. They consist chiefly of talc mingled with varying proportions of tremolite, actinolite, hornblende, and chlorite. The pure talc is found chiefly in zones along the margin of the soapstone mass or in veins traversing the soapstone. In these respects the deposits are remarkably similar to the talc and soapstone deposits of the Eastern Townships of Quebec and Vermont.

Maryland[3]

Small deposits of talc and soapstone are found in Maryland in association with masses of serpentine that occur scattered through the Piedmont region. A small part of the output is sawn into slabs for sinks, fire-brick, etc., but most of the product is ground and sold to manufacturers of acid-proof and fire-proof paint. "The highest grades of talc . . .

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[1] Peck, F. B.: "The Talc Deposits of Phillipsburg, N.J., and Easton, Pa."; Geol. Surv. of New Jersey, Ann. Rept. 1904, pt. 3.

[2] Pratt, J. H.: "Talc and Pyrophyllite Deposits of North Carolina"; North Carolina Geol. Surv., Econ. Paper No. 3, 1900.

Keith, Arthur: "Talc Deposits of North Carolina"; U.S. Geol. Surv., Bull. No. 213, pp. 433-38 (1903).

[3] Smith, W. B.: Maryland Geol. Surv., Cecil county, 1902, pp. 93-97, 100.

Clark, W. B., and Matthews, E. B.: "Maryland Mineral Industries"; Maryland Geol. Surv., vol. VIII, p. 160 (1909).

have not been found within the state in quantities large enough for successful mining." Some of the Maryland talc has been used in recent years for the manufacture of gas tips.

Georgia[1]

The important deposits of talc in Georgia are confined to the belt of highly folded and faulted Palæozoic strata that crosses the northwestern part of the state. They are divided by Hopkins into two groups: (1) those associated with a formation known as the Murphy marble, from which they have been formed by metamorphism, and (2) those which he believes have been derived from magnesia-rich igneous rocks that have intruded metamorphosed Palæozoic sediments—the Ocoene series. The deposits of the first class are lenticular or irregular in form and range from a few inches to 6 feet or in one case 40 feet in width. The deposits of the second class occur as zones up to 8 feet thick within or on the margins of layers or sheets of serpentine or a mixture of serpentine, chlorite, etc., known as "blue John."

ITALY[2]

The most important talc deposits in Italy are situated near Perosa and Pinerolo, southwest of Turin, in the western part of Piedmont. The talc is exceptionally pure and is used almost entirely either in toilet or medicinal preparations or in the massive form as lava.

FRANCE[3]

The most extensive deposits of talc in France lie on the north side of the Pyrenees mountains southeast of Foix in the Department of Ariège. Other places from which talc is being produced are Luzenac, near Cette, in the department of Hérault; Luzech, in the department of Lot; and localities in the departments of Pyrenees-Orientales, Isère, Aude, Savoie, and in the island of Corsica.

GERMANY[4]

Nearly the whole of the talc produced in Germany is obtained from deposits near the villages of Göpfersgrün and Thiersten in the Fichtelgebirges in northeastern Bavaria. The talc is entirely the massive variety, soapstone, and occurs in zones from a few metres to 500 metres long and several metres wide, developed on the contact of crystalline limestone or dolomite, and granite. The soapstone occurs in the zone in masses and sheets up to several hundred pounds in weight embedded in a decomposed brown matrix. Its colour is chiefly yellow or greenish white, except here and there, where it is spotted brown, green, or black, due to the presence of iron, graphite, or other impurities.

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[1] Hopkins, O. B.: "Asbestos, Talc, and Soapstone Deposits of Georgia"; Geol. Surv. of Georgia, 1914, pp. 90-309.

[2] Peck, F. B.: Mineral Industry, vol. XXI, p. 673 (1917).
Ladoo, R. B.: "World Resources of Talc and Soapstone"; U.S. Bureau of Mines, Reports of Investigations, 1919.

[3] "Talc"; Imp. Min. Res. Bureau, 1921.
Dammer, B., and Tietze, O.: Die Nutzbaren Mineralien, vol. 11, pp. 365–6 (1914).

[4] Dammer, B., and Tietze, O.: Die Nutzbaren Mineralien, vol. 11, p. 368 (1914).

AUSTRIA[1]

The principal talc deposits of Austria are at Mautern, Aflenz, and other localities in the eastern spur of the central Alps, Styria. At Mautern the talc lies on the contact of Carboniferous graphitic schist and overlying limestone and greywacke, in a zone up to 3 metres wide. Here and there the talc is white, but in other places it contains impurities and has a yellow-green, or grey colour. Weinschenk attributes the origin of the deposits to the alterations of the schist by waters derived from igneous intrusions.

SPAIN

Talc is found in Spain on the south side of the Pyrenees north of Figueras in the province of Gerona, near Mijas in the southern part of the province of Malaga, and in northeastern Almeria. The deposits in the first locality are similar to those on the north side of the Pyrenees in France. Those in Malaga occur as irregular lenses in the serpentine of the Sierra de Mijas.

INDIA[2]

Talc and soapstone are widely distributed in India and in the massive form were long ago carved by the natives into cooking utensils, ornaments, etc. One of the most important talc localities of India is Jubbulpore district, in the Central Provinces, where the talc occurs in pockets in dolomite. A grinding mill has been erected at Jubbulpore. The production from these deposits in 1920 was 2,295·5 long tons valued at £4,334.2[3] but this fell to 89·8 tons valued at £123 in 1922. Other localities in India where talc or soapstone occur, are: in Singhbhum and Mayurbhanja in Bihar and Orissa; in Nellore and Salem in Madras; in the Meiktila, Minbu, Pokokku Hill Tract, and other districts in Burma; in Hamirpur in the United Provinces; near Dev Mori in Idar state, Bombay;[4] and at Dogetha, Gisgarb, and Morra, in Jaipur, Rajputana.[5] The deposits in Singhbhum are stated by Fermor to lie "at or near to the sheared margin of peridotite intrusions into the Dharwarian slates and shaly slates."[6] The talc of Minbu district, Burma, occurs as veins up to 8 or 9 inches wide traversing dark green talcose serpentine.[7]

NORWAY[8]

Both talc and soapstone occur in Norway. The principal part of the production of talc is derived from deposits near Bergen in North and South Bergenhus. Most of the talc grinding mills are situated on Sogne

[1] Dammer, B., and Tietze, O.: Die Nutzbaren Mineralien, pp. 366-7 (1914).
Weinschenk, E.: Abhandl. Bayer. Akad. d. Wiss., vol. XXI, pt. 2, pp. 270-78 (1901).
[2] Mallett, F. R.: Rec. of the Geol. Surv., India, vol. XXII, pt. 2, pp. 59-67 (1889).
[3] Pascoe, E. H.: "Mineral Production of India"; Rec. Geol. Surv., India, vol. LIV, pp. 199 (1921); vol. LV, pp. 198-99 (1923).
[4] Middlemiss, C. S.: "Note on Steatite Deposits of Idar State"; Rec. Geol. Surv. India, vol. XLII, pp. 52-3 (1912).
[5] Heron, A. M.: Rec. Geol. Surv., India, vol. XLIII, p. 21 (1913).
[6] "The Mineral Resources of Bihar and Orissa"; Rec. Geol. Surv. India, vol. 53 pt. 3, pp. 301-2 (1921).
[7] Hayden, H. H: "Report on the Steatite Mines, Minbu District, Burma"; Rec. Geol. Surv., India, vol. XXIX, pt. 9, pp. 71-79 (1896).
[8] "Talc"; Imp. Min. Res. Bureau, 1921, p. 18.
Dammer, B., and Tietze, O.: Die Nutzbaren Mineralien, vol. 11, p. 368 (1921).

Fjord north of Bergen or near Vikör, southeast of Bergen. Deposits of soapstone occur in numerous localities in Norway, particularly in Gudbrandsdal, in Bergenhus, and in the neighbourhood of Trondhjem. In the last-named district, there are several large quarries from which stone was taken for the cathedral in Trondhjem.[1]

UNION OF SOUTH AFRICA[2]

Talc occurs in a number of localities in the metamorphosed basal rocks of the Union of South Africa, but was not mined to any extent until the Great War, when several deposits were developed and an industry established. The principal occurrences are found in Barberton and Krugersdorp districts in the Transvaal; between Eureka Siding and Jamestown in Cape province; and near Pomeroy in Zululand. The talc is being mined and milled in Barberton district at the Verdite and Scotia mines. At the former it occurs in vertical bands up to 15 feet wide in serpentine resulting from the alteration of ultrabasic rocks of the Jamestown series. In Krugersdorp district talc schist is being mined and shipped to Johannesburg for grinding.

[1] Oxaal, John: Den Norske Steinindustri, Norges Geologiske Undersokelse, No. 70, p. 63 (1914).

[2] Wagner, P. A.: "Report on Certain Minerals Used in the Arts and Industries"; S. Afr. Jour. Ind., vol. I, pp. 903 09 (1918).

Hall, A. L.: "The Geology of the Barberton Gold Mining District, Union of S. Africa"; Geol, Surv., Mem. No. 9, pp. 310-12 (1918).

Trevor, T. G.; "Talc"; S. Afr. Jour. Ind., vol. III, pp. 531-5 (1920).

CHAPTER VI

STATISTICS OF TALC

The statistical data of interest to the Canadian producer of talc are chiefly: (1) the production of talc and soapstone in Canada and the proportion of this production exported; (2) the production of talc and soapstone in United States, the country where most of Canadian talc is marketed; and (3) the production of talc and soapstone in other countries, and especially in those countries that export talc to United States or that might compete with Canadian talc in those countries of the world where a market for Canadian tale might be established.

The properties which make talc useful for each of its applications are so restricted that many talc deposits useful for one purpose are entirely useless for others. For this reason, in the statements of production given in the tables that follow, the principal uses of the talc of each country, following the classification of uses given in Chapter I, are indicated.

The soapstone deposits of the Eastern Townships were mined in a small way for lining fire-places and ovens, and for foot-warmers, by the early settlers, but the earliest recorded attempt to mine the material extensively was in 1871 and 1872, when 300 tons valued at $1,800 was mined by Slack and Whitney from a deposit on lot 24, concession VII, Bolton township. There was also a small production from the Eastern Townships of Quebec during the years 1886 to 1889. Between 1885 and 1899 serpentinized limestone on Grindstone island, in Rideau lake, Leeds county, Ontario, was quarried and shipped by scow to Montreal to be ground for roofing material, and during 1896 to 1901 similar material was shipped from concession I, Leeds township, 2 miles west of Gananoque, to Montreal, for the same purpose. In the statistical reports of the Bureau of Mines, Ontario, and the Geological Survey, this serpentinized limestone has been classed as soapstone, but in reality it contains little, if any, talc and should be classed as serpentine. In 1896 the Henderson talc mine at Madoc, Hastings county, Ontario, was opened up and since then talc has been produced continuously from this region. Since 1920 there has been a small production of soapstone from Thetford district in the Eastern Townships of Quebec, and of talc from British Columbia.

The published data regarding the production of talc and soapstone, both for the different provinces and for Canada as a whole, are included in the following table:

Production of Talc and Soapstone in Canada[1]

Year	Quebec		Ontario		Canada	
	Tons, short	Value	Tons, short	Value	Tons, short	Value
		$		$		$
1872	300	1,800	Nil	....	300	1,800
1886	50	400	Nil	....	50	400
1887	100	800	Nil	....	100	800
1888	140	280	Nil	....	140	280
1889	150	1,200	Nil	....	195	1,170
1890	....	....	....	....	917	1,239
1891	10	....	Nil	....	10	....
1892	....	....	....	....	1,374	6,240
1893	....	....	....	....	717	1,920
1894	....	....	....	....	916	1,640
1895	....	....	....	....	475	2,138
1896	....	....	....	....	410	1,230
1897	....	....	....	....	157	350
1898	....	....	....	....	405	1,000
1899	....	....	100	500	450	1,960
1900	....	....	1,000	5,000	1,420	1,365
1901	....	....	400	1,400	259	842
1902	Nil	....	697	930	689	1,804
1903	Nil	....	920	2,625	990	2,739
1904	Nil	....	1,313	2,219	840	1,875
1905	Nil	....	1,120	2,240	500	1,800
1906	Nil	....	1,235	3,030	1,234	3,030
1907	Nil	....	1,870	5,010	1,534	4,602
1908	Nil	....	1,016	3,048	1,016	3,048
1909	Nil	....	4,350	8,700	4,350	10,300
1910	Nil	....	5,824	46,592	7,112	22,308
1911	Nil	....	5,404	47,725	7,300	22,100
1912	Nil	....	6,726	61,358	8,270	23,132
1913	Nil	....	20,738	125,340	12,250	45,980
1914	Nil	....	10,135	74,583	10,808	40,418
1915	Nil	....	11,005	85,325	11,885	40,554
1916	Nil	....	11,810	111,489	13,104	49,423
1917	Nil	....	16,076	179,554	15,803	76,539
1918	Nil	....	17,465	246,691	18,169	119,197

Year	Quebec		Ontario		British Columbia		Canada	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value
		$		$		$		$
1919	....	....	17,571	240,399	....	....	18,642	116,295
1920	....	....	20,359	306,319	120	....	21,671	166,934
1921	150	1,050	9,967	140,390	167	....	7,916	32,456
1922	203	7,700	12,874	178,397	277	....	13,195	188,458
1923	552	20,230	9,531	125,124	241	....	10,076	144,014
1924	449	20,273	10,718	130,577	165	....	11,209	152,032

Statistics: 1872—Chas. Robb, Geol. Surv., Canada, Rept. of Prog. 1871-2, p. 148. Quebec, 1877-1891—J. Obalski, Reports of the Commissioner of Crown Lands for the Province of Quebec; 1920-23—Theo. Denis, Reports on Mining Operations in the Province of Quebec. Canada, 1886-7—E. Coste, Geol. Surv., Canada, Ann. Repts., pt. S.; 1887-1906—E. D. Ingall, Geol. Surv., Canada, Ann. Repts. and Repts. of Sect. of Mines; 1907-1920—J. McLeish, "Mineral Production of Canada," Mines Branch, Dept. of Mines, Canada; 1921-24—S. J. Cook, "Mineral Production of Canada," Dom. Bur. Stat. Ontario—T. W. Gibson, Ann. Repts. Ont. Bureau of Mines. British Columbia—Fleet Robertson, Ann. Reports of Mines, B.C.

1 The discrepancies between the statistics for the province of Ontario and those for the Dominion are due chiefly to the fact that the talc from the Henderson mine is ground and sold by the George H. Gillespie Company, which purchases the crude talc from the owners of the mine (formerly Cross and Wellington, now Henderson Mines, Limited). The Dominion statistics up to 1922 are the tonnage and valuation of the crude talc mined, whereas the Ontario statistics are the tonnage and valuation of the ground talc sold by the George H. Gillespie Company. A small quantity of crude talc is shipped to United States annually.

For many years a few hundred tons of a rock consisting of talc, actinolite, and other minerials has been mined and ground for roofing material at Actinolite (formerly Bridgewater), Hastings county, Ontario. This material has been described as actinolite, but, as pointed out in Chapter IV, talc is more abundant in these occurrences than the actinolite. The production since the year 1901 has been as follows:

Production of Actinolite in Canada

Year	Tons	Value	Year	Tons	Value	Year	Tons	Value
		$			$			$
1901	521	3,126	1912	92	1,000	1919	80	880
1902	800	6,150	1913	66	720	1920	100	1,160
1903	....	1,650	1914	119	1,304	1921	78	975
1904	408	102	1915	220	2,420	1922	50	575
1905–09	Nil	Nil	1916	250	2,750	1923	53	583
1910	30	330	1917	120	1,320	1924	90	1,925
1911	67	746	1918	228	2,508			

Production: 1901-0[illegible]—T. W. Gibson, Ann. Repts. Ont. Bureau Mines; 1915-1919—J. McLeish: "Mineral Production of Canada," Mines Branch, Dept. of Mines, Canada; 1921-2[illegible]—S. J. Cook, "Mineral Production of Canada," Dom. Bur. Stat.

Exports of Talc from Canada[1]

Year	United States				United Kingdom		Other countries		Total	
	Crude		Refined		Refined		Refined			
	Tons, short	Value $	Tons, short	Value $	Tons, short	Value $	Tons, short	Value $	Tons, short	Value $
1921	71	437	6,486	111,776	......	....	22	277	6,579	112,490
1922	......	....	9,747	142,636	66	792	41	510	9,854	143,938
1923	......	....	6,928	95,036	219	3,109	85	1,094	7,232	99,239

[1] Warne, W. A.: Chief, External Trade Branch, Dom. Bur. Stat.

Consumption of Talc and Soapstone in Canadian Industries, 1922

—	Number of companies	Domestic	Foreign	Total
		Pounds	Pounds	Pounds
Medicinal and pharmaceutical preparations	....	208,977	89,340	298,317
Enamelware, porcelain, and pottery	2	300,000	....	300,000
Paper mills	....	....	....	2,082,000
Roofing and mineral wall-board	5	....	....	2,700,705
Rubber	9	783,556	55,000	838,556
Soap	16	211,700	70,000	281,700
Foundry				
Paint				

"Special Report on the Consumption of Prepared Non-Metallic Minerals in Canada," Dom. Bur. Stat., 1923.

UNITED STATES[1]

Talc and Soapstone Mined and Sold in the United States, 1920-1922, by States

State	1920		1921		1922		Per cent of total quantity
	Short tons	Value $	Short tons	Value $	Short tons	Value $	
Vermont (medium to low grade)[1]	86,489	816,794	48,648	438,534	75,485	654,715	38
New York (medium grade)	68,168	977,228	37,489[2]	464,645[2]	71,470	1,116,914	36
Virginia (soapstone)	21,715	729,767	17,721	601,878	25,351	736,132	13
California (high grade)	13,199	232,182	8,233	128,183	12,638	187,011	6
Pennsylvania, New Jersey (low grade)	11,183	121,302	7,205	76,912	8,373	87,367	4
North Carolina	2,267	75,474	731	17,048	2,194	23,049	1
Maryland	4,372	17,948	[3]	[3]	1,667	14,667	2 (Maryland and Other states)
Other states[4]	3,242	64,754	1,959	28,737	1,506	40,042	
	210,635	3,035,449	121,986[2]	1,755,942[2]	198,684	2,859,897	100

[1] Inserted by the writer.
[2] Revised figures.
[3] Included under "Other states."
[4] 1920 and 1921; Georgia, Massachusetts; 1922; Georgia.

World Production of Talc and Soapstone (Short Tons)

Country	1918	1919	1920	1921	1922
Australia[1]	749	585	615	388	524
Austria[2] (exports)	....	....	7,597	8,854	14,831
Canada (high grade)	18,169	18,642	21,671	7,916	
France[3] (high grade)	63,459	39,242	57,767[5]	....	
Germany[3] (soapstone)	10,260	15,983	23,085	7,295[5]	
India[4]	5,082	2,391	4,123	2,318	1,115
Italy[3] (high grade and lava)	19,146	18,942	23,969	23,148	27,562
Norway[2]	17	3,294	3,098	3,066[5]	
Spain[3]	3,668	3,335	2,366	1,229[2]	3,776[2]
Union of South Africa[5]	730	882	654	590	
United Kingdom[5]	1,048	772	404	....	
United States[2]	208,307	184,843	210,635	121,986	198,684

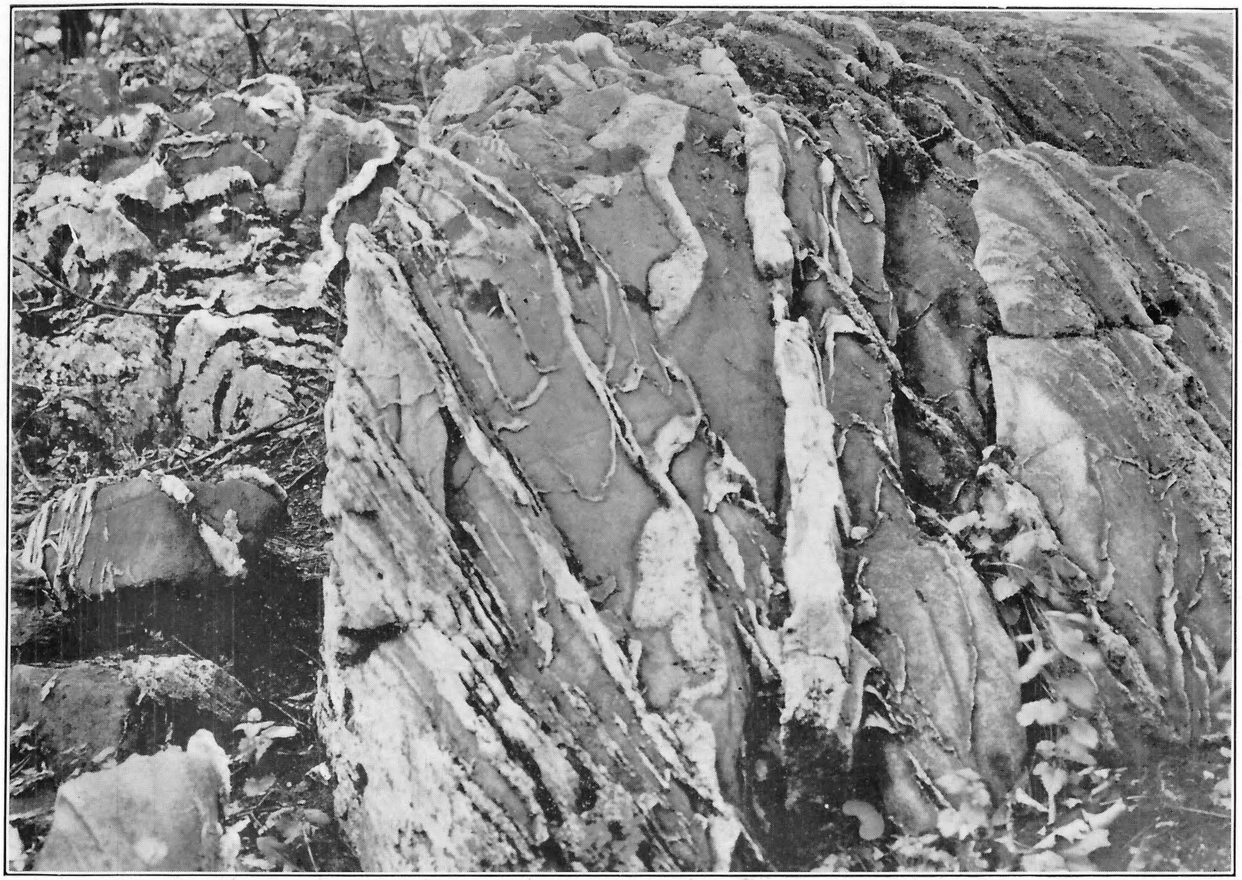
[1] New South Wales, Dept. of Mines, Ann. Repts., South Australia, Dept. of Mines, Min. Rev.
[2] Sampson, E.: "Talc and Soapstone in 1922"; U.S. Geol. Surv., Min. Res. of U.S., 1922, pt. II, p. 85.
[3] Peck, F. B.: Mineral Industry, vol. XXXI, p. 659 (1922).
[4] Pascoe, E. H.: Rec. Geol. Surv., India.
[5] "Talc"; Imp. Min. Res. Bur., 1924.

[1] Sampson, Edward: "Talc and Soapstone"; U.S. Geol. Surv., Min. Res. U.S., pt. II, pp. 82-83 (1922).

PLATE II

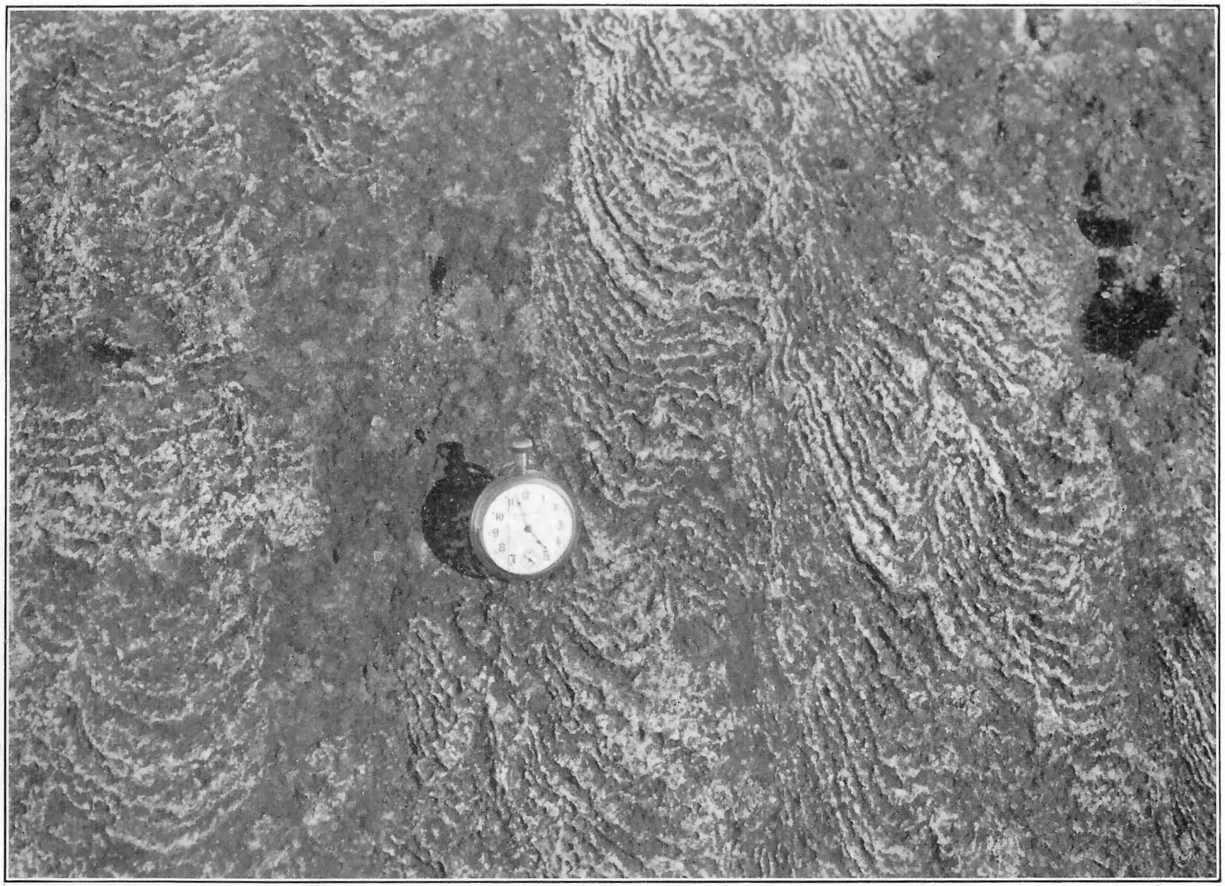
Indian and Eskimo carvings from soapstone: (1), (2), and (3), Eskimo, Labrador; (4), Indian pipe, Ontario; (5) Eskimo lamp, Coronation gulf, North West Territories.

PLATE III



Quartz veins and zones in dolomite, lot 21, concession V, Madoc township, Hastings county, Ontario. (Pages 18, 75.)

PLATE IV



Interlaminated tremolitic dolomite and granular quartz (*Eozoon canadense*), lot 14, concession XIV, Huntingdon township, Hastings county, Ontario. (Page 18.)

PLATE V

Aggregates of tremolite in dolomite, lot 1, concession VII Madoc township, Hastings county, Ontario. (Page 79.)

PLATE VI

Crumpled dolomite of Hastings series, lot 22, concession X Madoc township, Hastings county, Ontario. (Page 27.)

PLATE VII

Slaty sediments impregnated by quartz veins on right bank and near mouth of Nahatlatch river on property of Pacific Talc and Silica Company. (Page 43.)

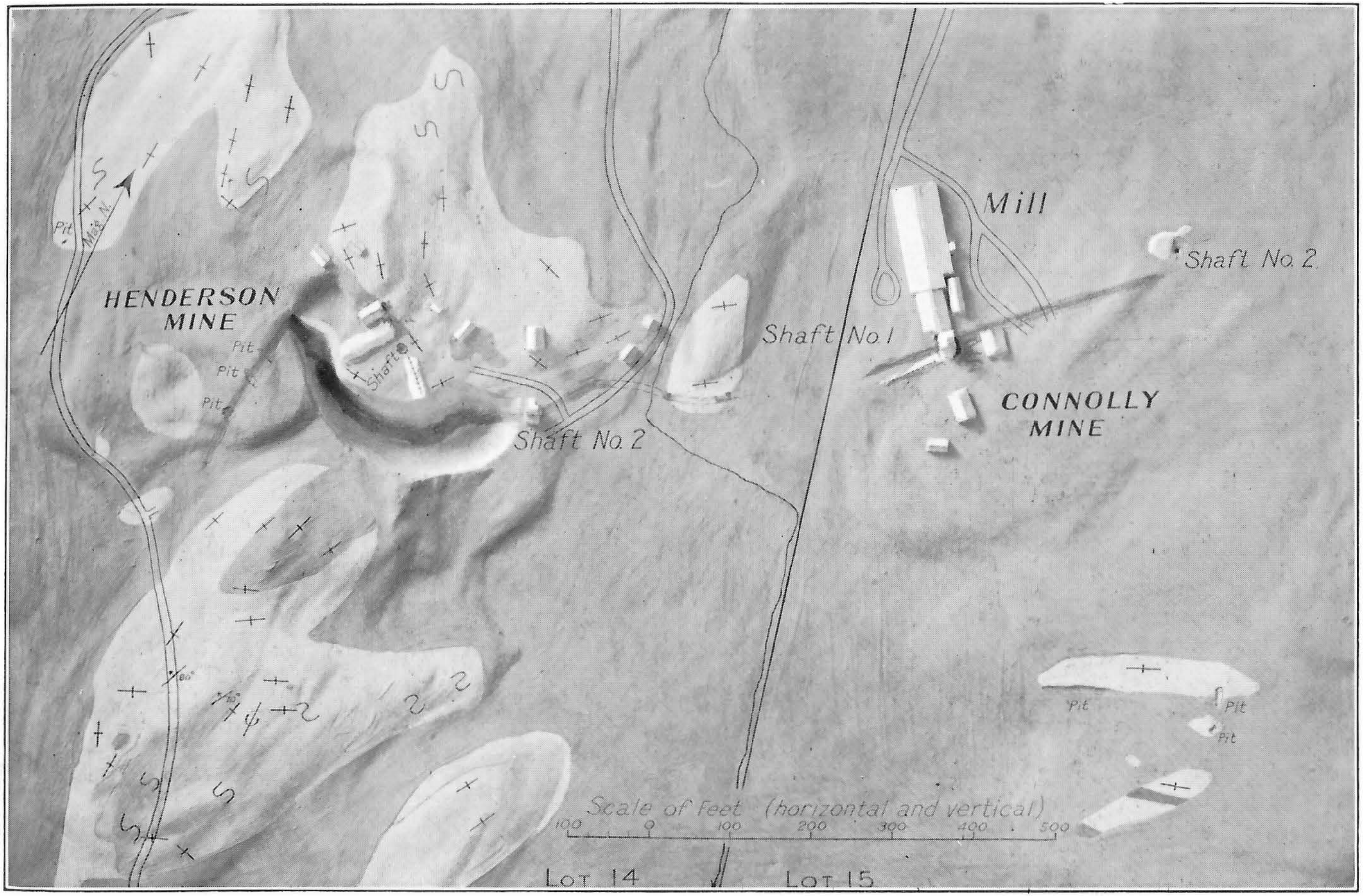
PLATE VIII

Brecciated grey dolomite in a matrix of white tremolitic dolomite, from No. 3 shaft, in north wall of talc deposit, Henderson mine, lot 14, concession XIV, Huntingdon township, Hastings county, Ontario. (Page 80.)

PLATE IX

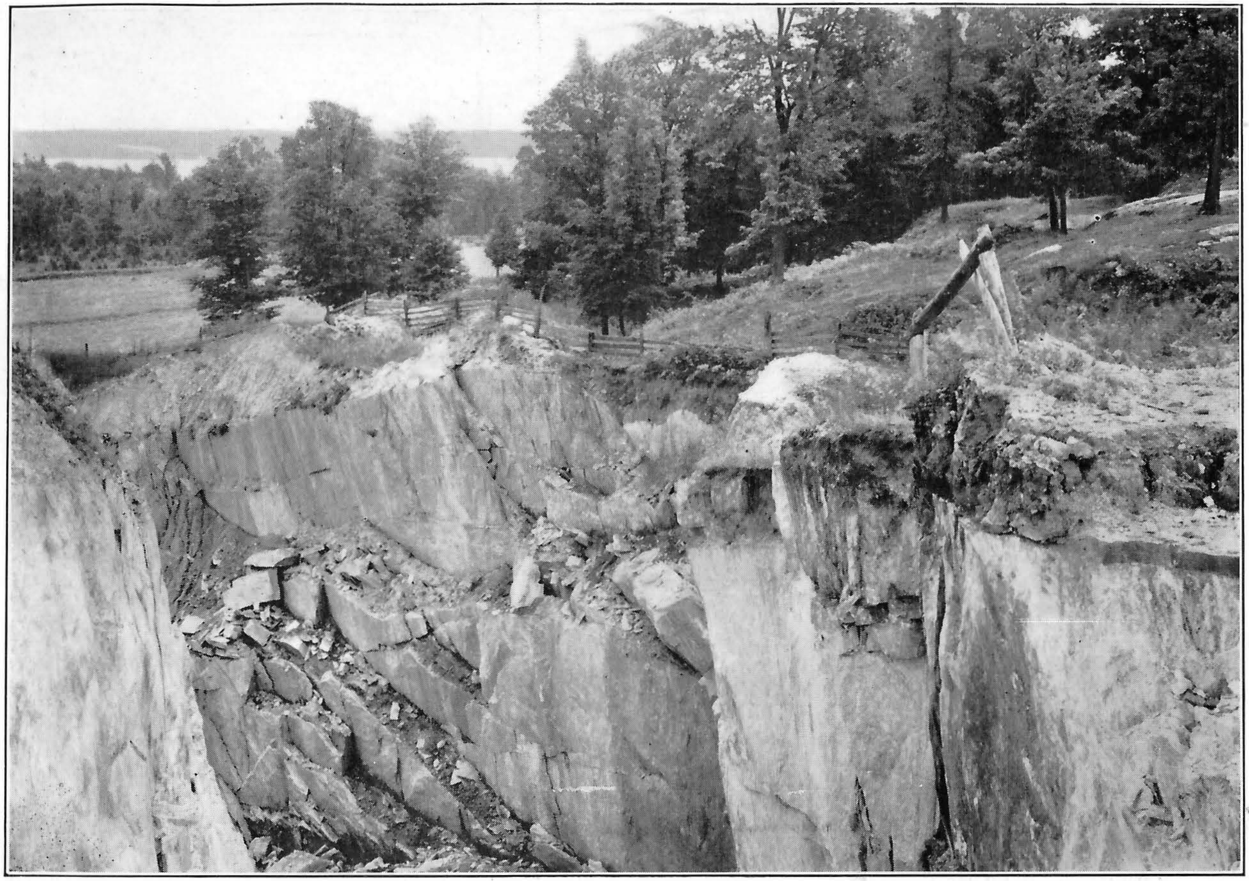
Crumpled quartzite 300 feet south of main pit, Henderson talc mine, lot 14, concession XIV, Huntingdon township, Hastings county, Ontario. (Pages 80, 81.)

PLATE X



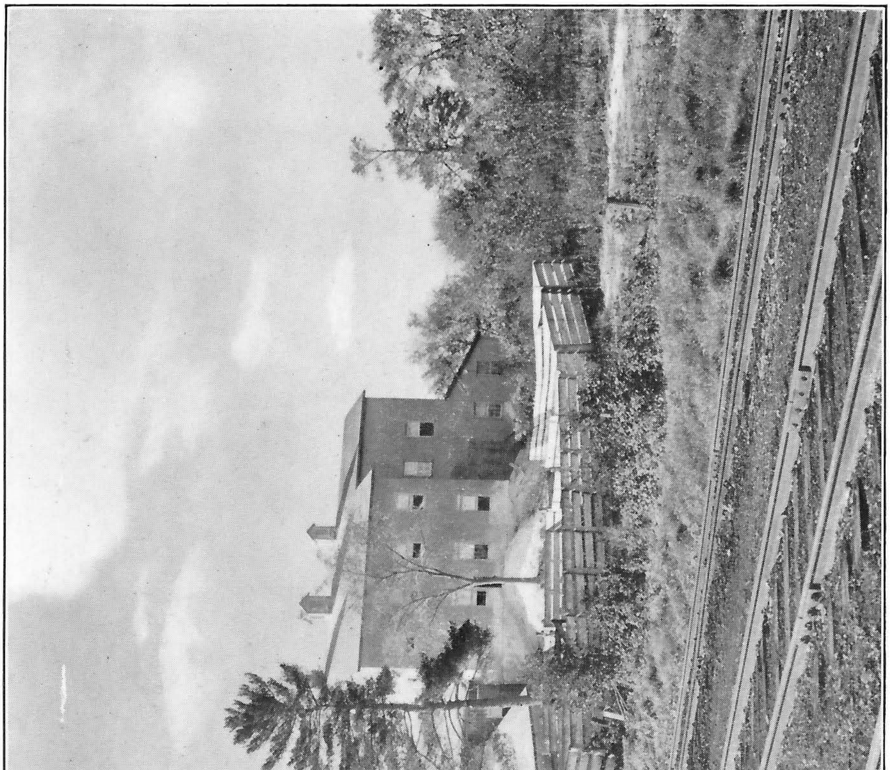
Relief model of Henderson and Connolly properties, Madoc, Hastings county, Ontario. (Page 81.)

PLATE XI



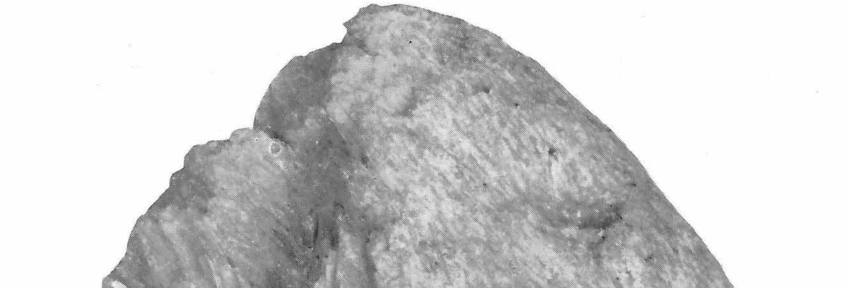
Main pit, Henderson talc mine, lot 14, concession XIV, Huntingdon township, Hastings county, Ontario. (Page 78.)

PLATE XII



Talc mill, of the George H. Gillespie Company, Limited, Madoc, Hastings county, Ontario. (Page 78.)

PLATE XIII



Tremolite, from wall-rock, Connolly talc mine, lot 15, concession XIV, Huntingdon township, Hastings county, Ontario. (Page 85.)

Micaceous talc, Grimsthorpe township, Hastings county, Ontario. (Pages 23, 90.)

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