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TALC, STEATITE, AND SOAPSTONE; PYROPHYLLITE

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FOREWORD

In 1938, of the eighteen Canadian mineral products embraced within the category of "Industrial Minerals", (an arbitrary grouping, but used here to include those minerals commonly termed "non-metallics"), talc and soapstone ranked eighth in point of value and probably ninth in respect to tonnage sold. For a number of years, although there have been periodic minor fluctuations in the quantity produced and value of output, the talc industry, on the whole, has remained remarkably stable, even the "depression" years not affecting production materially.

The main productive talc region has for many years been confined to the Madoc district, in Ontario, where two old-established mines and mills have been in steady operation. Almost all of the cut soapstone has come from deposits in the Thetford district, in Quebec, where a small but steady industry has been in existence since 1922.

Two special reports dealing with talc and soapstone have been published by the Department of Mines in the last sixteen years, one, by the writer, in 1922 (Talc and Soapstone in Canada, Mines Branch Report No. 583), and the other, by M. E. Wilson, in 1926 (Talc Deposits of Canada, Geological Survey Report No. 2092). These reports deal exhaustively with the occurrence, mining, preparation for market, and uses of talc, previous to 1926.

In a later report (Mines Branch Report No. 687, Section VII, published in 1928), the writer deals with the Canadian soapstone industry in more detail, and in the annual reports "The Canadian Mineral Industry," issued since 1924 by the Mines Branch, has reviewed current progress in the talc and soapstone industries.

In a recent report on the asbestos region of Quebec, by H. C. Cooke (Geological Survey Report No. 2440, published in 1937), brief descriptions of the soapstone deposits of this district are given, and their origin discussed.

Annual reports of both the Ontario and Quebec Provincial Mines Departments have reviewed current mining progress for the years concerned, in the two provinces.

In 1927, a short report (Talc and Soapstone in Nova Scotia) by J. P. Messervey was published by the Nova Scotia Department of Public Works and Mines, as Monograph Pamphlet No. 27.

The above publications comprise all of the major reports dealing with talc and soapstone in Canada.

In the present report, the writer has brought together the salient information on Canadian talc and soapstone occurrences contained in the earlier publications noted, together with later data on world production, methods of mining and milling, utilization, and markets. In addition, it also contains a section dealing with pyrophyllite, a mineral very similar to talc in many respects, and one that can be used in place of it for a number of industrial purposes.

Thanks are tendered to the various companies and individuals, who, by kindly furnishing information, either on the occasion of visits to properties or by correspondence, have materially assisted in the preparation of the data here presented.

Talc, Steatite, and Soapstone; Pyrophyllite

PART I

TALC, STEATITE, AND SOAPSTONE

CHAPTER I

CHARACTER, MODE OF OCCURRENCE, DEFINITIONS, USES, ETC.

TALC

The mineral talc is a hydrous silicate of magnesium, with the theoretical formula $H_2Mg_3(SiO_3)_4$, this corresponding to 63·5 per cent silica, 31·7 per cent magnesia, and 4·8 per cent water[1]. Investigation has shown[2], however, that the ratios of these constituents are variable within rather wide limits, the magnesium-silica ratio ranging from 1:1 to 4:3, and the water content from 3 to over 7 per cent. These variations show the following possible theoretical compositions for talc:

H_2O : MgO : SiO_2	1 : 4 : 5	1 : 3 : 4	2 : 4 : 5
Water	3·8	4·8	7·2
Magnesia	33·6	31·7	32·3
Silica	62·6	63·5	60·5

The water is driven off only at red heat.

Talc is a very common mineral, and is often found as large deposits having the form of bands, beds, lenses, or even vein-like bodies, made up of a loosely coherent aggregate of small flakes. It is essentially a secondary mineral, usually formed, it is believed, by hydrothermal alteration of original magnesium carbonate or silicate minerals, such as dolomite, pyroxene, amphibole, chlorite, etc. Talc pseudomorphs after a large variety of minerals are known, particularly in zones of intense metamorphism, quartz even converting to talc under suitable conditions, (e.g. in the steatite deposits of the Göpfersgrün district, Bavaria). The mineral names rensselaerite and pyrallolite have been given to varieties of talc pseudomorphous after diopside, enstatite, tremolite, etc., the material often being of a buff to brownish shade, depending on the original iron content of the primary mineral and the degree of oxidation. Where the

[1] Dana: System of Mineralogy, 6th Ed., p. 678.

[2] Foshag, W.F. and Wherry, E. T.: "Notes on the Composition of Talc", Amer. Mineralogist, vol. 7, No. 10, Oct., 1922, pp. 167-71.

crystals of the primary mineral were of large size, or where their outlines have become obscured or destroyed by metamorphism, the resulting massive talc may properly be termed "steatite" (*see* page 9).

The formation of talc on a major scale usually takes place either (*a*) under conditions of intense dynamic disturbance, where the magnesian host rock has suffered severe deformation and squeezing by tectonic agencies, with attendant heat and pressure, or (*b*) where such rock has been subjected to contact metamorphism through the agency of igneous intrusions[1].

Where the host rock is an older crystalline dolomite, or similar carbonate rock, the first stage often apears to have been the formation, by silicification, of a lime-magnesia silicate, such as tremolite, which finally alters to talc. In such case, particularly where alteration has remained incomplete, the talc may contain considerable residual silicate, as in the deposits of fibrous talc of the Gouverneur district, New York (so-called "Asbestine", "Tremoline", "Loomite", etc.). The principal impurities in talcs of such origin are usually dolomite (often loosely termed "lime"), quartz, and various residual silicate minerals.

Where the host rock is an ultrabasic, ferromagnesian, igneous rock, such as pyroxenite, peridotite, or serpentine, the first stage is the formation of chlorite, which in turn alters to talc. Where alteration of the original ferromagnesian minerals has been only partial, their form will be preserved, with the formation of a soft talc-chlorite rock, termed "soapstone" (*see* page 11). In zones of more intense metamorphism complete chloritization may take place, followed by more or less complete talcification. The common impurities found in talcs derived from such rocks are residual chlorite and sometimes serpentine, secondary carbonates (dolomite or magnesite), spinel, magnetite, and the sulphides pyrite or pyrrhotite.

Where a talc body, once formed, has been subjected to no further dislocation or disturbance, the final product is commonly a deposit of bedded or schistose type, consisting of fissile layers of small talc flakes. Often, however, such bodies have suffered later deformation, and are found squeezed into irregular, lens-shaped masses, occupying all sorts of attitudes, and frequently steeply inclined. Talc, being extremely soft and possessing high slip, deposits of the mineral present little resistance to dynamic stresses and are the least competent member of the rock assemblage in which they occur. Accordingly, they are readily deformed and crushed under earth movement, providing planes of slippage along which the roof rock may ride. Evidence of such movement is often to be seen in the intense slickensiding developed in talc bodies, particularly in those of mountainous regions. Examples of the first, relatively undisturbed type

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[1] For a discussion of the theories of origin of talc and soapstone, see the following:
Gillson, J. L.: "Origin of the Vermont Talc Deposits", Econ. Geol., vol. 22, No. 3, May, 1927, pp. 246–87.
Burfoot, J. D.: "The Origin of Talc and Soapstone Deposits in Virginia", Econ. Geol., vol. 25, 1930, pp. 805–26.
Hess, H. H.: "The Problem of Serpentinization and the Origin of Certain Chrysotile Asbestos, Talc and Soapstone Deposits", Econ. Geol., vol. 28, No. 7, Nov., 1933, pp. 634–57, vol. 30, No. 3, May, 1935.
Hess, H. H.: "*Hydrothermal* Metamorphism of an Ultrabasic Intrusive at Schuyler, Virginia", Amer. Jour. Science, Oct., 1933, pp. 377–408.
Bain, G. W.: "Serpentinization: Origin of Certain Asbestos, Talc and Soapstone Deposits", Econ. Geol., vol. 29, No. 4, June-July, 1934, pp. 397–400.
Stuckey, J. L.: "Talc Deposits of North Carolina", Econ. Geol., vol. 32, No. 8, Dec., 1937, pp. 1009–18.
Wilson, M. E.: "Talc Deposits of Canada", Geol. Surv., Canada, Econ. Geol. Series No. 2, 1926, pp. 17–32.

are to be found in the Robertsonville district, in the Eastern Townships, Que., whereas the Vermont deposits afford illustrations of extremely disturbed bodies.

The finest and highest-priced commercial talcs are found in deposits in younger, bedded dolomites that have suffered relatively little metamorphism or recrystallization. Recrystallization, especially under conditions of contact metamorphism, is usually attended with the introduction of foreign mineral elements, resulting in the formation of the varied range of secondary silicates common in the older (Precambrian) carbonate rocks and also in the talc deposits associated with them. In the younger and less highly altered dolomites, talc appears to have been formed by a direct process of silicification of the magnesia constituent, the lime being removed in solution. Examples of this last type are the Italian and French talcs, renowned for their high purity and fine white colour, which occur in dolomites of Jurassic age, and also the Manchurian talc.

The colour of talc is essentially dependent on the processes by which it has been formed and the rocks (minerals) from which it has been derived. Talc formed from dolomitic rocks ranges in the mass from pure white, through cream, to sometimes pale apple-green, grinding to a snow-white powder. In thin, individual flakes talc is practically colourless, and in massive form it is translucent to a high degree, particularly the green shades. When derived from ferromagnesian minerals, via chlorite, it is commonly pale greenish grey in the mass and yields an inferior powder of similar off-colour shade. The colour in this case is due to the content of ferrous iron in the various mineral impurities present in the form of fine disseminated grains, and including also skeletal remnants or shreds of residual chlorite within the talc flakes themselves. The colour of these talcs is hardly susceptible of improvement in commercial practice, though in some cases a portion of the coarse impurities may be removed by air separation in the grinding process. Some success has also attended recent attempts to beneficiate talc by flotation in a Vermont mill, the product being materially improved in colour. (*See* pages 46 and 107.)

As indicated in succeeding sections, the name "talc" is often used as a comprehensive term to include the straight mineral, in the form of aggregates of flakes or fibres; the compact, cryptocrystalline variety steatite; and a soft, impure talcose rock (soapstone), of very variable talc content. Consequently, it is often difficult to gather from the literature just what type of material is meant in the descriptions of occurrences, as well as in statistical records. It is impossible, therefore, to adopt here any strict definition for talc, and, in the circumstances, it is necessary to follow commercial usage and restrict the term, in general, to the higher grade talcs employed in the ground form, but including, also, the more compact type used extensively for sawing into crayons. As will become apparent, it is use, rather than actual composition and character, that dictates the particular term applied to the different types of talc. Massive steatite, used for "lava" purposes, is often termed "soapstone", while in the ground form it may be dubbed "talc." On the other hand, the more compact and coherent talcs, when used for sawing into crayons, retain in practice the designation "talc", but when cut into furnace bricks are termed "soapstone": powder made from such material may be classed, variously, as either "talc" or "soapstone". A common, popular term for powdered talc formerly was "French Chalk", but this name has now gone out of general use. The name "Agalite" is sometimes applied to powdered talc, particularly for that used in the paper industry. (*See also* page 2.)

Uses

The uses of talc are many and varied, and few, if any, minerals surpass talc in their range of industrial usefulness. Combining the desirable properties of extreme softness and smoothness, good lustre, or sheen, high slip, or lubricating power, low moisture, oil and grease absorption, chemical inertness, high fusion point, low electrical and heat conductivity, good retention (for filler purposes), extreme whiteness (giving good hiding power for pigment use), high specific heat, and possessing the additional advantage of being abundant and cheaply mined and prepared for market, powdered talc enjoys a steady demand in many industries.

The United States is by far the world's largest producer and consumer of talc, and probably more research into the properties and possible uses of the mineral has been conducted there than in any other country. A cross-section of the trade in that country, therefore, will give a good picture of the principal outlets for talc, as these may affect Canada. Up-to-date information on the American talc-consuming industries is available in recent published reports[1], from which the following data are largely taken: these should be consulted for a complete record of uses and consumption trends. The main details have been outlined in the introductory portion of the section dealing with the talc industry of the United States (*see* pages 38 to 40) and need not be repeated here. The following data, taken mainly from the cited paper by Gillson, will, however, amplify the picture of talc uses. Consumption percentages, by industries, as noted below, refer in all cases to the year 1937[2], and include talc, pyrophyllite, and ground soapstone[3].

The following five trades are the leading users of talc: paint, paper, ceramics, rubber, and roofing, in order of consumption. They take 75 per cent (170,000 tons) of the total talc sold, the remaining 25 per cent (60,000 tons) being distributed over a number of minor uses: for many of these latter, however, talc is an important, and even an indispensable, material.

[1] References Nos. 9 and 10 of the Bibliography at the end of this report. More detailed information on the properties and uses of talc is contained in the earlier report by Ladoo (1923), No. 6 of the Bibliography.

[2] AUTHOR'S NOTE.—Since this was written, American talc trade statistics for 1938 have become available (Minerals Yearbook 1939) and show some change in consumption trends from 1937. The paint industry continued to hold first place, taking 25 per cent (53,000 tons) of the 213,000 tons total. The ceramic industry moved from third into second place, with 14 per cent of the total, tonnage unchanged (30,000 tons). Roofing talc made a substantial gain and ranked third instead of fifth, with 13 per cent (28,000 tons), while paper talc dropped from second to fourth place, also with 13 per cent. The rubber trade took fifth rank, with 12 per cent (25,000 tons). Cosmetic talc sales jumped 38 per cent, with a gain of over 1,500 tons, and accounted for 3 per cent of the total. Foundry facings showed little change and remained seventh on the list, with 1 per cent.

[3] NOTE—In the latest official reports of the U.S. Bur. of Mines, as well as in Gillson's paper, the mineral pyrophyllite is included with talc and soapstone. Pyrophyllite closely resembles talc in its physical characteristics, and serves substantially the same industrial uses as talc. It may be regarded as the alumina analogue of talc, having the composition $HAl(SiO_3)_2$, with 66·7 per cent silica, 28·3 per cent alumina, and 5·0 per cent water. (*See* Part II, page 121.)

Paint Industry

The paint trade now consumes 26 per cent (60,000 tons) of all the talc sold in the United States, as against nearly 50 per cent in 1931. The percentage decrease is accounted for by the largely increased production and growing consumption by other industries.

The higher grade, white talcs are the principal ones used, and include both the foliated and fibrous types. The latter come mostly from New York State and are marketed under such trade names as "Asbestine", "Tremoline", "Loomite", etc. In paints, talc serves both as an extender (filler) and as a pigment. The fibrous talcs have been shown to have the desirable property of locking or bonding the paint film, and are used largely in cold-water paints, or distempers, for covering interior plaster finishes. Flake talc has good hiding power and is a very desirable pigment, its form giving added protective qualities to the paint film. According to Tyler[1], ground mica threatens to encroach on flake talc in paints, having similar protective properties.

Paper Industry

Paper follows paint in point of talc consumption, with 14 per cent (32,000 tons) of total sales. Talc is used as a filler or loader in many grades of paper, from the cheapest to the most expensive grades. It has better retention in the fibre of the paper than clay, and its flake nature makes it additionally desirable. For the quality grades, only the finer white talcs are used, but a certain amount of off-colour, grey talc goes into ledger paper. Talc also is employed as a surfacing agent in higher grade coated stock to impart sheen and to decrease absorption.

Ceramic Industry

The latest statistics of talc consumption show a very important gain in the amount used by the ceramic industry[2], which in 1937 took 10,000 tons more than in 1936 and ranked almost equal with the paper industry, using 13 per cent (30,000 tons) of the total. In 1931, only 1 per cent was so used. It should be noted, however, that a very large part of this material was pyrophyllite, which has rapidly come to the fore as a ceramic raw material and the production of which is fast increasing.

The use of massive "lava" talc for the production of sawn and machined, fired shapes for refractory, chemical, and electrical use is dealt with in the following section on steatite, which also includes mention of the use of ground talc for the manufacture of "synthetic lava".

One of the important uses of talc in ceramics is as an ingredient of sagger bodies (the containers used to protect green ware during firing), as well as of other kiln furniture, the talc serving to increase resistance to thermal shock[3].

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[1] Tyler, P. M.: "Technology and Economics of Ground Mica", Amer. Inst. Min. Met. Eng., Tech. Publ. No. 889, 1938, p. 14.

[2] U.S. Bur. of Mines: Mineral Markets Reports, No. 658, May 17, 1938.

[3] Hagar, D.: "Lengthening Sagger Life with Talc", Ceramic Age, vol. 21, No. 2, Feb., 1933, pp. 35–63.
Betz, G. C.: "Improving Kiln Furniture with Talc", Ceramic Age, vol. 21, No. 4, April, 1933, pp. 104-25.

A great deal of research[1] has been in progress in recent years, particularly in the United States, looking to the more extensive use of talc, as well as of its alumina counterpart pyrophyllite, in ceramic products. Merits claimed for talc in ceramic bodies have been stated[2] to be: (1) Talc is a cheap source of magnesia, which acts as a flux; (2) it imparts to the body high resistance to thermal shock and high electrical resistance at elevated temperatures; (3) it has a high specific heat and is resistant to acids. On the other hand, talc has a short fusion range, which may impart a short firing range to the body; also, its use in large proportions increases costs, since, although talc is a cheap source of magnesia, it is an expensive source of silica.

Large amounts of talc (and pyrophyllite) are now used in glazed wall tile for bathrooms, this product having accounted for a large part of the increased consumption in 1937. For this purpose, as well as for many other white-ware bodies, including electrical porcelain and semi-vitreous tableware, talc is of value in preventing delayed crazing of the fired and glazed body[2]. Contrary to first belief, lime-bearing talcs, with a CaO content of 6·2 per cent, have proved to give better results in white-ware bodies than lime-free talcs.

In some types of glass, both clear and opal, talc is used to increase resistance to chemical attack and mechanical shock.

The thermal decomposition of talc has been studied by Ewell, Bunting, and Geller[3], who found that one molecule of water is driven off between 380° and 500°C., and the remaining molecule (of combined water) between 800° and 840°C. In the process, specific gravity increased from 2·83 to 2·91, and at the higher temperature the talc decomposes to enstatite and amorphous silica. Inversion of the enstatite to clinoenstatite takes place between 1,200° and 1,300°C., with conversion of the amorphous silica to cristobalite. The results support the view that water in talc in excess of 1 molecule is not water of constitution, but may be held electrostatically between cleavage planes.

Rubber Industry

The rubber trade uses large amounts of powdered talc, and ranks fourth in point of consumption, with 12 per cent (27,000 tons) of the total. The great bulk of the talc used is employed for dusting purposes, to lubricate moulds and to prevent surfaces sticking together during manipulation or vulcanization. It is also used to bury white goods and

[1] Geller, R. F. and Creamer, A. S.: "Talc in Whiteware", Journ. Amer. Ceram. Soc., vol. 20, No. 5, May, 1937, pp. 137-47.
Lintz, E. H.: "The Use of Talc and Pyrophyllite in Semi-vitreous Dinnerware Bodies", Journ. Amer. Ceram. Soc., vol. 21, No. 6, June, 1938, pp. 229-37.
Geller, R. F. and Creamer, A. S.: "Talc in Whiteware Bodies of the Wall-Tile Type", Journ. Amer. Ceram. Soc., vol. 18, No. 9, Sept., 1935, pp. 259-69.
Fallon, F. F.: "A Study of Some Ceramic Bodies Containing Talc", Journ. Amer. Ceram. Soc., vol. 18, No. 7, July, 1935, pp. 199-201.
Kraner, H. M. and McDowell, S. J.: "Talc as the Principal Body Ingredient in Vitrified Ceramic Bodies", Journ. Amer. Ceram. Soc., vol. 8, No. 10, Oct., 1925, pp. 626-35.
Hagar, D.: "Effect of a Tremolitic Talc in Whiteware Bodies", Journ. Amer. Ceram. Soc., vol. 19, No. 1, Jan., 1936, pp. 14-23.
Schofield, H. Z.: "A Study of Replacement of Cornwall Stone by Talc and Feldspar in a Wall-Tile Body", Bull. Amer. Ceram. Soc., vol. 16, 1937, pp. 203-4.
[2] Hagar, D.: "Talc May Stop That Crazing", Ceramic Age, vol. 21, No. 3, March, 1933, pp. 74-5.
King, R. M.: "Talc as a Ceramic Body Ingredient", Ceramic Industry, vol. 25, No. 2, 1935, pp. 70-1.
[3] Ewell, R. H., Bunting, E. N., and Geller, R. F.: "Thermal Decomposition of Talc", Journ. Research, U.S. Nat. Bur. Standards, Nov., 1935, vol. 15, pp. 551-6.

keep them in shape during the vulcanizing process. Some is used in compounding, as in semi-hard valve composition, and in wire insulation, but an excess tends to produce a stony effect[1].

The value of talc for most rubber uses lies in its high slip and lubricating power, imparting a fine, smooth surface to the finished goods. High-grade white talc is not essential, and much of the material used is off-colour, grey talc, or even powdered soapstone. Powdered mica competes on an increasing scale with talc for rubber use, and choice between the two materials is usually dictated by price.

Roofing Industry

The roofing trade is the fifth largest consumer of talc, with 10 per cent (23,000 tons) of the total consumption. A large part of the material used is coarser ground, inferior grey talc and ground soapstone, used in roofing paper both as a filler and as an inert, fire-proofing and weather-resistant coating. As a backing for tar paper and roll-roofing, asphalt shingles, etc., similar grades of talc compete with ground mica, to prevent sticking; and, in granule form, they are also employed as a surfacing material for such products. Being often in the nature of almost a waste product in the preparation of higher grades, such talc sells at a low figure, but it also is the principal business of many producers.

As in the rubber industry, talc and ground mica are strong competitors in the roofing trade, and choice is often largely dependent on price. On account of its more pronounced flake form, mica is preferred by some manufacturers owing to its greater covering power.

Cosmetic Industry

Although of minor importance from the tonnage angle, cosmetics of a wide variety, principally talcum powder, but including also soaps, creams, salves, lotions, rouge and lipstick, and many other toilet preparations, use considerable amounts of talc. Nearly 4,500 tons, representing 2 per cent of the total sold, go to the cosmetic trade. Only the highest grade, white talcs are employed, the bulk of which comes from Italy, France, and, more recently, Manchuria. Some Canadian talc from the Madoc district, Ontario, as well as some California talc, is also so used. Freedom from gritty impurities, such as carbonates ("lime") and silicates, which destroy smoothness and slip, is a prime consideration for the highest grades of cosmetic talcs, to the preparation of which extreme care is given. Such grades sell as high as $80 per ton, wholesale delivered price.

Foundry Industry

The foundry trade is the last trade in point of importance for which figures of consumption are given in United States Government reports. This takes about 3,000 tons, or 1 per cent of the total talc sold. All of

[1] Pearson, H. C.: "Crude Rubber and Compounding Ingredients", 1918, pp. 111-12.

the material so used is employed for foundry facings, to coat moulds, either mixed with, or replacing, graphite. For this purpose a preference exists for a special type of rusty, red talc, termed "Bull Run Talc", obtained from Virginia.

Textile Industry

Considerable quantities of higher grade, white talc are used in the manufacture of various textiles, as a loader or filler, and also on account of its bleaching properties, to impart a good white colour to the goods. Cotton sacking for sugar, flour, etc., is one of the larger consumers, but it is also used in many other fabrics, as well as in cordage, rope, and string.

Miscellaneous Uses

Ladoo (6), in 1923, listed sixty uses for ground talc, and there is no doubt that the mineral finds employment to some extent in an exceedingly wide variety of industrial products. A list of such minor uses would serve little useful purpose, but the following more important ones may be mentioned.

As a filler, or loader, talc is used in asbestos compositions, including shingles, blocks, and slabs; in composition floorings and wall plasters; in fertilizers, to render the product free-running; in insecticides, as a carrier of the poison and to promote sticking; in linoleum and oilcloth; and in polishes and plastic compositions. As an ingredient of concrete[1], particularly in foundation work, talc is claimed to impart water-proof qualities to the mixture, as well as to improve workability, promote flow in pouring, and increase density.

As a lubricant, talc is a constituent of some cup greases. As a dusting material, it is used to give a finish to wire nails; to coat bottle, cork, and candy moulds, to prevent sticking; as well as to polish vegetable grains, such as rice, barley, corn, beans, peanuts, etc., and gunpowder grains. It is further used between the inner tube and casing of rubber tires, to prevent pinching; to give a smooth finish to gloves, leather goods of all kinds, and turned wooden articles; and as a bedding material in the steam chests used to cure insulated cable.

In cut (sawn) form an important use for the denser and finer grained talcs, possessing a greater degree of mechanical strength, is in the form of crayons or pencils, used to mark steel and glass. For such purpose talc is the one material that will make a mark on hot or cold metal, glass, etc., that is visible when the material is cooled or heated. Similar talc is employed for tailors', or "French", chalk, though much of this is now made from pressed powdered talc. Steel-makers' talc crayons are usually about 5 inches long, by $\frac{1}{2}$ to $\frac{3}{4}$ inch wide, and $\frac{3}{16}$ inch thick; the pencils, the same length, by $\frac{1}{4}$ inch square. They are sawn out from selected block talc by small circular saws.

[1] Wicks, F. R.: "Crystalline Talc as an Admixture in Concrete", Proc. Amer. Soc. Test. Materials, vol. 31, Pt. 2, 1931, pp. 534-53.

STEATITE

In the narrower, mineralogical sense, the term "steatite" is generally applied to massive, compact, cryptocrystalline talc, without visible grain, and usually of a pale yellow or cream colour. Such talc is generally derived from the alteration (silicification) of carbonate rocks, such as dolomite or magnesite, having a negligible iron content; and not infrequently, also, bands or inclusions of steatite may be found in larger bodies of foliated talc, where they probably represent portions of the ore-body that have escaped complete recrystallization, remaining cryptocrystalline. Similar pale, massive talc sometimes, though more rarely, may result from hydrothermal alteration of original low-iron magnesian silicate minerals, pyroxenes (diopside or enstatite), and members of the amphibole group, and even also may be pseudomorphous after quartz, phlogopite mica, etc.; such talc comes within the definition of true steatite.

However, the name steatite is often applied more loosely to the more compact, foliated, or fibrous talcs, particularly to the finer grained talc schists, and even, also, to the more highly talcose soapstones, more especially when such material is used for lava purposes. References in the literature to "steatite", therefore, often have little significance as indicating precisely what type of material is meant. The writer holds the definition given in the opening paragraph to be the more correct and, therefore, has restricted the use of the term in this report as far as possible to include only such material as described there.

The mineral name agalmatolite (from the Greek word for an image) is sometimes applied to the steatite used for carving purposes, though the term is indefinite, being applied also to a compact form of muscovite mica resulting from the alteration of a number of different minerals, as well as to compact, massive pyrophyllite. Pagodite is another name for the same material from China, from the Chinese use of it for the carving of small ornaments in the form of pagodas and temples.

Steatite, in the sense noted, is a much rarer material than ordinary talc, and commercial deposits that will yield sound material suitable for sawing and forming into lava articles are scarce. A large part of the supply has been obtained from India (Jubbulpore), and Germany (Bavaria). A little has also been produced in the United States, from deposits in Maryland, North Carolina, and Georgia. In Canada, small pockets of steatite occur in dolomite at the base of Mount Whymper, on the Alberta-British Columbia divide, near Castle: some attempts at development have been made; but there has been no commercial production. (*See* page 57.)

Gillson (10) studied the Maryland steatite microscopically, and found it to be composed of a dense, interlocking mass of splinter-like grains, many of them of curved form. The North Carolina and Georgia material, although usable for lava purposes, should more strictly be classed as a harder, coherent talc.

Uses

Steatite may be ground, like ordinary talc, for the production of powdered talc, but its chief value has been for the making of "lava" articles. "Lava" is the trade name given to small shapes, sawn, turned, drilled, threaded, etc., from block steatite, and then fired (calcined), these being used for various refractory, chemical, and electrical uses. Originally, gas and oil burner tips and nozzles were an important use, but the electrical industry now consumes a large part of the output in the form of insulators of a wide variety of types and forms. The radio industry provides an outlet for many types of lava insulators, which are specially desirable for high-frequency work.

Greenawalt[1], and Gillson, (10) p. 884, have described the manufacture of natural lava shapes. A block is first sawn out to the required size, allowing $\frac{1}{8}$ inch for the finishing cut. It is then scribed, placed in a lathe or milling machine, and machined to exact size, by turning, grooving, threading, drilling, tapping, etc., as may be required. Deeper sections are milled first, working up to the shallower sections last. A compressed air jet is used to keep the cuts clean of dust and the lay-out lines clear. Light, cold-rolled, sheet steel tools are used. Skilled machinists are required for the work, which is often of a highly intricate nature, demanding extreme precision. Threaded parts with as many as 64 threads to the inch are made. The machined articles are then placed in a drying oven and slowly dried at around 200° F., after which they are fired in coal-fired or electrically heated kilns. Firing is done very gradually, the temperature being slowly raised and finally held for about 6 hours at 1800°F. Firing converts the soft steatite to a steel-hard material, with negligible shrinkage in the process, the final shapes being accurate to 0·0005 inch. Firing losses are extremely low.

Whereas natural steatite was originally employed for the above purposes, the scarcity of suitable material, coupled with high waste-losses and cost of fabrication, has led to the supplanting of it for many uses by "synthetic lava", a ceramic product consisting of fired shapes made by dry-pressing or extruding powdered steatite or talc powder compounded with a silicate of soda binder and fluxes, the talc material forming 80 per cent, or more, of the mixture[2]. However, for certain purposes, and particularly where high precision or intricate shape is involved, natural lava still stands pre-eminent. On firing, the talc is converted into a mass of interlocking crystals of clinoenstatite, producing a hard, vitrified body having high insulating properties and an extremely low power factor. The addition of alumina to such a mixture results in the so-called "Alsimag" insulators, which have an even lower dielectric loss factor and are superior, also, in other respects to the straight talc bodies. Shapes made from such synthetic lava have higher shrinkage in firing than those made from natural steatite, and allowance has to be made for this. Firing losses are also said to be greater. They have an advantage in their colour, being white, whereas the natural steatite articles are of a reddish brown or buff shade.

Thiess has recently discussed[3] the properties of vitrified synthetic lava insulator bodies.

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[1] Greenawalt, L. J.: "Making Models from Easily-Machined Material", Machinery, March, 1935, p. 416.
[2] Thurnauer, H.: "Review of Ceramic Materials for High-Frequency Insulation"; Journ. Amer. Ceram. Soc. vol. 20, No. 11, Nov., 1937, pp. 368-72.
Trade literature of American Lava Corporation, Chattanooga, Tenn.
[3] Thiess, L. E.: "Some Characteristics of Steatite Bodies"; Journ. Amer. Ceram. Soc., vol. 20, No. 9, Sept., 1937, pp. 311-14.

Fineness of grain and compactness of texture, as well as chemical (mineral) purity, freedom from flaws and cracks, and uniform shrinkage on firing, are prime considerations in a steatite to be used for lava purposes. Low chlorite and carbonate content are particularly desirable. In a paper by Diller, Fairchild, and Larsen[1], the following analyses of commercial lava steatite are given:

Chemical Analyses of Talc Used for Gas Burners

—	German	Indian	North Carolina	Maryland	Theoretical
Silica	61·37	61·00	61·35	58·68	63·5
Alumina	1·96	2·12	4·42	3·75	....
Ferric oxide	Nil	Nil	Nil	Nil	....
Ferrous oxide	1·47	1·74	1·68	5·52	....
Magnesia	30·23	29·83	26·03	26·80	31·7
Lime	Nil	Nil	0·82	Nil	....
Water	5·36	5·56	5·10	5·33	4·8
Total	100·39	100·25	99·40	100·08	100·0

According to advice furnished by one of the largest American lava manufacturers[2], the following analyses are representative of good commercial steatites:

—	Chinese	Manchurian	Indian
Silica	62·35	61·40	61·24
Ferric oxide	0·05	0·45	0·02
Alumina	0·17	0·56	1·42
Lime	Nil	0·14	Nil
Magnesia	32·10	32·50	32·42
Soda	0·77	Nil	Nil
Potash	0·19	Nil	Nil
Loss on ignition (water)	4·37	4·98	4·90
Total	100·00	100·03	100·00

SOAPSTONE

The term "soapstone" is a loose one, and often is used in common parlance to denote any soft and compact talcose rock that can be fairly readily sawn and worked. In some cases such rock may contain little or no talc, being really a fine-grained chlorite or mica schist, a soft slate, or a basic igneous rock that has undergone sufficient alteration to render it soft without advancing to the point where sufficient talc has been formed to justify the rock being classed as a true soapstone. On the other hand, the name is often applied in the literature to a greyish green, laminated, schistose rock consisting mainly of fine talc flakes, with only minor amounts

[1] Diller, J. S., Fairchild, J. G., and Larsen, E. S.: "High-grade Talc for Gas Burners", Econ. Geol., vol. 15, No. 8, Dec., 1920, p. 671.
[2] Personal communication from H. Thurnauer, American Lava Corporation, Chattanooga, Tenn., July, 1938.

of impurities, usually mostly chlorite, from which the talc has been derived. Such rock often also contains small amounts of iron-bearing minerals, such as pyrite or pyrrhotite, spinel, etc., and carbonates, usually dolomite or ankerite, and sometimes magnesite, in the form of small, disseminated grains. Bands or lenses of this type of material are frequently found either bordering or enclosed in bodies of altered ultrabasic rocks, such as pyroxenites, peridotites, and gabbros which have been converted wholly or in part to serpentine, and constitute a more pronounced stage of alteration of such rocks.

Where alteration has proceeded to the point that talc is the principal mineral present, forming roughly 75 to 95 per cent of the rock, it seems more desirable that such material be classed as "talc", rather than as "soapstone", even though it may be used in the form of cut stone rather than in powdered form. However, use, rather than the actual nature of the material, has often come to be the dictating factor in the term applied to such high-talc rock, and it is hardly likely that any uniformity in the matter can be expected. Similarly, steatite (see above) is often referred to as " soapstone " when it is used for sawn and shaped " lava " articles, being classed as " talc " when it is ground; and ground soapstone is often termed "talc".

It is obviously impossible, in the circumstances, to attempt to adopt here any strict definition for soapstone. However, in practice, the writer prefers to apply the term only to a rock that conforms to the following definition, since it would seem highly desirable that some uniformity be aimed at. " Soapstone: a soft, talcose rock, usually green to grey in colour, resulting from the hydrothermal alteration of pyroxenite, peridotite, or other ultrabasic igneous rocks, and preserving the grain and texture of the original rock". Preservation of original grain is the important feature of such a definition, since it implies that metamorphism has not advanced to a stage where the primary rock has been converted wholly to talc, with complete recrystallization and development of a massive (steatite) or foliated or fibrous (talc) texture. The greenish colour cited is not an essential feature, since the particular shade depends on the relative iron content of the original ferromagnesian minerals. Where these were low in iron, or where oxidation has taken place, the colour may tend to brown, yellow, or cream, though such shades are less usual. The material in such case is generally one of the pseudomorphous sub-varieties of talc, such as rensselaerite or pyrallolite[1], and some steatite also belongs here, as, for example, that from the Göpfersgrün district, in Bavaria.

The name soapstone derives from the greasy or soapy feel imparted to the rock by its talc content, and the same term is also employed in other languages, e.g. the French *pierre de savon,* and German *Seifenstein.* In Germany, the term *Speckstein* (from *Speck,* fat) is used, though this is more generally applied to true steatite. Other names derive from the uses to which the rock is put, and include *potstone* (German *Topfstein,* French *pierre de chaudron* or *pierre à marmite.* Similarly, the French *pierre*

[1] Dana: System of Mineralogy, 6th Ed., p. 678.

ollaire derives from the Latin *olla,* a pot. The German *Gilstein* and *Kleberstein* are local terms of obscure origin. The German *Bildstein* comes from *Bild,* an image or statue, and *Lavastone* (German *Lavezstein*) from the fact that the stone will withstand high temperatures.

Uses

Owing to its softness, which renders it easy to quarry and carve, and to its durability, soapstone[1] early attracted the attention of primitive man, who fashioned from it all manner of domestic utensils, pots, dishes, lamps, etc., using it also for the carving of ornamental objects, images, beads, and so forth. Even to-day, it is similarly employed by primitive peoples in all parts of the world, and in the Orient, particularly in China, India, and Japan, the carving of such articles from soapstone (including also steatite) is an industry of considerable importance.

For the same reasons, soapstone, in the form of sawn blocks, has been employed to some extent for building purposes, more especially in areas contiguous to large deposits of the stone, and some large edifices have been built of it, including the mediaeval cathedral of Trondhjem, in Norway. In Canada, the Broughton Soapstone and Quarry Company a few years ago constructed an office building entirely of soapstone, produced from their quarry at Broughton, Que., as an example of what could be done with the stone, even the interior trim, fireplace, etc., all being fashioned of the material.

The harder types have good durability as stair-treads, and, taking a fair polish, can be employed in all kinds of interior and exterior decorative work, such as wainscotting, mantels, benches, etc., and it can readily be turned or carved into monuments, urns, plant basins, bird baths, sun-dials, and similar articles.

In more modern times, the high heat retention of the stone made it of value, and the early settlers on this continent made extensive use of heated cut soapstone bricks as a "warming-stone" in carriages and sleighs, and even in beds, a practice which has survived until comparatively recently. The same property made the stone useful for bake-oven hearths, oven linings, stoves, griddles, fireless cooker plates, and similar domestic purposes, and it is still so used.

Its low fusibility, or refractoriness, makes it of considerable value as a furnace stone, and it has been employed extensively in metallurgical work. The added property of resistance to chemical attack has rendered it especially suitable for use, as sawn blocks and bricks, in the construction of alkali recovery furnaces in kraft pulp mills, in which used sodium sulphate ("black ash") is burnt at a high temperature for the removal of the contained carbonaceous matter. For this purpose, soapstone has long been an indispensable material, with no known substitute. Recently, however, a new type of water-jacketed, steel furnace has been introduced into the kraft industry and has cut down the use of soapstone materially. no longer used (1956)

[1] Hughes, H. H.: "Soapstone", U.S. Bur. of Mines, Inf. Circ. No. 6563, Feb., 1932. (Detailed, 18-page report dealing with the nature, mining, and uses of soapstone.)

In sawing soapstone for furnace use, it is essential that the blocks or bricks be cut with their long dimensions parallel to the grain, or schistosity, of the rock, so that the blocks can be set end-on to the furnace wall. If sawn in any other direction, the blocks will spall off under heat, with material shortening of the life of the furnace. It is also desirable that freshly quarried stone be allowed to dry out before being used, and that stone be not mined when it is frozen, since wet stone will spall in service, and frozen stone has a tendency to act similarly on removal from the ground or during the sawing operation.

Considerable diversity exists in the dimensions specified for soapstone furnace bricks for kraft mill use. Producers, therefore, seldom carry large stocks of cut stone, but saw to individual contract, since both the dimensions of wall-stone, and the size and taper of bricks used in furnace arches and for lining the dryer shells used to evaporate the sodium sulphate "black liquor" to "black ash", are subject to change, according to the requirements of the purchaser. A survey of a number of Canadian kraft mills, made some years ago[1], showed that the following sizes of soapstone bricks and blocks were in use:

6 x 6 x 12 inches	9 x 12 x 13½ inches
6 x 6 x 18 "	9 x 12 x 18 "
6 x 12 x 12 "	12 x 12 x 12 "
8 x 8 x 18 "	12 x 12 x 18 "

In sawing tapered bricks, very careful adherence to specified dimensions is demanded, and any departure from the exact size ordered may lead to rejection of shipments.

Laboratory tests of soapstone, to determine its suitability for furnace work, are not usually held to give very useful criteria, and it is generally considered preferable to have full-size blocks tested out in commercial furnaces under actual working conditions against standard stone. Wilson and Pask[2] have recently published the results of tests made on Washington soapstone to determine its behaviour at high temperatures, and have shown that at 1000°C. the talc is converted to the mineral enstatite ($MgSiO_3$), which at 1200°C. suffers a further change to clinoenstatite ($Mg_2 (SiO_3)_2$). Too high a content of iron-bearing minerals, particularly sulphides or magnetite, was found to cause fusion and slagging, with resultant loss of strength of the stone.

The acid-resisting properties of soapstone have made it a very desirable material for laboratory and chemical plant use, soapstone slabs being extensively employed for bench and table tops, fume cupboard hoods, sinks, and tanks. It is also used for lavatories and laundry tubs, having low moisture, oil, and grease absorption, and being readily cleaned. With the advent of the electrical age, soapstone, on account of its non-conducting properties, came into high favour for switchboard panels, as well as for a variety of types of electrical insulators.

[1] Spence, H. S.: "The Canadian Soapstone Industry", Invest. Min. Res. and the Mg. Ind., 1926, Mines Branch, Dept. of Mines, Canada, Rept. No. 687, pp. 19-24.

[2] Wilson, H. and Pask, J. A.: "Talc and Soapstone in Washington", Amer. Inst. Min. Met. Eng., Contribution No. 99, 1936, pp. 12-22; "The Effect of Temperature on the Structure of Soapstone", Journ. Amer. Ceram. Soc., vol. 20, No. 11, Nov., 1937, pp. 360-63.

Due to its many desirable properties for such varied uses, soapstone probably is unsurpassed among the natural rocks in its field of general usefulness throughout the ages.

In addition to its varied uses in the form of cut stone, soapstone is also used extensively in the powdered state for similar purposes as low-grade talc, there often being little distinction made, or possible, between the two materials. Considerable quantities of the dust made in the sawing operations are marketed, principally to the roofing trade and also for other low-grade uses, such as Portland and chrome refractory cements, pipe-covering compounds, concrete, etc. Quarry and cutting waste is also ground for similar uses, as well as for the rubber trade. Attempts have been made to bond soapstone powder for the production of "synthetic" soapstone slabs, for use as oven or range-linings and similar purposes[1].

[1] Phillips, J. G.: "The Production of Shapes from Soapstone Dust", Invest. Ceramics and Road Materials, 1930-31, Mines Branch, Dept. of Mines, Canada, Rept. No. 726, pp. 67-74.

CHAPTER II

TALC AND SOAPSTONE INDUSTRY IN CANADA

HISTORICAL

Records of talc production in Canada date back to 1886. During the twenty-year period 1886-1905 a small annual output was recorded, the total amounting to 11,000 tons. Most of this material represented low-grade talc and soapstone obtained chiefly from deposits associated with the serpentine belt in the Eastern Townships, Quebec, with a little also from Nova Scotia and Ontario. The production seldom exceeded a few hundred tons in any one year, and was used mainly in ground form for foundry and roofing purposes. It was not until 1906, when active development of the deposits of high-grade, white, foliated talc in the Madoc district, in Ontario, commenced, that output started to rise, and this district, with two actively-producing mines and mills, has since continued to be the principal source of all the talc produced.

In Nova Scotia, small amounts of talc were mined many years ago near Whycocomagh, in Inverness County, Cape Breton Island, and also near Louisburg, Cape Breton County. (Although mined and sold as talc, this latter was actually sericite: *see* page 101.)

In 1922, production of cut soapstone began from the extensive deposits of this material in Thetford and Leeds Townships, in the asbestos-producing region around Thetford Mines, in the Eastern Townships of Quebec, and the industry has continued to develop satisfactorily. Small amounts of soapstone waste are ground and, with the fine dust produced from the sawing operations, are marketed as a low-grade powder, principally to the roofing trade. Some grey, off-colour talc occurring with the soapstone is also ground and sold to the paper, rubber, and other trades. Other deposits in the same general region, from some of which talc has been mined, lie in the Townships of Bolton and Potton in Brome County; Wolfestown, Wolfe County; and Ireland and Inverness, Megantic County. An occurrence near Eastman in Bolton Township was prospected by a shallow shaft in 1935, and development is currently underway on a deposit near Highwater, in Potton Township, close to the Vermont line.

Deposits of soapstone also occur in the Kenora and Rainy River Districts, in western Ontario, and some interest was shown in these between 1921 and 1926. Several companies were promoted to produce stone, and there was a small production of cut stone from an occurrence on Eagle Lake. The industry was short-lived, however, and no further development has taken place.

In British Columbia, a number of talc occurrences are known, and some of them have been worked on a small scale at intervals during the last twenty years. Total production, however, has been small, most of it being shipped to Vancouver for grinding to supply the local roofing trade. Most of the supply has come from deposits at Keefers, in Yale Mining

Division; McGillivray, on the Pacific Great Eastern Railway, in Lillooet Mining Division; and Kapoor, in Victoria Mining Division, on Vancouver Island. Talc of steatitic character occurs at the base of Mount Whymper, on the British Columbia-Alberta divide, in Windermere Mining Division, as well as at the head of Redearth Creek. Some interest has been shown in these deposits as a possible source of "lava" talc, and a company was promoted to develop the last-named occurrence, but no production was attained. Soapstone occurs at Verona siding, near Hope, in Yale Mining Division; sample blocks are stated to have given good results in pulp mill furnaces, but there has been no production.

PRODUCTION

The following table shows the annual production of talc in Canada since 1906, the year when the industry started to show sustained growth with the active development of the deposits of the Madoc district, Ontario. As noted above, these deposits have accounted for the great bulk of the output, with a small amount also produced in British Columbia and Quebec. The table does not include cut soapstone, statistics for which are given in Table II, but may include some ground soapstone, waste, and sawing dust from the Quebec quarries.

During the three-year period 1935-37, the latest for which substantially complete world production statistics are available, Canada produced from 2·2 to 2·8 per cent of the total world output of ground talc and soapstone.

TABLE I

Production of Talc in Canada, 1906-38(1)
(In Short Tons)

Year	Tons	Value	Year	Tons	Value
		$			$
1906	1,234	3,030	1923	9,759	129,664
1907	1,534	4,602	1924	10,883	134,207
1908	1,016	3,048	1925	13,706	173,180
1909	4,350	10,300	1926	14,772	174,586
1910	7,112	22,308	1927	15,110	178,931
1911	7,300	22,100	1928	14,925	179,187
1912	8,270	23,132	1929	15,509	181,212
1913	12,250	45,980	1930	11,841	136,048
1914	10,808	40,418	1931	11,836	122,644
1915	11,885	40,554	1932	12,103	112,287
1916	13,104	49,423	1933	15,181	143,156
1917	15,803	76,539	1934	13,959	136,480
1918	18,169	119,197	1935	13,803	139,479
1919	18,642	116,295	1936	14,508	144,500
1920	21,671	166,934	1937	12,457	123,301
1921	10,134	144,565	1938	10,853	109,810
1922	13,028	182,658			
			Total	388,515	3,389,755

(1)Compiled from reports of Dominion Bureau of Statistics.
NOTE.—Previous to 1921, a large proportion of the Madoc talc was exported in the crude form to the United States for grinding: since that year most of the output has been sold in ground form.

Table II shows the production of soapstone since the inception of the industry for this class of material in Quebec in 1922. Most of the output represents sawn furnace stone for the alkali recovery furnaces of domestic kraft pulp mills, but the production returns cover, also, grinding waste and sawdust.

TABLE II

Production of Soapstone in Canada, 1922-38(1)

Year	Tons	Value	Year	Tons	Value
		$			$
1922	167	5,800	1931	*(a)*	34,439
1923	607	20,843	1932	*(a)*	46,751
1924	449	20,273	1933	*(a)*	47,680
1925	768	32,655	1934	*(a)*	44,297
1926	995	42,609	1935	*(a)*	32,053
1927	1,411	57,174	1936	*(a)*	32,770
1928	*(a)*	40,171	1937	*(a)*	40,513
1929	*(a)*	47,986	1938	*(a)*	35,038
1930	*(a)*	50,168	Total	....	631,220

(1) Figures from reports of the Dominion Bureau of Statistics.
(a) Figures of quantity not available since 1927.

According to reports of the Dominion Bureau of Statistics (14), there were six active producers of talc and soapstone in Canada in 1938, one in Ontario and five in Quebec. In the same year the price of crude talc averaged about $6 per short ton, while ground talc sold at from $9 to $17.50 per short ton, according to grade, all f.o.b. mines or mills. Crude soapstone was quoted at $1.50 to $2 per short ton, and dressed stone at about $28 per ton. Due to increased competition in the soapstone industry, as well as to slackened demand by pulp mills, several of which have substituted steel-walled furnaces for the older, all-soapstone type, the price of cut soapstone blocks and bricks has dropped in recent years to about $2 per cubic foot, as against the $4 figure formerly obtained. Soapstone weighs 180 pounds per cubic foot, giving 11 cubic feet of dressed stone per short ton.

MARKETS FOR GROUND TALC, STEATITE, AND SOAPSTONE

Domestic Market

Ground Talc

According to reports of the Dominion Bureau of Statistics (14), a partial census of Canadian industries using talc indicates an annual consumption of about 5,500 tons by the various trades from which returns were obtained. This consumption, by industries, is shown in the following table.

TABLE III

Consumption of Ground Talc (a) in Canada, by Industries, 1934-38

Industry	1934		1935		1936		1937		1938	
	Tons	Value *(b)*	Tons	Value *(b)*	Tons	Value *(b)*	Tons	Value *(b)*	Tons	Value *(b)*
		$		$		$		$		$
Rubber	*(c)*	*(c)*	*(c)*	*(c)*	*(c)*	*(c)*	607	11,449	538	*(c)*
Electrical apparatus	97	2,299	166	4,297	191	4,926	209	5,256	149	3,853
Paints	1,676	40,926	1,811	45,654	1,948	47,378	2,063	50,394	2,330	63,788
Soaps and cleansers	184	2,956	139	2,583	128	2,680	151	3,123	241	4,437
Toilet preparations	402	24,714	504	29,250	397	22,393	401	18,976	435	*(c)*
Medicinals and drugs	85	3,732	103	6,269	*(c)*	*(c)*	*(c)*	*(c)*	*(c)*	*(c)*
Polishes	1	27	1	32	10	222	16	330	17	559
Roofing	1,546	20,448	1,363	16,034	1,839	21,500	2,696	25,194	2,414	24,374
Pulp and paper	1,482	23,895	1,361	24,652	1,124	22,497	865	16,385	1,051	17,552
Total	5,473	118,997	5,448	128,771	5,637	121,596	7,002	131,107	7,175	114,563

(a) Includes also some ground soapstone.
(b) Cost at works.
(c) Not reported.

It should be noted that the above list of consuming industries does not include the textile trade, which uses large amounts of ground talc, but for which no figures are available. There is also, possibly, a small consumption by the ceramic trade. Inclusion of these industries would certainly swell the total very considerably. A closer estimate of the total annual consumption can probably be gathered from the figures given in Table IV, where, by taking production less exports and plus imports, totals of 7,470 tons, 7,570 tons, 7,222 tons, 5,968 tons, and 6,548 tons for the above years are obtained, or around 6,000 to 7,500 tons annually.

Steatite

There is no production of lava articles, either natural or synthetic, in Canada; hence there is no domestic market for this class of talc, except, possibly, for the production of ground talc. Steatite of good lava quality is a rather rarer commodity, and despite the growth of synthetic lava, made from powdered talc, suitable material could probably always command a market with American firms specializing in the production of natural lava articles.

Soapstone

Statistics of the quantity of cut soapstone, in the form of furnace blocks and bricks, used by domestic pulp mills are not available, but the value of the production of soapstone in the Eastern Townships of Quebec, the only producing region, totalled about $32,000 in 1936, $40,000 in 1937, and $35,000 in 1938. The great bulk of the output of Quebec soapstone has gone to domestic pulp mills, at a price in recent years stated to be between $2 and $3 per cubic foot, so that the above values would represent pulp mill sales of between 11,000 and 16,000 cubic feet (1,000 to 1,500 tons) annually[1]. The market for soapstone has suffered from the introduction in recent years, by certain of the pulp mills, of water-jacketed steel furnaces for alkali recovery, and the price has dropped considerably below the level of $4 per cubic foot formerly obtained. The Quebec stone has found a market chiefly in pulp mills within the Province, at Three Rivers, Windsor Mills, East Angus, and La Tuque, with shipments made also to Bathurst, New Brunswick, and as far west as Dryden, Ont. In 1937, a shipment of 1,000 cubic feet was made to Australia. A little of the more talcose stone has been cut into crayons.

Part of the waste from the Quebec quarries is ground, both locally and in Montreal, for the production of powdered soapstone, and the dust from the sawing benches, collected by air exhaust, is similarly utilized; most of such material goes to the roofing and rubber industries. A grey, off-colour talc occurring with the soapstone in one of the quarries is ground for similar use and also for the paper trade.

[1] NOTE.—Statistical records do not separate cut stone from sawing waste and dust, considerable quantities of which are sold, so that these figures are probably rather in excess of actual sales.

American Market

From the statistics in Table IV, 57 to 60 per cent of the total Canadian talc production in the period 1934-38 was marketed in the United States. No data on consuming industries are available, but it is thought that most of such exports went into textile and cosmetic uses. The eastern United States is deficient in domestic sources of high-grade, foliated white talc, suitable for bleaching and cosmetic use, and the eastern market is largely supplied by imports. California produces high-grade white talc, probably superior to the Madoc article, but high freight rates have largely prevented competition from this source. In 1936, Canada supplied 34 per cent of the American imports, in 1937, 27 per cent, and in 1938, 29 per cent.

British Market

According to a recent report[1] of the Department of Trade and Commerce, Ottawa, talc imports into the United Kingdom from Canada have ranged between 1,291 and 1,676 tons annually in the period 1932-35[2]. These amounts represent about 7 to 9 per cent of the total talc imports. Canada is practically the only Empire source, the bulk of the supply being obtained from Norway, Japan (Manchuria), France, and Italy. Most of the material is used for bleaching purposes in the textile industry. Italian talc is regarded as the finest quality, followed by French and Manchurian. The best Italian talc sells at £11 per ton, with lower grades selling as low as £3. Manchurian talc has become firmly established in the British market, and competes strongly against the French and medium and lower grade Italian: it sells at from £3 to £8 per ton. French talc prices range from £3 to £10 per ton, according to quality. Norwegian talc is of inferior grade and sells at a little over £2 per ton. A little talc is also imported from Spain, and is considered of fair quality.

Canadian talc is esteemed for its good white colour, but is stated to lack the slip and lustre of the best grades. It is held to be too expensive for medium-quality use, and inferior to the Italian, French, and Japanese products. Nevertheless, there is a certain steady demand for it, at quotations ranging from about £4 8s. to £4 15s. per ton.

In the British market, colour, lustre or sheen, texture, weight, and price are the important factors. The finer grades are in demand for finishing (bleaching) lace and other fine textiles, paper, cosmetics, and polishes. Medium and lower grades go also to the textile trade, and to the soap, paint, rubber, cordage, wall-paper, electrical insulation, linoleum, oil-cloth, and roofing-felt industries.

Small amounts, estimated at about 12 tons per annum, of massive steatite are imported for cutting into steel-makers' crayons and tailors' chalk, the price paid being 27 shillings a hundredweight. No apparent demand exists for cut soapstone furnace blocks and bricks.

No duty is levied on talc, steatite, or soapstone entering the United Kingdom, irrespective of source.

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[1] Birkett, C. B.: "Market for Talc in the North of England"; Commercial Intelligence Journal, Department of Trade and Commerce, Ottawa, No. 1788, May 7, 1938, pp. 684-85.

[2] NOTE.—These figures are slightly higher than the exports shown in Table IV, and may include some material imported for re-export to Continental countries.

TRADE STATISTICS, EXPORTS AND IMPORTS

Table IV gives figures of production of talc and soapstone, by provinces, and exports and imports of talc, for the five-year period 1934-38. Nearly all of the soapstone produced found a domestic market, and exports of talc were almost wholly material from mills at Madoc, Ontario. It will be noted that a large proportion of the Madoc production finds an export market, principally in the United States. As already noted, Canada, in 1936, supplied 34 per cent of the total American imports, in 1937, 27 per cent, and in 1938, 29 per cent.

A fact that stands out prominently from the figures for talc in Table IV, as well as from the approximate consumption totals for the same years calculated on page 20, is the close annual uniformity for the five-year period, there being only relatively minor variations, both in tonnage and value, in the production, exports, and imports totals. This would tend to indicate a saturation point in the present available markets for Canadian talc, with the domestic consuming industries adequately supplied. The Madoc mines, which in 1920, the peak year, produced over 21,000 tons, could probably increase their output considerably over the recent annual figure of around 14,000 tons, if conditions warranted. Madoc talc is unexcelled for colour, but contains a small amount of gritty impurities which lower its slip and mitigate against its employment for the highest-grade uses. If beneficiated for removal of such impurities, it might possibly merit a higher rating, and find wider markets (*see* pages 68 and 107).

Most of the imports from the United States are believed to be fibrous white talc, for the paint and paper trades, from New York State, with some lower grade grey talc from Vermont; the remainder, of European origin, is probably mostly high-grade French and Italian talc, used mainly in the cosmetic industry.

TARIFFS

Canadian talc and soapstone enter the United States subject to the following duties: Ground talc or soapstone valued at not over $12.50 per ton, pays 25 per cent ad valorem[1]; valued at over $12.50 per ton, 35 per cent. Crude material pays ¼ cent per pound. Cut soapstone, steatite, or talc, in the form of blocks, bricks, slabs, crayons, blanks, etc., is dutiable at 1 cent per pound.

Talc, steatite, and soapstone enter the United Kingdom free of duty, irrespective of source.

Talc, ground or crude, enters Canada under the British preferential tariff of 15 per cent, and under the intermediate tariff of 25 per cent[2].

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[1] NOTE.—Under the new Canada-United States Trade Treaty of 1938, effective January 1, 1939, the $12.50 value was raised to $14, and the 25 per cent rate of duty reduced to 17½ per cent. The other items remain unchanged.

[2] Under the above Trade Treaty, imports from the United States are dutiable at 20 per cent.

TABLE IV

Production, Exports, and Imports of Talc and Soapstone, 1934-38[1]

—	1934		1935		1936		1937		1938	
	Quantity, short tons	Value, $	Quantity, short tons	Value, $	Quantity, short tons	Value, $	Quantity, short tons	Value, $	Quantity, short tons	Value, $
PRODUCTION										
Talc										
Ontario	13,934	135,978	13,710	138,161	14,461	143,701	12,457	123,301	10,853	109,810
British Columbia	25	502	93	1,318	47	799	Nil	Nil	Nil	Nil
	13,959	136,480	13,803	139,479	14,508	144,500	12,457	123,301	10,853	109,810
Soapstone										
Quebec	(a)	44,297	(a)	32,053	(a)	32,770	(a)	40,513	(a)	35,038
Total	....	180,777	....	171,532	....	177,270	....	163,814	....	144,848
EXPORTS										
Talc										
United States	8,151	83,535	7,947	80,504	8,742	87,907	7,453	74,686	6,229	64,629
United Kingdom	1,046	14,729	930	9,660	1,368	12,957	1,200	10,858	675	5,654
Other countries	189	3,367	50	659	112	1,207	45	409	48	459
Total	9,386	103,631	8,927	90,823	10,222	102,071	8,698	85,953	6,952	70,742
IMPORTS										
Talc or soapstone, ground or unground										
United States	2,496	29,812	2,214	29,431	2,548	32,063	2,812	38,660	2,301	31,214
United Kingdom	121	5,875	....	....	....	....	....	....	....	....
Italy and other countries	280	9,218	480	15,054	387	11,082	371	9,419	346	9,172
Total	2,897	44,905	2,694	44,503	2,936	43,185	3,183	48,079	2,647	40,386

[1] Dominion Bureau of Statistics, "The Talc and Soapstone Industry" (Annual Reviews). (a) Figures not available.

PRICES

The price of ground talc varies within wide limits, according to grade (purity and fineness of grinding). The following prices were quoted in 1939 for commercial talc of Canadian and American origin, all f.o.b. mills, per short ton:

Canada (Madoc), white, foliated talc, superfine grade, 400 mesh, $30; 300 mesh, $21; 200 mesh, $17; lower grades, $14 to $7.50. Grey talc (Quebec), $8.

Georgia, $6 to $9.

New York, fibrous, $12 to $16.

Vermont, grey, $9 to $9.50.

Imported French talc, sold in the United States in 1938, had an average value of $16; Italian talc, superfine grade, used largely for cosmetic purposes, was valued at $30 to $40, with f.o.b. wholesale prices delivered to customers of $45 to $80. Sardinian talc (steatite) sold at $40 to $50; and Manchurian at $30 to $40, with some off-colour grade at $20[1].

Canadian cut soapstone, for domestic use, sold in 1938-39 at $2 per cubic foot, f.o.b., and soapstone waste for grinding at $1.25 per ton. Ground soapstone was quoted at $6 to $8.

[1] Prices quoted in this paragraph are taken from U.S. Minerals Yearbook, 1938.

CHAPTER III

THE WORLD TALC AND SOAPSTONE INDUSTRY

STATISTICAL

Talc is a relatively abundant mineral, and commercial deposits exist in many parts of the world. Available production records show that in recent years some twenty-seven countries have contributed to the world supply, sixteen of which produced in excess of 1,000 tons annually.

Total recorded world production in 1937, the last year for which fairly complete statistics are available, amounted to 511,008 metric tons.

The United States is the world's foremost talc-producing country, with an annual output for the period 1935-37 about twice that of China, the next largest producer, four times that of France, and four to five times that of Italy. Annual production in the United States during this period has risen from 156,685 to 208,650 metric tons, equivalent to from 36 to 43 per cent of the total world production. Other leading producers, in approximate order of tonnage, are Norway, Austria, Canada, India, Germany, Sweden, and Spain, all of which have a recorded annual output of 5,000 tons and upward.

The following table shows the world production of talc, by countries, for the eight-year period 1930-37:

TABLE V

World Production of Talc by Countries, 1930-37(1)

(In Metric Tons)

Country	1930	1931	1932	1933	1934	1935	1936	1937
Argentina	......	......	......	......	......	......	176	177
Australia—								
New South Wales	280	230	293	368				
South Australia	811	817	1,071	1,399	1,767	1,465	1,527	1,517
Tasmania	14	15	5	9				
Austria (3)	18,530	16,979	17,276	20,854	20,671	20,768	19,891	14,089
Canada	10,742	10,710	10,980	13,772	12,663	12,521	13,165	11,301
China (Manchuria)	(2)	42,891	44,316	65,430	68,000	(3) 74,844	(3) 83,094	(3)111,134
Egypt	......	......	232	2,531	2,623	366	351	2,266
Finland	2,800	3,000	1,625	1,288	1,586	2,185	1,683	881
France	85,900	83,900	68,500	77,449	68,897	59,500	51,550	56,300
Germany (Bavaria)	5,794	4,208	3,197	5,106	6,934	7,163	9,589	7,790
Great Britain	188	163	262	169	......	......	......	......
Greece	256	484	618	1,272	118	552	864	1,838
India, British	6,967	5,217	6,617	17,322	9,535	12,798	10,128	13,249
Italy	38,131	38,620	32,404	34,427	37,636	41,692	43,938	45,714
Morocco, French (3)	561	693	837	526	788	721	1,368	814
Norway	14,996	11,392	13,536	19,885	27,723	27,782	29,714	24,701
Rumania	3,353	3,068	1,798	1,112	1,933	1,998	2,529	1,976
Spain	5,438	6,585	6,574	10,064	5,285	(2)	(2)	(2)
Sweden	5,117	4,837	4,525	4,396	6,500	6,061	7,146	7,937
Union of South Africa	380	337	251	271	218	282	413	376
United States	162,734	148,553	111,784	150,613	125,649	156,685	196,124	208,650
Uruguay (3)	1,463	1,789	2,625	1,270	879	1,200	772	302
Total	364,455	384,488	329,326	427,533	399,405	428,583	473,972	511,008

(1) From "The Mineral Industry", 1938, p. 584.
(2) Data not available.
(3) Exports.

The above figures show that in the period 1931-37 Canada ranked about seventh in the list of producing countries.

In addition to the countries listed in the above table, Brazil and U.S.S.R. (Russia) also produce talc, but data of production are not available. No distinction is made in the table between material classified as straight talc, and its sub-varieties steatite and soapstone (*see* pages **3**, **9**, and **11**). Practically the whole of the world output of ordinary foliated or fibrous talc is finely ground before finding industrial uses. Steatite, the massive, compact variety, is used in part in the natural form to make turned, threaded, and otherwise formed refractory shapes, known in the trade as "lava" articles, and is in part also ground. In addition, there is a large consumption of steatite in the Orient, particularly in China, for the production of carved ornamental objects of all kinds. The same holds for soapstone, an impure talcose rock, largely used in the sawn state as blocks, bricks, and slabs for refractory and other purposes, but also ground to make an inferior grade of talc powder. China, Germany, and India are important sources of steatite, and sawn soapstone is produced chiefly by the United States, Sweden, Norway, Finland, Canada, and possibly also Russia.

World trade in talc for the three years **1935-37** is shown by the following tables of exports and imports:

TABLE VI

World Exports of Talc (Domestic Produce), 1935-37(1)

(In Long Tons)

Exporting Country	1935	1936	1937
Austria	20,620	19,659	13,865
Belgium-Luxemburg	131	65	266
Canada	7,971	9,127	7,766
Chile	288	49	276
Czechoslovakia	1,007	2,119	2,448
Egypt	707	473	*(a)*
Finland	899	2,122	2,425
France	13,993	14,782	18,765
Germany	853	740	961
Italy	17,870	9,746	15,922
Japan	*(b)* 6,314	*(b)* 8,194	*(b)* 11,303
Manchuria	73,665	81,785	109,384
Morocco	709	1,346	828
Norway	19,723	22,927	22,964
Rumania	739	650	310
Russia (U.S.S.R.)	831	4	......
United Kingdom	295	58	112
United States	6,191	5,955	7,927
Uruguay	1,181	704	279

(1) From "The Mineral Industry of the British Empire and Foreign Countries", Statistical Summary 1935-37, Imperial Institute, 1938, p. 399.
(a) Figures not available.
(b) Re-exports of imported Manchurian talc. (Author's note.)
NOTE.—It will be noted from the above table that, for the period under review, Canada ranked seventh in the list of talc-exporting countries.

TABLE VII

World Imports of Talc (Less Re-exports), 1935-37(1)

(In Long Tons)

Importing Country	1935	1936	1937
Algeria	459	586	486
Argentina	1,479	1,229	623
Australia	551	557	684
Austria	462	830	457
Belgium-Luxemburg	3,852	4,275	5,163
Canada	2,405	2,622	2,842
Colombia	152	132	204
Cyprus	177	31	72
Czechoslovakia	3,793	4,354	5,238
Denmark	2,514	2,162	2,047
Egypt	908	989	1,210
Finland	773	693	987
France	3,469	2,597	2,737
Germany	24,523	24,144	15,834
Japan	64,219	64,674	86,742
Latvia	183	84	151
Mexico	264	266	464
Peru	128	81	131
Poland	3,211	3,403	3,720
Rumania	141	143	140
Tunis	471	638	376
United Kingdom	23,025	24,542	29,750
United States	21,337	21,893	23,997
Yugoslavia	446	263	439

(1) From "The Mineral Industry of the British Empire and Foreign Countries", Statistical Summary 1935-37, Imperial Institute, 1938, p. 400.

NOTE.—Thirteen minor importing countries, each with an average of less than 100 tons per annum, are omitted; the aggregate amount represented is only 500 tons.

THE INDUSTRY BY COUNTRIES

Below are given brief notes on the occurrence, mining, and treatment of talc in the chief producing countries. In spite of the large aggregate tonnage produced, and of the commercial importance of the mineral, there is a surprising dearth of up-to-date information on the talc-mining industry throughout the world. The general literature is fairly extensive, but, except in the case of a few countries, e.g. the United States, Italy, Canada, and one or two of the less important producers, deals mainly with geology and incidental matters, with little or no reference to mining, production, character of ore, commercial utilization, etc. Much of the information included in the following section is taken, except where otherwise indicated in the footnotes, from the following text-books, which constitute the most complete and most recent sources of data available:

O. Stutzer, Lagerstätten der Nicht-Erze, vol. 5, 1933, pp. 320-370. (Contains an extensive bibliography of 142 references.)

Dammer und Tietze, Die Nutzbaren Mineralien, vol. 2, 1928, pp. 395-411. (Contains numerous text references.)

Earlier important reference works, which, however, deal only with the world talc industry up to around 1920, are the following:

Imperial Mineral Resources Bureau, The Mineral Industry of the British Empire and Foreign Countries, Talc, 1921.
World Resources of Talc and Soapstone, U.S. Bureau of Mines, Reports of Investigations, October, 1919.
Mineral Industry, annual volumes, 1906-20.
Talc and Soapstone in Canada, Mines Branch, Department of Mines, Canada, Report No. 583, 1922.
Talc and Soapstone, U.S. Bureau of Mines, Bull. No. 213, 1923.

ARGENTINA

There is a small production of talc in Argentina, amounting to 175 metric tons in 1936 and 1937. Grinding talc is produced at Quebracho del Gato, in San Juan Province, and at La Cortadera and La Cueva, both in Las Heras County, Mendoza Province, the output going to the bleaching, rubber, leather, and foundry trades. Soapstone, used for sawn refractory shapes, is produced at El Vallecito, in Ayacucho County, El Retiro and Bosque Alegre, in Punilla County, and J. de la Quintana, Santa Maria County, all in Cordoba Province: some of the waste is also ground for the rubber industry[1].

Talc imports are stated[2] to total around 6,500 tons per year, of which about 2,000 tons represent ground talc from France, Italy, and Uruguay. However, imports appear to have been declining in recent years, being given[1] as only 632 tons in 1937, as compared with 1,248 tons in 1936, 1,502 tons in 1935, and 1,717 tons in 1934. Most of the 1936 imports were of Manchurian origin. Crude talc, also, is imported from Uruguay and Chile, and is ground in seven grinding plants in Buenos Aires.

AUSTRALIA

Most of the talc production of Australia is derived from New South Wales and South Australia, with a few tons produced also in Tasmania.

In New South Wales, material classified as soapstone has been mined for some years at Wallendbeen, the production in 1936 being reported[3] as 394 tons. In the same year, there was a production of 105 tons of impure talc schist at Cow Flat, in the Rockley Division. In 1937, the output from the above localities was, respectively, 442 tons and 76 tons. Most of the production is ground and sold locally for use in foundry facings, roofing, paints, rubber, and insecticides, while some is also sawn into bricks and slabs. A little is employed for lava purposes.

In South Australia[4], there was a recorded output in 1936 of 450 tons of soapstone from deposits of this class of talc at Gumeracha, in the Hundred of Talenga, 20 miles east of Adelaide, and of 537 tons of

[1] Personal communication from J. A. Strong, Canadian Government Trade Commissioner, Buenos Aires, August, 1938.
[2] Die Chemische Industrie, vol. 57, No. 41, October 13, 1934, p. 784.
[3] Ann. Rept., Department of Mines of New South Wales, 1936, p. 34.
[4] Mining Review No. 66, Department of Mines of South Australia, 1937; Bull. No. 13, Geol. Surv. of South Australia, 1928, pp. 38-42.

high-grade white talc from an occurrence near Lipson, in the Hundred of Yaranyacka, 8 miles north of Tumby Bay, Eyre Peninsula. The former is apparently used for the production of sawn stone, with some powdered waste and dust bonded with silicate of soda[1] to make linings for lead smelting furnaces, while the latter is shipped to Adelaide for grinding. Some material classed as steatite[1] is also produced at Kenton Valley, 20 miles northeast of Adelaide, and used for general refractory purposes, in ovens, grates, fireless cookers, etc.

Total Australian production in 1937 amounted to 1,517 metric tons.

AUSTRIA

Austria has an important talc mining industry, ranking fifth among the producing countries in 1936, with exports totalling 19,577 long tons. In 1937, exports declined to 14,000 tons. A large part of the production goes to Germany. The productive region[2] lies mainly in the Styrian Alps, where the Mautern and Rabenwald districts furnish a large part of the output. The talc occurs as bedded deposits in a highly disturbed and folded complex of gneiss and schists of various types, dolomite, and, in some cases, serpentine.

Important producing mines are those of the Naintsch Company, on Rabenwald Mountain, near Anger; the Rannach Talkumwerk, at Rannach, north of Graz; and the Federweiss-Interessentenschaft at Mautern.

The Rabenwald talc[3] is mined chiefly from adits and in part, also, from open quarries, the crude talc being conveyed by cable-way to the grinding plant at Anger, three miles distant. Both white and grey talc are produced, and, before grinding, the run-of-mine ore is first dried at the mine in electrically heated dryers and then sorted according to colour and grade. Part of the output of lower grade material is sawn into furnace bricks. Merits claimed for the best grade are the fine white colour and the extremely low lime content.

Other deposits have been worked on a lesser scale in the Central Alps of Salzburg and Tyrol, as well as near Judenburg, in the Niedere Tauern Mountains and near Hirt, in Carinthia. Steatite, used for "lava" and ceramic purposes, is mined at Kaintaleck, near Bruck an der Mur in Upper Styria.

In the Mautern district, the talc is similarly mined[4] by means of adits, connecting with vertical and inclined shafts. Levels are run to the orebody, which dips steeply into the mountain and follows the footwall of a limestone bed lying between phyllite and graphite schist, and the talc is removed by drifts and stopes opened along the strike. Worked-out stopes and drifts are filled with waste from upper levels as work proceeds. The talc occurs in lenses of variable width, with 35 feet as a maximum. Careful sorting of ore underground is practised in order to keep grades separate.

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[1] Information from F. Palmer, Canadian Government Trade Commissioner, Melbourne, August, 1938. (*See also* footnote page 15.)
[2] Stutzer, O.: (1), pp. 328-31.
[3] Steirisches Talkum, booklet published by the Schwefelkies-Bergbau Naintsch Gesellschaft, Graz.
[4] Rosenberg, H.: Talkum-Brevier, Frankfurt, 1914, pp. 81-87.

Further cobbing and sorting is carried out at the surface, to remove limestone waste, and the crude talc is then dried on large hearths and ground. Grinding is performed by buhrstone mills, in closed circuit with silk bolting trommels. Some of the crude talc is also sawn into bricks.

CHINA

China, including Manchuria, is one of the world's leading talc producers, with a reported output in 1934 of 68,000 metric tons. No later official production statistics are available, but Manchurian talc exports were reported at 74,844 metric tons in 1935, 83,094 tons in 1936, and 111,134 tons in 1937. As noted under Japan, also, Japanese imports of Manchurian talc in 1937 totalled over 96,000 tons. The country is thus the second largest world source of talc, being surpassed only by the United States. Southern Manchuria, especially, is reported to possess immense reserves of high-grade talc, exploitation of which has grown rapidly in recent years, largely for export to Japan (*see* under Japan) to supply the paper, textile, and cosmetic trades. The deposits occur in dolomite, and range up to 100 feet in thickness. Most of the Manchurian production is stated[1] to come from the Newchwang, Tashichiao, and Haicheng districts, in Fengtien, one of the largest mines being that at Talin, near Tashichiao station on the P. M. Railway. In China proper[2], talc is mined in Chekiang, Fukien, and Shantung Provinces. The Chekiang talc is ground for local cosmetic uses, with the coarser grades employed in rice polishing and in paints[3]. Important deposits are also stated to occur in Chihli Province, but have not as yet been developed.

In addition to furnishing important amounts of high-grade industrial grinding talc, both for domestic use and export, China produces considerable massive steatite, some of it in handsome mottled and veined shades, much of which is employed for ornamental carving purposes. Some is also ground for use in ceramics, textiles, and for polishing and lubricating use. Important centres of production of this class of talc (classed as "soapstone") are Shoushan, near Foochow, in Fukien Province, and Tsingtien, in Chekiang, and the material is also mined in Shantung, Kweichow, and Shensi Provinces.

Manchurian talc is essentially lime-free, and on this account, as well as on the score of general high quality, commands a premium over the general run of industrial talcs. The best grades sell[4] in the United States for $30 to $40 per ton.

CZECHOSLOVAKIA

Extensive deposits of massive soapstone were formerly worked at Zöptau and Wernsdorf, in Moravia, and occurrences of talc similar in character to that of the Austrian Alps are known in the Carpathians. The country has, however, no place in the recorded statistics of world talc pro-

[1] Japan-Manchoukuo Year Book, 1936, p. 812.
[2] The Mineral Industry of the Far East, Shanghai, 1930, pp. 392–95, 416.
[3] Die Chemische Industrie, vol. 57, No. 18, May 5, 1934, p. 342.
[4] U.S. Bur. of Mines, Mineral Trade Notes, 6, 1, Jan. 20, 1938, p. 28.

duction, though exports of 2,448 long tons were reported in 1937. A report[1] stated in 1936 that a company was being formed to operate a large talc deposit at Sinec, northeast of Budapest, both for domestic consumption and export.

EGYPT

Egypt first appeared in statistical records as a producer of talc in 1932, the output rising to a maximum of 2,623 metric tons in 1934. In 1937, the production was 2,266 tons. Total production from 1907 to the end of 1937 is reported as 8,500 tons.

The production comes mainly from deposits near Berenice, Aschabab, on the Red Sea, and is shipped to Cairo for grinding[2]. In 1937, the great bulk of the output was reported[3] as derived from Wadi el Atshan and Wadi Kharit, in the Eastern Desert, between Aswan and Berenice, with a few hundred tons also from Bir el Hamr in the same region. A few tons of massive talc were also mined at Bir Fawakir, east of Luxor.

FINLAND

Finland has a small production of talc, which ranged between 1,500 and 3,000 metric tons in the 1930-36 period. The output declined to 881 tons in 1937. The material comes principally from the Nunnanlaks district, on the west side of Lake Pielisjärvi, in Karelia, near the Russian border in southeast Finland. It is described[4] as a "talc-magnesite" rock, of soapstone character, associated with basic schists and serpentine, and forms deposits ranging up to several hundred feet in thickness. Formerly quarried for building purposes, the stone is now principally used for the production of sawn furnace blocks.

FRANCE

France is the largest talc producer in Europe, and in 1935 ranked third in world production, with an output of 59,500 metric tons. Exports in the same year totalled about 14,000 tons. In 1937, the production was 56,300 tons, with exports nearly 19,000 tons.

The industry centres principally around Luzenac, southeast of Foix, in the Department of Ariège, on the north side of the Pyrenees, where two large mines, operated by the Société Anonyme des Talcs de Luzenac and the Société Française de Talc, account for nearly 90 per cent of the total production. The deposits[5] lie at an elevation of nearly 6,000 feet above sea-level, on the east flank of the Pic de Soularac, and are operated only during the summer months (June to October). The Luzenac deposits, which have been worked for about 70 years, are among the largest known: they occur as lenses from 50 to 200 feet thick, enclosed in heavy talcose

[1] Die Chemische Industrie, vol. 59, No. 39, Sept. 26, 1936, p. 821.
[2] Die Chemische Industrie, vol. 56, No. 16, April 22, 1933, p. 298.
[3] Personal communication from The Director, Geological Survey of Egypt, 1938.
[4] Stutzer, O.: (1), pp. 339-41.
[5] Stutzer, O.: (1), p. 337.

dolomite beds, which can be traced along the strike for nearly two miles. There are four producing mines[1], employing about 700 men. The crude talc is mined by electric shovels from a series of benches, hand-sorted, and conveyed by aerial cable-way to grinding mills at Luzenac, five miles distant, where it is first coarsely crushed, then ground in pebble mills, and finally screened through centrifugal silk bolters.

In addition to the above operations, talc is also mined in Ariège in the Ustou valley, and at Quérigut and Montferrier; at Briançon, in the Alps; near Garde, in Isère, and at Voûte Chilliac, in Haute Loire. There is a small production of lava steatite, also, near Villefranche and Reynes, in the Department of Pyrénées-Orientales.

French talc, like the Italian article, enjoys a high reputation for quality and colour, and large quantities are exported for various high-grade uses. Much of the production goes to the paper, bleaching, and cosmetic trades, with some lower grade material to the rubber and insecticide industries.

GERMANY

Germany produces considerable steatitic talc, (7,790 metric tons in 1937), but is dependent on imports for most of her requirements of ground talc. Imports of the latter in 1936 totalled 24,144 long tons, and in 1937, 15,834 tons, about half of it secured from Austria. In addition, 2,557 tons of "soapstone" (steatite) was imported in 1937, most of it from Manchuria.

Most, if not all, of the German production is massive steatite ("Speckstein"), obtained from deposits at Göpfersgrün and Holenbrunn, near Wünsiedel, in the Fichtelgebirge, Bavaria. The steatite occurs along the contact of granite with limestone and phyllite, and is an alteration product of a variety of minerals, including quartz, dolomite, hornblende, etc. It is used extensively for "lava" purposes. Some low-grade talc, in part of soapstone character, associated with serpentine, has also been mined at various times near Schwarzenbach a.d. Saale; Zell, in Oberfranken; and various other places in the same general region in Bavaria[2].

According to Whitaker[3], the Holenbrunn steatite is mined by Steatit Magnesia A.G., which processes the material in a local plant, where large moulded or cast insulators are also made. In addition, the company has two plants at Lauf, Bavaria, turning out dry-pressed steatite bodies, as well as a variety of sawn, turned, and drilled steatite shapes.

GREECE

Greece produces a small tonnage of talc, the largest recorded output since 1930 being 1,838 metric tons in 1937. The best material is obtained[4] from the Island of Tinos (Cyclades). A lower grade of talc schist occurs

[1] Vie, G.: Mines, Carrières, vol. 12, No. 127, May, 1933, pp. 17-18.
[2] Stutzer, O.: (1), pp. 324-27.
Dammer und Tietze: (2), pp. 402-3.
[3] Whitaker, F. A.: General Ceramics Company, Keasbey, N.J.; personal communication, June 2, 1938.
[4] Stutzer, O.: (1), p. 337.

on the Island of Siphnos, as well as on the Island of Syra. The Siphnos stone ("lapis siphnius") is mentioned by Pliny, and has been used since ancient times for the carving of vases and other ornamental shapes, utensils, etc.

BRITISH INDIA

Talc of varying degrees of purity is widely distributed in India, much of the material being impure talc schist. According to Coggin Brown[1], such talc schist rock ("pot-stone") has been quarried for centuries, especially in southern India, for carving into culinary and other utensils, for building purposes, and for decorative carving of all kinds, images, etc. There is believed to be a trade of considerable proportions in such material in almost every province, which, however, does not appear in the official returns of production.

In the period 1930-37, the recorded production of talc (listed as "steatite") in India ranged between around 5,000 and 17,000 metric tons, the latter quantity in 1933. There was a drop to 10,000 tons in 1936 from the 12,798 tons figure of 1935, but the output rose again in 1937 to 13,249 tons. More than half of the output comes from Jaipur State, in Rajputana, where deposits have been worked at Dogetha, Morra, and Gisgarh, and also in Udaipur. A talc-milling plant was erected a few years ago at Dausa, in Jaipur, which produces ground talc for the domestic soap, paper, paint, and textile trades, with the finest grade going to export. Second among the fourteen recorded producing districts is Jubbulpore, in the Central Provinces, where talc occurs in a dolomite formation, followed by Hazaribagh, in Bihar and Orissa. Varying lesser amounts are produced in the Salem and Mellore district, in Madras; at Hamirpur, in the United Provinces; in Mysore; and elsewhere[2].

ITALY

Italy is one of the world's leading talc producers, and in 1937 reported an output of 45,714 metric tons, with exports of nearly 16,000 tons. The United States is a heavy importer of Italian talc, taking 7,000 tons in 1937. Italian talc is of high quality, both on account of its purity and snow-white colour, and is one of the highest-priced talcs on the market, being in special demand for cosmetic uses.

Most of the Italian production[3] comes from mines controlled by a single company, the Societa Talco e Grafite Val Chisone, and situated at

[1] Brown, J. Coggin: "India's Mineral Wealth", 1936, pp. 254-58.
[2] Trans. Min. Geol. Inst. India, vol. 25, Pt. 2, Nov. 1930, p. 162.
Records Geol. Surv. India, annual volumes.
Memoirs Geol. Surv. India, vol. 59, Pt. 1, pp. 234-37.
[3] Spence, H. S.: "Talc in Italy", Can. Min. Jour., Oct. 8, 1926, pp. 971-72.
Gastaldi, M. V.: "La Societa Talco e Grafite Val Chisone, Pinerolo", L'Illustrazione Italiana, No. 9, Feb. 28, 1926.
Ridoni, E.: "Il Talco" (booklet), 1918.
"L'Industrie della Grafite e del Talco in Piemonte", 6th Industrial Mining Congress, Liège, 1930, Geological Section, pp. 417-21.
"Il Talco e la sua Storia", Rivista Mensile del T. C. I., Le Vie d'Italia e dell', America Latina, No. 8, August, 1930.
"Il Talco e la Grafite delle Alpi Cozie", L'Industria Mineraria d'Italia e d'Otremare, Nos. 4-6, April-June, 1938. (Reprinted as illustrated pamphlet, 23 pages.)
Levi, C.: "Il Talco Italiano", Milan, 1934. (Illustrated pamphlet, 40 pages.)
"Reparto Isolantite e Talco Ceramico". (Descriptive pamphlet of lava and ceramic talc products of Societa Talco e Grafite Val Chisone, 1935.)

high altitudes (4,700 to 6,800 feet) in the Cottian Alps, west of Pinerolo, in Piedmont. The same company also mines talc on the French side of the mountains. Owing to the elevation of the deposits, mining is confined to the summer months. The crude talc is sent down the mountainside by aerial cable-way to storage sheds in the valley, whence it is transported by truck to mill at Malanaggio. The deposits form irregular beds and lenses in dolomitic limestone, dipping rather flatly into the mountainside and with thicknesses up to 25 feet. A single mine, the La Roussa, is credited with a production of about 10,000 metric tons per annum. Milling is performed both by Raymond mills and stone chaser mills, in closed circuit with bolting trommels and air separators. Exhaust fans draw off an ultra-fine dust product from the chasers, elevators, and bolters, this forming the finest cosmetic grade. The remainder goes mainly to the paper, rubber, and textile trades, with some also used locally at Villar Perosa in the manufacture of dry-pressed electrical insulation articles. A considerable part of the output goes to world export. Five standard grades are made[1], ranging in price from $20 to $40 per ton, f.o.b. Most of the exports to the American continent comprise the higher priced grades, the wholesale, delivered price of which ranges from $45 to $80 per ton.

Lava talc (steatite) has also been produced since 1926 in Italy, the source being at Iglesias and Orani (Nuoro), in Sardinia, where deposits are operated by the Societa Anonima Talco Enrico Tron, of Leghorn.

In 1932, Italy was credited with twenty-one producing talc mines, employing a total of about 500 hands.

JAPAN

Japan has not appeared in the statistical record of talc-producing countries since 1927, in which year she had a reported production of 59,000 long tons[2]. In the preceding five-year period (1922-26), annual production was given as between 35,000 and 48,000 tons, the material including "talc, steatite, and agalmatolite". In 1930, credit was given[3] for an annual production of around 40,000 tons.

Despite these statistics, there is little doubt that practically the whole of the above large tonnages should in reality be credited to Manchuria, the material being imported into Japan in the crude form for grinding, and in the ground form being subsequently reported as of Japanese origin. While Ladoo[4] lists eleven provinces in Japan in which talc and pyrophyllite are stated to occur, there would appear to be no domestic mining of these materials, the country being wholly dependent on imports for its supplies of talc.

According to recent advice[5], the rapid development of the textile, paper, cosmetic, and other industries in Japan has occasioned a great increase in demand for ground talc, about 98 per cent of the present requirements

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[1] U.S. Bur. of Mines, Mineral Trade Notes, 6, 1, Jan. 20, 1938, p. 28.
[2] "The Mineral Industry of the British Empire and Foreign Countries", 1927-29 (1930), p. 325.
[3] Torgasheff, B.: "The Mineral Industry of the Far East", 1930, p. 392.
[4] Ladoo, R. B.: (6), p. 12.
[5] Personal communication from C. M. Croft, Commercial Secretary, Canadian Legation, Tokyo, July, 1938.

being filled by imported crude Manchurian talc ground in Japanese mills. There are stated to be ten Manchurian talc mines under Japanese operation, the output of which is handled by the Japan-Manchukuo Trading Company. The crude talc is quoted at between $5.50 and $14.50 per short ton, c.i.f. Osaka, and the ground product at from $7.25 to $15.50 per ton, f.o.b. mills, according to grade. Imports of talc (and soapstone) into Japan in 1936 totalled 64,674 long tons, and in 1937 were over 86,000 tons, practically all of which was of Manchurian origin. Although a proportion of the production of ground talc finds a foreign market (9,158 short tons, valued at about $117,843, in 1936), the great bulk of it goes to domestic industries, making Japan probably second only to the United States in point of talc consumption. Most of the output goes to the textile, paper, rice-polishing, and cosmetic trades, and there is probably also some consumption of cut furnace stone (block talc) for metallurgical purposes and for ovens and stoves.

NORWAY

Norway produces important quantities of talc (in part soapstone), the output having doubled in the period 1930-35. Production in the latter year totalled 27,782 metric tons, rose to nearly 30,000 tons in 1936, and in 1937 was just under 25,000 tons.

Most of the Norwegian talc is derived from serpentine, and is of grey, off-colour grade, similar to that of Vermont and the Eastern Townships, Quebec. As in Quebec, some of the material is to be classed as soapstone, and this is sawn into blocks and slabs for furnace and building use, etc. The production has come mainly[1] from mines and mills at Arnafjord, on the Sognefjord, north of Bergen, and at Ostensjö, near Vikör, on the Samlenfjord, east of Bergen, on the west coast. Both talc and soapstone are also obtained from Otta, Vågå, and Sel, in Gudbrandsdal, as well as from Vefsen and Björnödal, in Nordland, and Gulosen, Bakaune, near Trondhjem. Several large quarries exist in the latter district, from which stone used in the construction of Trondhjem Cathedral was taken. Deposits of dolomitic talc are also known, as in the Höle region, Högsfjord, in Ryfylke, near Stavanger, but these are of less commercial importance.

The output of ground talc goes mainly to the roofing, rubber, and paint trades, with some also used in flooring compositions. A large part of the production finds an export market. Various types of grinding machinery are used, including Kent mills, ball mills and rolls, while some mills use the micronizing process (*see* page 105) for special grades. In 1938, most of the Norwegian talc output came from mines at Altermark, Rana, in Nordland; Arnafjord, in Sogn; Höle, Högsfjord, in Ryfylke; and Kvam and Vågå in Gudbrandsdal. Most of the cut soapstone produced came from the Fredheim quarry at Vågå. The crude talc is ground partly in mills located at or near the mines or is shipped to grinding plants at Bergen[2].

[1] Stutzer, O.: (1), p. 339.
Dammer und Tietze: (2), p. 403.
[2] Personal communication from C. Trost, A/S Norwegian Talc, Bergen, September, 1938.

RUMANIA

Rumania has a small production of talc, the output in 1936 being reported as 2,529 metric tons, and in 1937, 1,976 metric tons. The producing localities are Rusea Montana, in the District of Severin, where talc of foliated type occurs; and Cerisor, in the District of Hunedoara, where the material is of more massive, steatitic type, suitable for lava purposes.

UNION OF SOUTH AFRICA

Natal. According to a recent report[1], development has recently been undertaken on a group of claims in the Inanda Native Reserve, on the Umhloti River, where talc ("steatite") occurs. Several quarries have been opened and a small grinding plant has been erected at Congella. The deposit is briefly described in the report noted below[2] as consisting of a body of steatite (soapstone?), up to 200 feet thick, associated with altered hornblendic rocks.

Transvaal. There is a small production of talc (376 tons in 1937) from Kaapmuiden, in the Barberton district, Transvaal[3], where both foliated and massive green talc, as well as grey, schistose soapstone, derived from basic intrusives, occurs. A deposit has also been opened up in the Pretoria district. Most of the product is ground for local use in the rubber, soap, tanning, and other industries, with some cut also into crayons, pencils, etc. Talc has been produced since 1915, but the annual output has never exceeded a few hundred tons[4]. The Kaapmuiden talc is mined by adit and inclined shaft, and is ground on the property, grinding being done by high-speed pulverizers, combined with air separation[5].

SPAIN

Spain's talc production in the period 1930-34 averaged between 5,000 and 6,000 metric tons per year, rising to 10,000 tons in 1933. Most of the output[6] comes from mines near Darnius, La Bajol, and Massenet de Cabranys, in the Province of Gerona, on the south side of the Pyrenees, where talc similar to that across the mountains in France is found. A lower grade of talc, associated with serpentine, has been worked on a small scale in southern Spain, in the Sierra de Mijas, in Malaga, and similar material also occurs in the Sierra de Somontin, in the northeast part of Almeria.

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[1] The African World, Feb. 20, 1937. (Cited in U.S. Bur. Foreign and Domestic Commerce, Minerals Circular No. 12, April 17, 1937, p. 28.)

[2] Department of Mines, Union of South Africa, Quart. Inf. Circ., April-June, 1936, p. 45.

[3] Ladoo, R. B.: (6), p. 126.

[4] Mineral Resources of the Union of South Africa, Department of Mines, 1936, p. 410.

[5] Hall, A. L.: Trans. Geol. Soc. South Africa, vol. 30, 1927, pp. 69-88; South African Min. Eng. Journ., Aug. 27, 1937, pp. 741-2.

[6] Stutzer, O.: (1), p. 337.

SUDAN

No straight talc is produced in the Sudan, though a deposit of rather doubtful commercial grade is reported to occur at Qala en Nahl.

A talc-magnesite rock occurring in Kassala Province of the Anglo-Egyptian Sudan has recently (1935) been investigated by Tanganyika Concessions, Ltd., with a view to the manufacture from it of refractory bricks. It is stated that 500 tons of the rock was to be shipped to England for a large-scale manufacturing test[1]. The deposits, which are controlled by the Nile Congo Divide Company, are associated with serpentine and are stated to be very extensive. The rock consists[2] essentially of ferruginous magnesite (breunnerite) in a groundmass of talc, with talc forming 33 to 50 per cent of the mixture. A natural rock of this character is estimated to have important use in the refractories field, since, on calcining at high temperatures, the two minerals interact to form forsterite, which has valuable refractory properties and high crushing strength. It is stated[3], also, that separation of the magnesite and talc by flotation is now being accomplished in commercial practice. (*See* pages 46 and 107.)

SWEDEN

Talc production in Sweden has averaged around 4,000 to 8,000 metric tons in recent years (1930-37). Most of the output consists of soapstone[4], which is quarried at Handoel, in Jaemtland, and which is employed on an extensive scale for the production of sawn blocks and bricks for furnace walls, slabs and panels for stoves, electric heaters, etc., and of various turned and worked shapes for industrial and ornamental purposes, including monumental and building use. The cathedral at Trondhjem, in Norway, is built in part of Handoel soapstone. The deposits are operated by the Handoel New Soapstone and Water Power Company, of Stockholm. This company reported to the writer in 1925 that only 5 per cent of the total stone mined could be used for cutting purposes, the remainder being waste. Of the 5 per cent sawn, 2 per cent went into stove and heater slabs, panels, etc., and 3 per cent into furnace bricks.

SWITZERLAND

Although Switzerland does not figure in the table of talc-producing countries, a number of economic occurrences of talc of soapstone character ("potstone" or "lava-stone") are described in the literature[5]. Most of the production appears to have found local use as sawn and worked stone for stove and decorative purposes, utensils, etc., with some purer material also ground to produce powdered talc. Among the more

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[1] Mining World and Engineering Record, vol. 129, No. 3346, July 27, 1935, p. 93. (Quoted in U.S. Bur. of Mines, Mineral Trade Notes, vol. 1, No. 2, Sept. 20, 1935, p. 31.)

[2] Bull. Imp. Inst., 34, 1, Jan.-March, 1936, pp. 86-89.

[3] Ceramic Age, "Talc Flotation", Aug. 28, 1936, p. 41.

[4] Spence, H. S.: "Soapstone in Sweden", Can. Min. Journ., Oct. 22, 1936, p. 1013.
Trade booklets, etc., of Handoel New Soapstone Company, Stockholm.

[5] Stutzer, O.: (1), pp. 332-36.
Dammer und Tietze: (2), pp. 401-2.
de Quervain, F. und Geschwind, M.: "Die Nutzbaren Gesteine der Schweiz", Bern, 1934, pp. 80-85.

important deposits are those in the Somvix and Disentis district, in the Tavetsch valley, Graubünden; near Andermatt and Hospental, in the Urseren valley, north of the St. Gotthard massif, in Canton Uri; and at Pontresina, in the Upper Engadine. All of the occurrences are associated with serpentines and chlorite or mica schists.

TASMANIA

Tasmania has a few small deposits of talc, which, however, are not considered to possess much commercial importance. A small production (110 tons in 1937) is recorded[1] from a narrow vein of white, fine-grained talc, associated with mica schist, at Gawler, near Ulverstone, on the north coast of the island; and other deposits are known at Mt. Stewart, near Waratah, and at Dundas, where the mineral occurs with altered pyroxenite and serpentine, respectively.

UNITED STATES

The United States[2] is the world's leading producer of talc, with production in 1938 from nine States. The reported output (recorded as sales) in 1937 totalled 208,650 metric tons, an increase of 12,500 tons over 1936, and an all-time record. In 1938, production dropped about 9 per cent, to 193,025 tons. For some years past, the American production has averaged two to three times that of the next largest producers, China and France. The production figures relate only to talc (both ground and sawn) and ground soapstone, sawn soapstone (produced mainly in Virginia and Washington) not being included. They include, however, ground pyrophyllite, the alumina counterpart of talc, used for similar purposes, production of which has recently been growing rapidly in North Carolina.

Evidencing the growing industrial importance of talc in the United States, increases were registered in 1937 in all phases of the industry including domestic sales of crude talc and of ground, sawn, and manufactured products, imports, and exports. Average value of talc sales, also, was a little higher in 1937 than in 1936. It may be noted that a large part (10,000 tons) of the 1937 increase in sales went to the ceramic industry, which only a few years ago used little talc. Business slackened slightly in 1938, with a decrease of 7 per cent in quantity and 10 per cent in value of sales.

Soapstone has been mined for many years on a large scale in Virginia, where it is sawn into furnace blocks and bricks, slabs and panels for various purposes, etc., and more recently there has also been an output from Washington, mainly to supply furnace stone for the Pacific coast pulp mills. (*See* pages 47 and 49). No statistics of production are available.

The following table shows statistics of sales of talc, pyrophyllite, and ground soapstone, as reported by producers for the six-year period 1933-38:

[1] "The Geology and Mineral Deposits of Tasmania", Bull. No. 44, Geological Survey, Department of Mines Tasmania, 1938, p. 99.
[2] "Talc, Pyrophyllite and Ground Soapstone", U.S. Bur. of Mines, Minerals Yearbook, 1938, pp. 1187-94: 1939, pp. 1273-80.
Johnson, B. L.: "Marketing Talc, Pyrophyllite and Ground Soapstone", U. S. Bur. of Mines, Inf. Circ. No. 7080, June, 1939.

TABLE VIII

Sales of Talc, Pyrophyllite, and Ground Soapstone in the United States, 1933-38, by Classes

Year	Crude		Sawn and manufactured		Ground		Total	
	Short tons	$	Short tons	$	Short tons	$	Short tons	$
1933..	5,985	46,553	246	31,686	159,792	1,653,643	166,023	1,731,882
1934..	8,767	55,659	174	46,918	129,564	1,346,108	138,505	1,448,685
1935..	10,725	57,259	841	63,211	161,150	1,727,585	172,716	1,848,055
1936..	10,910	59,556	618	90,542	204,663	2,193,073	216,191	2,343,171
1937..	11,087	52,750	1,101	111,680	217,811	2,397,323	229,999	2,561,753
1938..	13,498	72,845	1,729	70,268	197,548	2,159,447	212,775	2,302,560

Consumption trends in the United States have latterly been showing some readjustment. For many years the paint, paper, rubber and roll-roofing trades, in about the order shown, took most of the output. In 1938, the ceramic industry assumed second place, with 14 per cent of total sales, followed by the roofing and paper industries, each with 13 per cent. The paint trade, which formerly used nearly one-half of the total sales, now uses only about one-fourth. The rubber trade registered a marked decline in consumption, ranking fifth, with 12 per cent.

The large increase in consumption by the ceramic trade is ascribed largely to the growing use of talc in glazed wall-tile, now a standard article in tiled bath-rooms, as well as to increased use of both talc and pyrophyllite in ceramic bodies generally.

The above-mentioned five uses accounted for 75 per cent of the total consumption of talc, pyrophyllite, and ground soapstone in 1938, as shown in the following table:

TABLE IX

Sales of Talc, Pyrophyllite, and Ground Soapstone in the United States, 1936-38, by Uses

Use	1936		1937		1938	
	Short tons	Per cent of total	Short tons	Per cent of total	Short tons	Per cent of total
Paint	56,613	26	59,660	26	53,506	25
Paper	30,996	14	32,127	14	27,329	13
Ceramics	19,073	9	29,793	13	29,590	14
Rubber	27,076	13	26,941	12	25,734	12
Roofing	25,160	12	23,551	10	27,607	13
Cosmetics	4,293	2	4,340	2	5,970	3
Foundry facings	2,781	1	3,228	1	2,511	1
Various	25,091	12	29,265	12	20,732	10
Not reported	25,108	11	22,094	10	20,156	9
Total...	216,191	100	229,999	100	212,775	100

Average value per ton of all grades showed a small, steady increase from 1934 to 1937, ranging from $10.43 to $12.50, and in 1938 stood at $10.82, a drop of 32 cents per ton over 1937 prices.

In addition to the large domestic production, the United States also imports a large amount of talc, imports for the six-year period 1933-38 having ranged between 20,449 and 26,876 short tons, the last figure being the total for 1937. Italy, Canada, France, China, and Japan, in the order named, are the principal sources of supply, furnishing 98 per cent of the total in 1938. In 1937, Canada furnished 27 per cent of the total talc imported, and in 1938, 29 per cent.

Prices of imported talc vary widely, from around $10 to $80 per ton, delivered to the customer. Canadian talc competes most usually on an equal price basis with the domestic product, at around $10 per ton. French talc sold in 1937 at an average of $16 per ton, while Manchurian talc fetches $30 to $40 per ton, with some inferior, off-colour grades selling at $20. Italy furnishes the highest-priced talc of all, used largely for cosmetic purposes, at wholesale delivered prices ranging from $45 to $80 per ton. Ground Sardinian talc (steatite) sells in the United States at $40 to $50 per ton.

United States exports of talc more than doubled between 1933 and 1937, totalling 8,878 short tons in the latter year, valued at nearly $150,000. A decline to 7,118 tons, valued at $124,194, was registered in 1938. The material was classified as "talc, steatite and soapstone, crude and ground". To this value must be added nearly one million dollars for prepared, fine talc in the form of packaged talcum powder and other cosmetic preparations.

Talc Industry, by States

According to the United States Bureau of Mines[1], production of talc and ground soapstone in 1936 was derived from thirty-five mines, distributed in the following nine states: California, Georgia, Maryland, New York, North Carolina, Pennsylvania, Vermont, Virginia, and Washington. Cut soapstone for furnace blocks, slabs, panels, and other purposes was produced in Virginia and Washington, and talc crayons were made from Georgia, North Carolina, and Vermont talc. Steatite of "lava" grade was produced in Maryland.

The output of ground talc includes a considerable range of grades, ranging from the higher grade white talcs, associated with altered dolomite, from New York, California, North Carolina, and Georgia, to the grey, off-colour types (in part soapstone) derived from serpentines or other ultrabasic, intrusive rocks, from Vermont, Virginia, and Washington, as well as, in part, from North Carolina and Georgia.

California

California had twelve talc and soapstone producers in 1936[2], five of which furnished ground talc, four crude talc, two ground soapstone, and three crude soapstone. Most of the crude and ground talc came from

[1] "Talc and Ground Soapstone"; U.S. Bur. of Mines, Minerals Yearbook, 1937, p. 1329.
[2] "Talc and Ground Soapstone", U.S. Bur. of Mines, Minerals Yearbook, 1937, p. 1330.

deposits near Bigpine, Keeler, Darwin, and Tecopa[1], in Inyo County, and near Silver Lake Station, in San Bernardino County. The product is in part ground at local mills, and in part shipped to grinding plants at Los Angeles. Sales of talc and soapstone in 1937 totalled 32,495 short tons, most of which was high-grade talc from Inyo and San Bernardino Counties.

According to Ladoo[2], the Inyo County talc is massive to granular in texture, and occurs as lenses in dolomite. The crude talc has a pale grey to greenish cast, but grinds to a pure white. It is very low in both silica and lime. At one of the larger mines, that of the Sierra Talc Company[1], mining is by adits and block caving, and the crude talc is trucked to the grinding plant at Keeler, 18 miles distant. Grinding is performed by Raymond mill, connected to a Cyclone air separator, making a minus 200-mesh product and a fine, dust grade.

The San Bernardino talc[2] is of the foliated type, pure white, and possesses high slip, with very low lime content. It occurs as inclined, irregular shoots, 4 to 7 feet thick, in a schist formation. At the mine of the Pacific Coast Talc Company, near Silver Lake, talc is won by shrinkage stoping from a main drift connected with an inclined shaft. Waste is used to back-fill empty stopes. The crude talc is shipped to Los Angeles for grinding. Grinding is done by a 5-roller, high-side, Raymond mill, connected with an air separator, making two mesh sizes of product, minus 200 mesh and minus 325 mesh.

California talc finds a market chiefly in the paper, textile, rubber, and paint trades, with the finest grade used also for cosmetics. Some also goes into ceramics and concrete.

Crude and ground soapstone are produced at Berkeley, in Alameda County; Shrub, in Eldorado County; and Saugus, in Los Angeles County. The material is sold chiefly for roofing granules, as a filler in roofing paper, and also for use in magnesite cement.

Georgia

All of the talc mined in Georgia comes from deposits near Chatsworth, in Murray County, where three mines and mills were in operation in 1936. The main production originally consisted of talc for sawing into metal workers' crayons, this industry being about forty years old.

The Chatsworth talc body[3] is a large deposit, averaging 150 feet in width, with a depth varying from 3 feet to 100 feet; it has been traced for nearly 5 miles. It is an alteration product of an ultrabasic intrusive. The talc used for crayons occurs in the form of pockets, 2 feet to 10 feet thick, enclosed in lower grade material used for grinding purposes. Mining is conducted from adits carried into the mountainside, from which drifts are run and the talc removed by room-and-pillar methods.

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[1] Sampson, R. J.: "Mineral Resources of the Resting Springs Region, Inyo County", Calif. Journ. Mines and Geology, vol. 33, No. 4, Oct. 1937, pp. 269–70.

[2] Ladoo, R. B.: (6), pp. 113–17.
Wickes, F. R.: "Crystalline Talc, Operations of the Pacific Coast Talc Company", Eng. Min. Journ. vol. 130, No. 7, Oct. 9, 1930, pp. 319–21.

[3] Trauffer, W. E.: "New Plant in Georgia Talc Field"; Pit and Quarry, June, 1936, pp. 64–66.

At the mill of the Southern Talc Company[1], crude talc is dumped to a 600-ton storage shed; it is then fed by conveyer belt to a Williams Junior hammer-mill, followed by a Williams 4-roller, high-side mill, connected to an air separator and dust collector, making two products. Coarse product from the separator is screened on a vibrating screen, making a minus 35-mesh granule product for roofing purposes, the overs being returned to the circuit.

Georgia ground talc, much of which is of off-colour grade, finds a market in the rubber, roofing, and foundry industries, with the better grades used to some extent by the paint and textile trades. Prices in 1937 were $6 per ton for grey talc and $8 for the whiter grade, minus 200-mesh product, f.o.b. mills.

An important part of the output of Georgia talc finds employment for steel-makers' crayons or pencils, the State being the largest American source of this commodity. Some has also been used for lava purposes. Ground talc is considered a by-product. The crayons are cut by means of motor-driven circular saws, the principal sizes made measuring $\frac{1}{4}$ or $\frac{1}{2}$ inch by $\frac{3}{16}$ inch by 5 inches.

Maryland

Massive talc of steatite grade is mined near Dublin, in Harford County, and manufactured into lava articles. According to Gillson, (10) p. 884, the Dublin steatite yields exceptionally large, sound blocks, cubes up to 12 inches being obtainable: in this respect, the steatite is the equal of that from any other known source. Some of the material is also used for grinding and finds a market with the ceramic, insecticide, paint, and roofing trades.

Similar talc is also found near Sykesville, in Carroll County, as well as in Cecil and Montgomery Counties. According to Clark and Matthews[2], the deposits are associated with serpentine bodies, and the material has been used as slab stone for the manufacture of sinks, tubs, fire-brick, etc. Some ground talc schist is produced at Marriottsville, in Carroll County, mainly for paint and foundry purposes.

According to Diller, Fairchild, and Larsen[3], the Dublin steatite is quarried from open pits, about 30 feet deep, the talc bodies ranging from 4 to 10 feet in width. Careful selection of run-of-mine material is made, only the softest, most compact, and uniform talc being used for lava purposes.

New York

New York leads all other States in point of talc production, with an output in 1938 of over 86,000 short tons, equivalent to 40 per cent of the total output. The peak year was 1929, with 109,543 tons.

The main productive region lies near Talcville, a few miles south of Gouverneur, in St. Lawrence County, where two companies, W. H. Loomis

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[1] Rock Products, vol. 39, Sept., 1936, pp. 48-51.

[2] Clark, W. B. and Matthews, E. B.: "Maryland Mineral Industries"; Maryland Geol. Surv., vol. 8, Pt. 2, 1909, p. 160.

[3] Diller, J. S., Fairchild, J. G., and Larsen, E. E.: "High-grade Talc for Gas-burners", Econ. Geol., vol. 15, No. 8, Dec., 1920, p. 668.

Talc Corporation and International Pulp Company, operate five mills, grinding talc from five mines. Average maximum depth reached in mining is about 900 feet. All of the talc is of essentially similar character, a good white in colour, and of a fibrous nature, due to the presence in it of substantial amounts (40 to 60 per cent) of residual or semi-altered tremolite. It occurs in both vertical and inclined bands or lenses in a white, crystalline, Precambrian dolomite of the Grenville series, which has been locally altered (silicified) by hydrothermal solutions derived from a porphyritic granite[1]. The first stage in the alteration was the formation of acicular or fibrous tremolite, a silicate of lime and magnesia, and enstatite, a silicate of magnesia, which later suffered complete or partial transformation to talc. Dolomite ("lime") and tremolite constitute the principal impurities. Due to its fibrous nature, the talc has been found particularly suited to special uses, notably paint and paper. It is also advocated for use in concrete admixtures and mortars, to which it imparts water-proof properties, and its use in ceramic products, both saggers and white-ware, has become important. A special grade, produced by the "micronizing" system of pulverizing, finds application in plastics.

At the larger of the two mills of the Loomis Talc Corporation[2], with a capacity of 150 tons of finished product per day, the crude talc is first broken down by jaw crusher and then passes through rolls in closed circuit with a screen; overs are returned to the rolls, and the throughs pass to a Hardinge mill and then to large pebble tube mills, 8 by 26 feet, in closed circuit with Gayco air separators. All crushing and grinding units are connected to dust collectors. The "micronized" grade is produced by a micronizer machine, using compressed air: particle size of the product is stated to average 17 microns. Products from this plant are marketed under the trade names of "Loomite" (for concrete use), and "Tremoline" (for ceramic use). All grades are stated to pass better than 99 per cent through 325 mesh. Paint grade, which runs 99·6 per cent minus 325 mesh, is stated to cost $20 per ton more for grinding cost than the standard grade passing 99·15 per cent through the same mesh. Study of grinding methods over a long period of years has enabled mill capacity to be almost doubled with no increase in grinding equipment. The talc bulk increases tremendously in grinding, the weight of the crude ore being 180 pounds per cubic foot, while the finished product weighs only 33 pounds per cubic foot, packed. This increase in bulk results in the carrying of a large circulating load of about 7 tons of finished talc per mill in the tube mills. Close attention is given to the preservation of a constant rate of feed throughout the entire circuit, by the use of constant-weight feeders and by keeping screw conveyers filled to capacity. Moisture released in grinding is drawn off by air suction. Production records kept over a period of one year have shown that 8¼ man-hours and 175 h.p. hours are expended per ton of finished talc, this including both mining and milling.

At the largest of the three mills operated by the International Pulp Company[2], the crude talc is brought in from the mines, 10 miles distant, in

[1] Gillson, J. L.: "Origin of the Vermont Talc Deposits", Econ. Geol., vol. 22, No. 3, May, 1927, pp. 278-9.
[2] For the data given in this and the following section, the writer is indebted to the managements of the two companies concerned.

open gondola railroad cars. Power is furnished by direct, water-driven turbines, which have lately been augmented by a 600 h.p. Diesel engine, as an auxiliary unit during daily low-water periods. Mill capacity is 100 tons per 24 hours. Crude is first broken in a jaw crusher, 30 by 36 inches, and is then reduced to ¾ inch in a Symons disk crusher, followed by passage through rolls, which reduce to ¼ inch. The crushed talc is then fed to two units, each consisting of three tube mills, 6 by 24 feet, in series, the mills being lined with Minnesota quartzite and charged with quartzite cubes. Air separators of the company's own design are used.

No initial drying of mill-feed is required at either of the above mills, the heat generated in grinding sufficing to drive off the moisture content.

Recently, methods of beneficiating the talc of the Gouverneur district have been investigated in the laboratories of the United States Bureau of Mines (*see* pages 107 to 108), but no attempt at commercial production of such cleaned talc has yet been made.

In addition to the production from the above region, talc is also mined near Natural Bridge, close to the line between Lewis and Jefferson Counties. The deposit here is associated with limestone and serpentine, and the talc differs in character from that of the Gouverneur district to the west, inclining to massive in texture and lacking the fibrous form of the latter. Milling of the talc[1] is performed by first breaking in a jaw crusher and hammer mill, followed by reduction in Hardinge mills, with final grinding in tube mills or in a Raymond high-side, 5-roller mill.

Earlier mining and milling operations for talc in the State have been described in a special report by Ladoo[2].

New York talc, short fibre, 325 mesh, was quoted at $11 to $17 per ton, f.o.b. mills in 1938.

North Carolina

Talc of two types occurs in North Carolina[3]. The more widely distributed type is a soapstone, derived from the alteration of basic igneous rocks, chiefly pyroxenites and dunites, but this has been little mined and is not of present economic importance. Higher grade material, associated with altered carbonate rocks (the Murphy marble), occurs in irregular, lenticular deposits in the extreme southwest corner of the State, in a zone stretching southwest from Asheville, through Hewitt, in the Nantahala River valley, Swain County, and Murphy, in Cherokee County, and passing on into Georgia. This zone has a length of over 40 miles within the State, and varies in width from a few hundred feet to half a mile. The talc deposits are considered to be lenses formed by local alteration of the enclosing marble through magmatic solutions derived from quartz-diorite dykes.

Mining was commenced some 80 years ago (1859), when talc was mined for furnace linings. Later, development in the Murphy area became extremely active, with production made from twenty-five localities. In recent years, most of the production has come from Kinsey, near Murphy, and from Hewitt.

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[1] Ladoo, R. B.: (6), p. 104.

[2] Ladoo, R. B.: "Talc Mining in New York", U.S. Bur. of Mines, Reports of Investigations, No. 2171, Oct., 1920.

[3] Pratt, J. H.: "Talc and Pyrophyllite Deposits in North Carolina", N. Carolina Geol. Surv., Economic Papers, No. 3, 1900.
Stuckey, J. L.: "Talc Deposits of North Carolina", Econ. Geol., vol. 32, No. 8, Dec., 1937, pp. 1009-18.

The talc is white to pale greenish in colour, and has, variously, a compact, foliated, or fibrous texture, with the last the more pronounced. Tremolite and dolomite, or calcite, with some quartz, are the commoner impurities. Most of the mining has been conducted by means of open pits or shallow shafts extending to a depth of about 50 feet.

In 1936, four companies produced[1] talc in the State, two near Murphy, one near Hewitt, and one at Glendon in Moore County. The production comprised both crude and ground talc[2], with some harder, green talc sawn also into crayons. Some of this latter type has also been employed for lava purposes. Grinding is performed by Raymond-type mills, and also by swing-hammer mills, combined with air separators.

Some of the harder and more massive talc from the Hewitt region was formerly mined for lava purposes[3], being used for the production of gas-burner tips. This is one of the only two American commercial sources of massive lava talc, the other being in Maryland.

Vermont

Vermont ranks second among the talc-producing States, and in 1938 produced 35,000 short tons, equal to 16 per cent of the total output. The main productive region lies in Lamoille and Washington Counties, in the northern part of the State, where two large and old-established mines[4] are worked at Johnson and Waterbury, respectively, with two other operations in Windsor and Windham Counties, near Chester, farther to the south. There has also been a considerable production from a mine near Rochester, in Orange County, but this operation was closed down in 1927.

All of the Vermont talc is associated with ultrabasic rocks, mainly serpentine, and most of it is of grey to buff, off-colour grade. Impurities are chiefly chlorite, dolomite (or magnesite), some secondary silicates, pyrrhotite, and arsenosulphides. Most of the output goes to the paper, rubber, and roofing industries, with some, also, to the textile trade. Some of the more compact material from the deposit at Waterbury is sawn into crayons.

The deposits[5] lie in the highly deformed terrain of the Green Mountains region, and have been much squeezed and contorted, commonly having rather steep dips. They form irregular bodies of so-called "grit", bordering large, lens-shaped masses of serpentine locally termed "cinder".

Mining is by adit or shaft, with stoping. At the Waterbury mine, the main adit extends over one-half mile into the hillside, with the inner end 600 feet below surface. At Johnson, the shaft is 250 feet deep, with 2,000 feet of ore-body opened up.

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[1] "Talc and Ground Soapstone", U.S. Bur. of Mines, Minerals Yearbook, 1937, p. 1330.

[2] NOTE.—The product of the Glendon plant is styled "pyrophyllite talc" and is actually pyrophyllite. D. Hagar (Ceramic Age, vol. 31, May, 1938, pp. 152-3) has drawn attention to the undesirability of the practice of classifying pyrophyllite with talc, and his objection would seem to be well-taken.

[3] Diller, J. S., Fairchild, J. G., and Larsen, E. S.: "High-grade Talc for Burner Tips", Econ. Geol., vol. 15, No. 8, Dec., 1920, pp. 665-73.

[4] Taylor, A. S.: "Soapstone and Talc Have Been Produced in Vermont for a Century", Pit and Quarry, vol. 21, No. 5, Dec. 3, 1930, pp. 33-48; "Vermont a Notable Producer of Talc", Compressed Air Magazine, Oct., 1930, pp. 3282-86.

[5] Gillson, J. L.: "Origin of the Vermont Talc Deposits", Econ. Geol., vol. 22, No. 2, May, 1927, pp. 246-87.

At the mills of the Eastern Magnesia Talc Company[1], at Waterbury and Johnson, the crude talc is first broken down by jaw and rotary crushers and is then dried in direct, coke-fired dryers. It is then ground either by rolls, Hardinge ball mill, or Raymond high-side, roller mills, depending on the grade of product to be made, all in combination with screens and air separators. For textile use, grinding is done in a vertical buhr-mill. Run-of-mine talc is milled, with no attempt to sort into grades.

At the Johnson mill, installation has recently been made of a device known as the "electric ear" for control of the ball mill feed. This device[2] works on the principle that when the volume of ore in the mill runs below the optimum grinding capacity, a correspondingly louder noise is produced through the impact of the balls on the shell. The volume of sound is converted into electrical energy, which, in turn, automatically increases or reduces the rate of feed. By this means, increases of 10 to 15 per cent in grinding capacity are said to be obtainable. (Compare the "electric eye" used at a Quebec mill for the same purpose, page 97.)

A recent development at the Johnson mill is the installation of a flotation unit[3] to separate the talc from the admixed impurities, mainly magnesite and arsenosulphides carrying nickel and cobalt. The feed for the flotation circuit, which has a capacity of 1 ton per hour (400 tons per month), is an intermediate reject from the air separators of the dry-grinding plant. This is fed first to a conditioner, using Calgon and zinc sulphate, and then goes to a Wilfley and a Deister table, in series, which remove the coarse metallics, principally gersdorffite and pyrrhotite. The table tailing passes to a 3-cell flotation rougher, making a talc concentrate and a magnesite tailing, the former going first to thickeners, followed by a filter-press, and then to an oil-fired Ruggles-Cole dryer, being finally ground in a Raymond, 5-roll, high-side mill. Alternatively, for micronizing (*see* page 105), the flotation rougher concentrate may be passed to an 8-cell cleaner, the product of which goes to a thickener and is then filter-pressed, dried, and ground as above, being finally passed through the micronizer unit.

The floated talc, although not entirely iron-free and therefore not suitable for the ceramic trade, has a very good white colour and is reported to meet U.S.P. specifications. The flotation feed contains about 55 per cent talc and 45 per cent magnesite. Recovery is about 70 per cent of both products, or about 750 pounds of the talc and 650 pounds of magnesite per ton of feed. The magnesite product is stated to contain 4·15 per cent insoluble and 6·6 per cent Fe_2O_3. Recovery of metallics from the tables is 1 ton per 400 tons of product treated; they are sold for their nickel-cobalt content.

Only trial lots of micronized talc have so far been made. This device, manufactured by the International Pulverizing Corporation, Moorestown, N. J., is designed to reduce by impact in a small chamber into which the feed is introduced with high-pressure, dry steam. Optimum capacity for the unit used was found to be 500 pounds of feed per hour,

[1] For the data given in this and the following section, the writer is indebted to the managements of the companies concerned.

[2] Hardinge, H.: The "Electric Ear, a Device for Automatically Controlling the Operation of Grinding Mills by Their Sound", Amer. Inst. Min. Met. Eng., Tech. Publ. No. 1076, 1939. *See also*, Bull. 42, Hardinge Company, York, Pa.

[3] Trauffer, W. E.: "Froth Flotation Recovers Valuable Material from Talc Waste", Pit and Quarry, vol. 32, Oct., 1939, pp. 28-30.

the product made averaging 5 microns. Operated first with steam, a change-over to compressed air has recently been made, with satisfactory results.

Talc from the Chester district is air-dried and is then broken down in a jaw crusher or hammer-mill, grinding being done either by a Raymond 5-roll, high-side mill or a Sturtevant ring-roll mill, combined with air separator and dust collector. The purer talc goes mainly to the paper and foundry trades, and some also goes to tanneries. The product of one mill is a coarsely foliated talc, almost micaceous or sericitic in appearance, which goes entirely to the roofiing trade.

Earlier talc mining and milling operations in the State have been described in a special report by Ladoo[1].

Vermont talc, 200 mesh, was quoted at $8 to $14 per ton, f.o.b. mills in 1938.

Virginia

Virginia possesses immense deposits of soapstone, development of which has been underway for many years (since 1880). The material is won from a number of large quarry openings, and is mostly sold in the form of cut and worked stone for a variety of purposes. There is also some production of ground soapstone in the State, but figures of tonnage and value are not available.

The soapstone, an alteration product of a variety of ultrabasic igneous rocks, including pyroxenites, gabbros, and serpentines[2], that occur as dykes, stocks, and plugs, is found in a wide belt extending in a southwesterly direction from Madison County in the north to Grayson County in the south, a distance of over 200 miles, with the greatest development in Albermarle and Nelson Counties, where most of the larger producing deposits are situated. This last region is said to produce more cut soapstone than any other locality in the world. The greater part of the present production comes from the operations of the Alberene Stone Corporation of Virginia, at Schuyler, whose product is styled "Alberene Stone." A second centre of production lies in Fairfax County, about 70 miles northeast of Madison County, with a third at Henry, in Franklin County, toward the southwest end of the belt. A reddish, weathered soapstone is mined near Clifton, in Fairfax County, and ground for foundry use, being marketed under the name of "Bull Run" talc. In addition, there are a number of other scattered localities in the same general region where soapstone is being, or has been, worked. Narrow veins of green, white, or yellowish foliated talc sometimes are found in the soapstone, and grey, impure, schistose talc also occurs in bands in the serpentines, but these materials are considered of only secondary commercial importance.

The Virginian soapstone is a medium- to fine-grained, grey-green rock, sometimes showing schistose structure or grain, and it is this schistose type that is best adapted for manufacturing. Three degrees of hardness are

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[1] Ladoo, R. B.: "Talc Mining in Vermont", U.S. Bur. of Mines, Sept., 1919.

[2] Burfoot, J. D.: "The Origin of the Talc and Soapstone Deposits of Virginia", Econ. Geol., vol. 25, No. 8, Dec., 1930, pp. 805-26.

Hess, H. H.: "Hydrothermal Metamorphism of an Ultrabasic Intrusive at Schuyler, Virginia", Amer. Journ. Science, Oct., 1933, pp. 377-408.

recognized, classified respectively as "soft stone", "tough stone", and "hard stone". The first contains the most talc, and is the preferred type. Mineral constituents of the rock include talc, 5 to 85 per cent; chlorite, 5 to 50 per cent; serpentine, trace to 25 per cent; amphibole, trace to 50 per cent; carbonates, trace to 25 per cent; magnetite, trace to 5 per cent; pyrite, trace to 2 per cent. The "hard" stone contains the most chlorite and amphibole and the least talc, with the proportions reversed in the "soft" stone, and intermediate in the "tough" stone. The stone occurs in irregular lenses along the margins of the original basic rocks, with similar strike and dip to the latter. The lenses sometimes attain very large size, as in the Schuyler and Alberene quarries, where the soapstone bodies range up to 300 feet in width, with lengths of 1,200 and 2,000 feet, respectively.

Quarrying and dressing of the soapstone have been described by Ryan[1] and also by Hughes[2]. Where the vein is wide enough, a wall of soapstone is left on both walls of the ledge, to reduce caving hazards. Individual quarry dimensions depend on the width of the ledge or band to be worked, but seldom exceed 100 by 100 feet. A few have been carried down to a depth of 200 feet. (*See* Plate VIII, page 108). In some instances, several pits have been opened in line along the strike, with a bridge wall 25 to 40 feet thick left between adjacent openings to support the walls. Channelling machines are used to slice "layer cuts" at right angles to the strike of the ledge, and "end cuts" along both walls. Undercutting machines make the bottom slice of each layer of stone removed. Each layer is cut out in sections 4 feet wide by 7 feet 6 inches deep, the full width of the quarry, so that each successive tier, or "floor", is 7 feet 8 inches deeper than the one above, which includes the 2-inch channel cut. Individual blocks of stone of the dimensions required, usually about 4 by 4 by 6 feet, are finally broken out of the sections by means of plugs and feathers.

After removal from the quarry, the blocks are placed on flat cars for sawing by means of gang saws. Care is taken to ensure sawing parallel to the grain or schistosity of the rock (*see* page 109). Sawn slabs are cut to the required dimensions and shape by circular cut-off saws and rip-saws, either toothed or faced with carborundum. Finishing of slabs consists in rubbing down to exact thickness on a revolving, circular steel table, using crushed steel shot as a grinding medium. If required, the slabs are finally polished on a buffing machine, using a carborundum mud or slurry. After such finishing, the slabs are grooved, drilled, and shaped for the particular use to which they are to be put, and are then ready for assembly or shipment. Furnace stone needs no finishing, and is merely sawn to size and smoothed with a steel planer. Fireless cooker disks are cut out from square plates on a lathe.

The stone is used for a variety of purposes, including furnace blocks and bricks for kraft mill use; switchboard panels; stair treads; laboratory fume-cupboard hoods, table tops, and sinks; tanks for various purposes; interior and exterior trim (including mantels and hearths); monumental use; garden stone (walks, benches, bird baths, etc.); griddles and fireless cooker disks; cores for electric heaters, etc.

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[1] Ryan, C. W.: "Soapstone Mining in Virginia", Amer. Inst. Min. Met. Eng., Tech. Publ. No. 160, 1929 (31 pages).

[2] Hughes, H. H.: "The Soapstone City", Rock Products, vol. 35, No. 3, Feb. 13, 1932, pp. 25–8; "Soapstone", U.S. Bur. of Mines, Inf. Circ. No. 6563, Feb., 1932.

Owing to the considerable variation in mineral content, hardness, texture, and grain of the stone, careful attention is paid to the grade used for the particular purpose to which it is to be put. The paper by Ryan[1] gives the following particulars in this regard. For electrical equipment, a medium hard stone, free of minerals that conduct current, is required, and for this purpose a foliated massive type is preferred. For laboratory equipment, stone substantially free of carbonates (dolomite or siderite) that will suffer attack by acids and fumes is essential. Stair treads are made from hard stone of uniform composition and texture, to ensure evenness of wear and freedom from edge-spalling. Open-textured, soft stone is preferred for furnace use, since an open texture tends to offset the differential expansion taking place in a rock of complex mineral composition at high temperatures; such stone is commonly freer to carbonates, also, than the more compact type, and is thus less liable to attack by calcination, with resultant disruption and loss of strength and wearing life. In general, it is the absence of certain objectionable characteristics, rather than the possession of any specific desirable properties, that dictates selection of stone, though the latter are, of course, in a way dependent on the former. In determining the commercial value of soapstone for various industrial purposes, close study of the wearing properties, heat retention, fusibility, electrical and heat conductivity, chemical resistance, and other properties, is essential for best results.

According to Hughes[2], only about 20 per cent of the total quarry output becomes finished, cut stone. A portion of the waste is used for the production of powdered soapstone, being first broken in a gyratory crusher and then ground in a ball-mill and tube mill, sizing being done by Hummer screens and air classifiers. A large proportion of the output goes to the rubber industry.

A recent report[3] of the United States Bureau of Mines states that dolomite can be removed from ground Alberene stone by electrostatic separation, with the production of a cleaner talc fraction; the associated tremolite and magnetite, however, could not be entirely taken out by such means. The same report (p. 35) indicates that the beneficiation of talc and pyrophyllite by various means, including flotation and table agglomeration, may be improved considerably by subjecting the feed material to a preliminary "attrition scrubbing" treatment, designed to remove smears of the softer valuable products from the associated, harder gritty impurities.

Prices of powdered soapstone in 1937 ranged from $4.75 to $5.50 for 200-mesh material, and from $6.25 to $7 for 325-mesh.

Washington

Soapstone, derived from basic intrusive rocks, and sometimes containing narrow talc veins, is extensively developed in northern Washington, occurrences being recorded[4] in Chelan, Lincoln, Okanagan, Stevens, and Skagit Counties. Most of the production has come from near Burlington,

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[1] Ryan, C.W.: Op. cit.
[2] Hughes, H.H.: Op. cit.
[3] U.S. Bur. of Mines, Reports of Investigations, No. 3473, Oct., 1939, p. 34.
[4] Glover, S. L. "Non-Metallic Mineral Resources of Washington", Dept. Conservation and Development, Washington, Bull. No. 33, 1936, pp. 115–18.

Marblemount, and Rockport, all in Skagit County, the material comprising both crude and ground talc, and crude and sawn soapstone for furnace blocks, etc. Talc, associated with dolomite, was formerly mined and ground near Mondovi, in Lincoln County, and similar material has also been obtained near Springdale, in Stevens County.

At Burlington, a mixture of impure talc and asbestos is mined and milled for the production of special furnace cements, paint and roofing fillers, concrete plasticizer, and other products. From deposits near Marblemount, crude block talc and cut soapstone are shipped for use as pulp-mill furnace linings: there was formerly a small production of ground talc, also, from the district.

The operations of Skagit Talc, Inc., on the Skagit River, near Rockport, the largest producer of sawn soapstone in the State, have recently been described[1]. Most of the output consists of cut furnace stone for kraft mills, but some is also sawn into slabs, panels, etc., for buildings and ornamental use, griddles, crayons, and other articles. Talc suitable for "lava" purposes is also produced. The deposit consists of six ledges, varying from 35 feet to over 100 feet in width, exposed on a steep mountain slope. Mining is underground, by means of an adit, contrary to the usual open quarry methods followed in mining soapstone, and the unique method is practised of first cutting out a room 16 feet long and the full width of the ledge, which is 75 feet to 125 feet wide, by means of a Radialax coal-cutter. The stone is then cut out in the form of bars 8 feet long and 18 inches square, by means of a 40-inch circular quarry saw fitted with carborundum teeth. The blocks of stone are then loaded on cars by an air-hoist, and lowered on a 300-foot gravity tramway to the sawing plant, situated 100 feet below the adit entrance. Here, the bars are cut up into the various sizes required by means of a circular head-saw, 60 inches in diameter, final sizing and shaping being done by smaller trimming saws, of 36 inches and 30 inches diameter, all fitted with carborundum teeth. The finished stone sold in 1936 at $3.75 per cubic foot, f.o.b. mine.

In 1937, there was a recorded production of 406 short tons of talc and ground soapstone in the State, and in 1938, 174 tons: figures of output of cut soapstone are not available. Some soapstone waste is shipped to a grinding plant in Vancouver, B.C., for the production of roofing powder.

A recent paper by Wilson and Pask[2] describes in detail the various talc and soapstone occurrences and operations in the State, and gives also the results of numerous comparative colour and firing tests on talcs and soapstones from various sources. An extensive bibliography of eighty-one references to talc and soapstone literature is included.

Other States

Occurrences of talc and soapstone are recorded in the following States[3], from some of which there has been a small production at various times.

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[1] Pit and Quarry, Sept., 1936, pp. 43-56.
Merten, H.: "Beginning of the Washington State Talc Industry"; Rock Products, Dec., 1935, pp. 30-31.

[2] Wilson, H. and Pask, J. A.: "Talc and Soapstone in Washington"; Amer. Inst. Min. Met. Eng., Contribution No. 9, Feb., 1936 (25 pages).

[3] Most of the data given here are taken from the reports by Ladoo (6), pp. 9 and 109, and Gillson (11), pp 276-81.

Massachusetts. Talc, in general similar to that of Vermont, is found at several localities in Massachusetts, including Rowe, in Franklin County; in Worcester County; and at Russell, in Hampden County. There has been a small production from the Rowe deposit. Soapstone, used by the Indians for pipes and cooking vessels, occurs at Wilbraham, near Springfield.

New Jersey. Talc has been mined from deposits north of Phillipsburg, on the east side of the Delaware River, opposite Easton, Pa., where the mineral occurs in similar association with serpentine that crosses the boundary of the two States in a northeast-trending belt[1].

Pennsylvania. Talc and soapstone deposits occur[1] north of Easton, from which there is a small production of ground material. The occurrences are associated with serpentine in a dolomite formation, both the talc and serpentine having been formed by emanations from pegmatites intrusive into the dolomite. Similar material is also found near West Chester.

Various. Ladoo (6) mentions an occurrence of fibrous talc in the Laramie Hills, near Wheatland, Wyoming; a deposit of medium- to high-grade talc near Dillon, Montana; and massive talc, of lava grade, near Talladega, Alabama. According to the same author, soapstone occurs near Benton, in Saline County, Arkansas; and similar material has also been worked at Manville, Rhode Island, and Francestown, New Hampshire.

URUGUAY

Trade returns show small exports of talc from Uruguay in recent years, the annual quantities for the period 1930-36 ranging between around 1,000 to 2,500 tons. Most of the exports go to Argentina.

The Uruguay talc is stated[2] to occur northwest of Colonia, at the mouth of the Parana River, opposite Buenos Aires. The deposit forms lenticular bodies in chloritic schist, the central portions of the lenses consisting of pure talc which grades outward into grey talc schist containing chlorite and quartz. Irregular inclusions of chalcedony and calcite in the ore-body suggest that the talc has been formed by alteration of a dolomite band enclosed in phyllite.

U.S.S.R. (RUSSIA)

Russia does not figure in the available world statistics of talc production, but the country possesses important reserves of talc rocks, in large part of soapstone character, and there is now, doubtless, a production of some magnitude. The last year for which production figures are available is 1928, when 5,480 tons were reported. Edwards, in a recent paper, gives the 1935 output as 14,000 metric tons[3]. Until the World War, the entire talc production consisted of cut soapstone, used for furnaces, stoves, etc., and it was not until 1916 that ground talc began to be produced from material of the Miass region.

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[1] Peck, F. B.: "The Talc Deposits of Phillipsburg, N.J., and Easton, Pa."; Geol. Surv. New Jersey, Ann. Rept, 1904, pp. 163-85.
[2] Stutzer, O.: (1), p. 357.
[3] Edwards, Tom: "The Mineral Deposits of the U.S.S.R."; Mining Magazine, vol. 58, No. 6, June, 1938, p. 341.

According to Kostilewa[1], talc rocks are extensively developed in the Ural Mountains, where they occur chiefly as an alteration of serpentines, pyroxenites and other ultrabasic types. Some high-grade vein talc occurs, but much of the material consists of inferior talc schist and soapstone. A chain of 276 known deposits of various types, a number of which have been worked, extends from Kamenka, in the Nizhni-Tagil district, in the north, through Sverdlovsk (Ekaterinburg) to Miass, south of Zlatoust, in the south, a distance of over 500 miles. Most of the output from these workings has consisted of cut soapstone for furnace and stove use, as well as, in part, for building purposes. One of the largest producing districts has been Sjirostan, south of Zlatoust, where there are a number of quarries. The deposits of the region south of Miass are estimated to contain large reserves of talcose material, which are now being used for the production of ground talc. Soapstone bricks for metallurgical use are sawn in a works at Sverdlovsk from stone produced at Shabrov. The Shabrov stone contains magnesite, and plans have been announced to recover this mineral and talc by flotation[2].

A further soapstone-bearing region is that of Korelski-Masselga and Listja-Guba, south of Lake Seg, in Karelia, northern Russia, from which stone is mined and sent to Leningrad to be sawn and worked up into articles of various kinds, principally switchboard panels. Talc, in the form both of talc schist and soapstone, is also reported to occur at a number of other places in the Government of Olonez, including the region around Wyg and Toros Lakes, as well as in the Caucasus, and in the Khirgiz steppes.

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[1] Kostilewa, E.: "Talk", Z. f. p. Geol., vol. 37, April, 1929, pp. 58–62. Stutzer, O.: (1), pp. 341–47.

[2] Die Chemische Industrie, vol. 57, July 7, 1934, p. 502.

CHAPTER IV

TALC AND SOAPSTONE MINES AND OCCURRENCES IN CANADA

In this chapter are given condensed data on the principal known deposits of talc and soapstone in Canada. Fuller details relating to certain of these occurrences, and more particularly in respect to their geology, are contained in the report "Talc Deposits of Canada," by M. E. Wilson (No. 15 of the Bibliography) on page 140. Wilson's report also contains numerous text references to descriptions of talc occurrences contained in publications of the Geological Survey. The writer's previous report, also, (No. 7 of the Bibliography) includes earlier information that it has not been thought necessary to repeat here, and these two works should be consulted for nearer information relating to any particular occurrence. The appended references following each of the deposits here described give the more important sources of published data. The locations of the various talc- or soapstone-bearing regions are shown on the index map, Figure 2, page 102.

BRITISH COLUMBIA

Most of the talc production in British Columbia has come from two small mines, one situated on Wolfe Creek, in the Victoria Mining Division, Vancouver Island, and the other near McGillivray, in the Lillooet Mining Division, on the Pacific Great Eastern Railway. Total output from both these operations has been comparatively small, and probably does not exceed 3,000 to 4,000 tons. Exact statistics of production are not available, but output in recent years is stated to have been only about 75 tons per year. Production value in 1935 was $573, with price of crude talc given as $5 per ton, and of ground talc, $20. Most of the output has gone to the local roofing trade in Victoria and Vancouver, with a small amount sold also to the paper and paint trades.

Aside from an occurrence of white, steatitic talc in the Windermere Mining Division, on the Alberta-British Columbia boundary (*see* page 57), the known talc deposits in the Province yield an off-colour grade of ground product, and the limited demand for high-grade, white talc is met by imported material from California or the Orient. In recent years, roofing trade requirements have been met on an increasing scale by ground mica, as well as by ground soapstone made from soapstone waste imported from the State of Washington, and this has resulted in decreased sales of ground domestic talc, as reflected in the present low output value cited above.

Victoria Mining Division (Vancouver Island)

Eagle Claim

Small amounts of talc have been produced intermittently since 1919 from a deposit on the Eagle claim, which lies about one-half mile above the mouth of Wolfe Creek, a tributary of Sooke River, in the Malahat district, near **Kapoor.**

Originally opened by W. G. Dickinson, of Victoria, who mined and shipped talc to Sidney for grinding, the property was later taken over by the Eagle Talc and Mining Company, of Victoria, who, in 1921, erected a small mill at the mine. This company ceased operations in 1925, and between 1925 and 1935 intermittent production was continued by Kennedy and Holland, of Victoria, under lease. The property has lain idle since 1935. Most of the production has gone to the roofing trade in Victoria and Vancouver.

The workings lie in the west bank of Wolfe Creek, where two small tunnels have been driven, following a narrow, steeply dipping talc band lying in a rather highly crushed assemblage of black, carbonaceous slate and argillite. A small shaft was also sunk to a depth of 35 feet from the bank above, from which a short drift has been run a distance of 65 feet.

When visited in 1937, all of the workings were in a rather badly caved condition. The inner end of the main tunnel then showed a face of 6 feet of talc, enclosing narrow bands of dark slate. Three lens-shaped bodies of talc are stated to occur, with widths ranging from 6 to 15 feet.

The crude talc is of greyish green colour, has a granular texture, and yields, on grinding, an off-colour powder of similar shade, which possesses only moderate slip. It is of inferior quality, owing to the presence of a considerable amount of impurities, largely carbonate, and would probably possess little commercial value except for the roofing trade. It is stated, however, that the finest ground material has been pronounced suitable for certain grades of paper, with sales, also, to the paint trade. Two analyses of samples of the crude ore, made in the chemical laboratory of the Bureau of Mines, gave the following:

—	1	2
Silica	33·68	34·38
Ferrous oxide	4·97	4·59
Ferric oxide	Nil	0·45
Alumina	1·65	0·83
Lime	15·32	8·68
Magnesia	22·88	26·94
Carbon dioxide	18·23	19·30
Water above 105° C	3·20	3·10
Total	99·93	98·27

Analysis of sample 1 would indicate the material to be composed of about 50 per cent talc substance, with 38 per cent of dolomite and calcite. The alumina is possibly present as kaolin, and the iron is largely pyrrhotite, with some magnetite.

The mill stands on a bench 75 feet above the workings, with which it is connected by a skipway. Milling was by rolls, connected to an air separator. Three grades of product were made, minus 200-mesh, minus 150-mesh, and plus 150-mesh, designed, respectively, for the paint, paper, and roofing trades. When visited in 1937, most of the mill equipment had been removed to a roofing-granule plant located one mile distant.

According to Wilson, (15) p. 37, similar talc occurs in a band up to 18 feet wide near the south end of Sooke Lake, about 3 miles northwest of the Eagle claim; this occurrence is not known to have been worked.

References. Spence, H. S.: (7), pp. 21-23.
Wilson, M. E.: (15), pp. 33-37.

Lillooet Mining Division

Lake Shore and Lucky Jane Claims

Talc has been worked intermittently since 1917 on the Lake Shore and Lucky Jane claims, near McGillivray, between mile 90 and mile 91 on the Pacific Great Eastern Railway. Talc was first mined here by the Pacific Roofing Company, of Vancouver, who shipped the crude talc to their Vancouver works for grinding and use. Later, British Columbia Quarries, Limited, of Vancouver, and John Creagle, of McGillivray, continued intermittent work and shipped small amounts under contract to the grinding plant of B. C. Refractories, Vancouver. The last work done was in 1935, and the total amount of talc shipped is estimated at around 500 tons.

The above claims lie alongside the railroad, and all the various small workings have been opened close to the track. The talc occurs as rather narrow vertical veins or bands, from 18 inches to 36 inches wide, which pinch and swell irregularly, and follow a rather erratic course in an assemblage of crushed and schisted chloritic slates and altered greenstones containing quartz veins and stringers and cut by granodiorite dykes.

The crude talc varies from light to dark green, yielding a fairly white powder with good slip. The veins have been highly sheared, and the ore is soft, inclined to fissile, and intensely slickensided. The earlier workings at mile 91 caved in around 1930, and all subsequent work has been carried out near mile 90. Mining has been by several short tunnels, the longest 100 feet, carried into the mountainside above the railway and following the talc leads (*see* Plate I): no plant was used, the talc being won by pick and shovel methods and shot down the hill into railroad cars.

Analyses of two samples of the crude talc, made in the chemical laboratory of the Bureau of Mines, showed:

—	1	2
Silica	57·62	58·06
Ferrous oxide	5·31	4·91
Ferric oxide	0·80	0·11
Alumina	2·46	2·25
Lime	0·10	Trace
Magnesia	28·53	28·82
Carbon dioxide	Nil	0·09
Water above 105° C	4·75	5·46
Total	99·57	99·70

References. Spence, H. S.: (7), p. 20.
Wilson, M. E.: (15), pp. 37-40.

Yale Mining Division

Gisby Claims

Three miles west of Keefers station, on the main line of the Canadian Pacific Railway, a belt of highly sheared talcose rocks occurs on the north side of the track, near the junction of the Nahatlatch and Fraser Rivers. Talc was originally struck 150 feet from the mouth of a tunnel driven at right angles to the strike of the formation in a search for gold, where a vertical band of green, highly slickensided talc, 5 feet to 8 feet wide, was cut. The talc band is exposed also at a point east of the main tunnel, in the side of the gorge of the Nahatlatch River, where a second short adit of 35 feet has been driven. In all, four distinct belts of talcose rock (a mixture of talc and carbonates), with an aggregate thickness of 350 feet, are stated[1] to occur, but the band of massive, green talc cut in the main adit appears to be the main deposit of clean talc.

The property has been worked for both talc and quartz, a heavy vein of the latter mineral paralleling the formation close to the railroad track. A group of five claims, known as the Gisby group, was originally taken up in 1919 by Talc Products, Limited, of Vancouver, and in 1920 B. C. Silica and Talc Company, also of Vancouver, worked the property for a short time on a royalty basis, shipping material to Vancouver for grinding. In 1922, the Pacific Talc and Silica Company was formed, and installed a small mill equipped with crushers, a Raymond pulverizer and screens, for the production of ground talc and crushed quartz. The operation was closed down after running intermittently for a few years, and the mill equipment was taken over in 1928 by B. C. Refractories and moved to Vancouver. No further work has been done on the property.

The talc of the band cut in the main adit is similar in character and colour to that occurring near McGillivray, on the Pacific Great Eastern Railway, grinding to a powder of fair colour and with good slip. Both of these deposits are well situated for development, being alongside a railroad, and could probably be worked to yield a moderate tonnage of medium-grade talc.

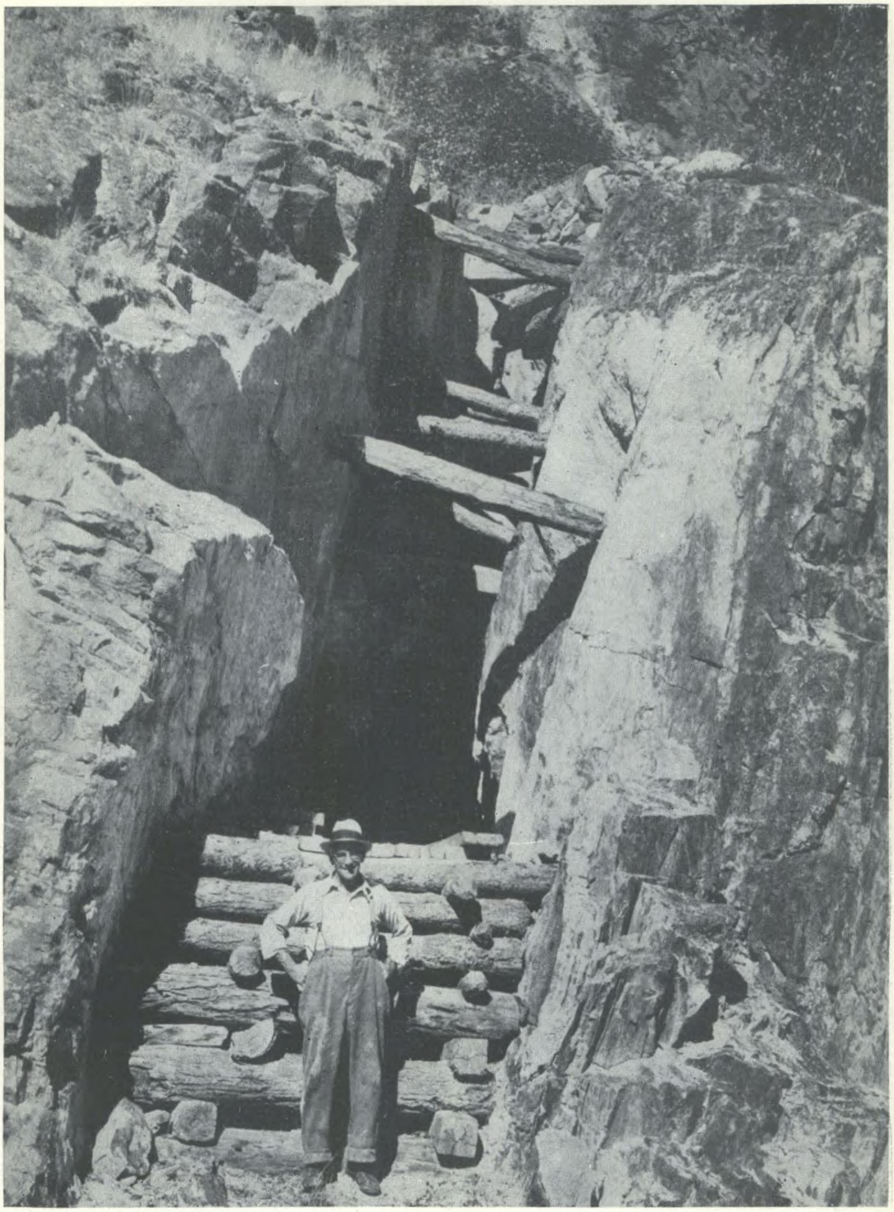
Analyses of samples of the talc from the main band on the property showed:

—	1	2
Silica	59·88	63·00
Ferrous oxide	4·54	0·92
Ferric oxide	Nil	.....
Alumina	1·18	3·02
Lime	0·10	.....
Magnesia	29·51	30·65
Carbon dioxide	0·02	.....
Water above 105° C	4·73	2·00
Total	99·96	99·59

1. Analysis by Bureau of Mines.
2. Analysis by Provincial Assayer, Vancouver.

References. Spence, H. S.: (7), pp. 19–20.
Wilson, M. E.: (15), pp. 41–49.

[1] Wilson, M. E.: (15), p. 45.



Talc working on Lake Shore claim, mile 90, Pacific Great Eastern Railway, near McGillivray, Lillooet Mining Division, B.C. The talc body occupies a sheared zone in an assemblage of serpentinized greenstones and chloritized slates. It illustrates well the typical association and mode of origin of a talc deposit by hydrothermal alteration of an ultrabasic rock—probably upon a fault-plane, which provided the channel for circulating hot waters. (*See* page 55)

A. View showing situation of deposits of black and mottled, bedded, steatitic talc in dolomite on Gold Dollar and Red Mountain claims, Alberta-British Columbia divide, near Banff, Alta. The claims lie at an altitude of about 8,000 feet.

B. Occurrence of black and mottled steatitic talc on Red Mountain claim. The talc forms a bedded deposit immediately above the talus slope in the foreground, and comprises a 10-foot lower member of higher grade material overlain by 60 feet of pyritiferous, rusty-weathering talc.

Emancipation Group

Near Jessica, on the Coquihalla River, 17 miles northeast of Hope, an attempt was made in 1932 to open up a soapstone property, and the B. C. Soapstone Syndicate, of Victoria, was formed for the purpose, but never came into actual production.

A band of serpentinized greenstone, one-quarter to one mile wide, runs northwesterly through this section, and is stated[1] to carry narrow talcose zones. Some stone was mined under royalty by the above syndicate in 1932 at Verona siding, on the Kettle Valley Railway, from which trial bricks were cut and tested out in various Coast pulp mills, with reported favourable results. From data supplied by J. M. Cummings, of the Provincial Department of Mines, analysis of the stone yielded as follows:

Silica	32·50
Ferric oxide	6·50
Alumina	3·10
Lime	Nil
Magnesia	33·53
Loss on ignition	22·20
Undetermined	2·17
Total	100·00

Fusion point was determined as 1577°C.

Windermere Mining Division

Silver Moon, Red Mountain, and Gold Dollar Claims

Several occurrences of steatitic talc have been known for some years along the Alberta-British Columbia boundary, in the vicinity of Mount Whymper and at the head of Redearth Creek. A little sporadic work has been done on the claims during the last twenty years, but this has been of a prospecting nature only and there has been no commercial production.

The talc outcrops lie close to the interprovincial divide (*see* Figure 1), and the deposits doubtless extend for some distance on both sides of this line. They lie for the most part within the boundaries of either the Banff or Kootenay National Parks, and though the claims staked were originally registered, they do not all appear to have been surveyed or Crown-granted, and there is now some question as to present ownership, title, and right to work, under National Parks regulations.

Silver Moon Claims. The occurrences on Mount Whymper lie on the southeast side of the mountain, 2 miles west of Vermilion Summit on the Castle-Windermere highway, and at an elevation of about 1,000 feet above and to the north of the road. The distance from Castle station, on the main line of the Canadian Pacific Railway, is 13 miles. The original claims were staked by Messrs. Fox, Hill, and Serra, of Banff, Alta., in the name of the Banff Talc Company, about twenty-five years ago. A few small surface pits and one short 30-foot tunnel have been opened along a series of outcrops of a flat-lying deposit of steatite that appears to have the form of a number of small irregular and impersistent pockets or lenses

[1] Wilson, M. E.: (15), p. 49.

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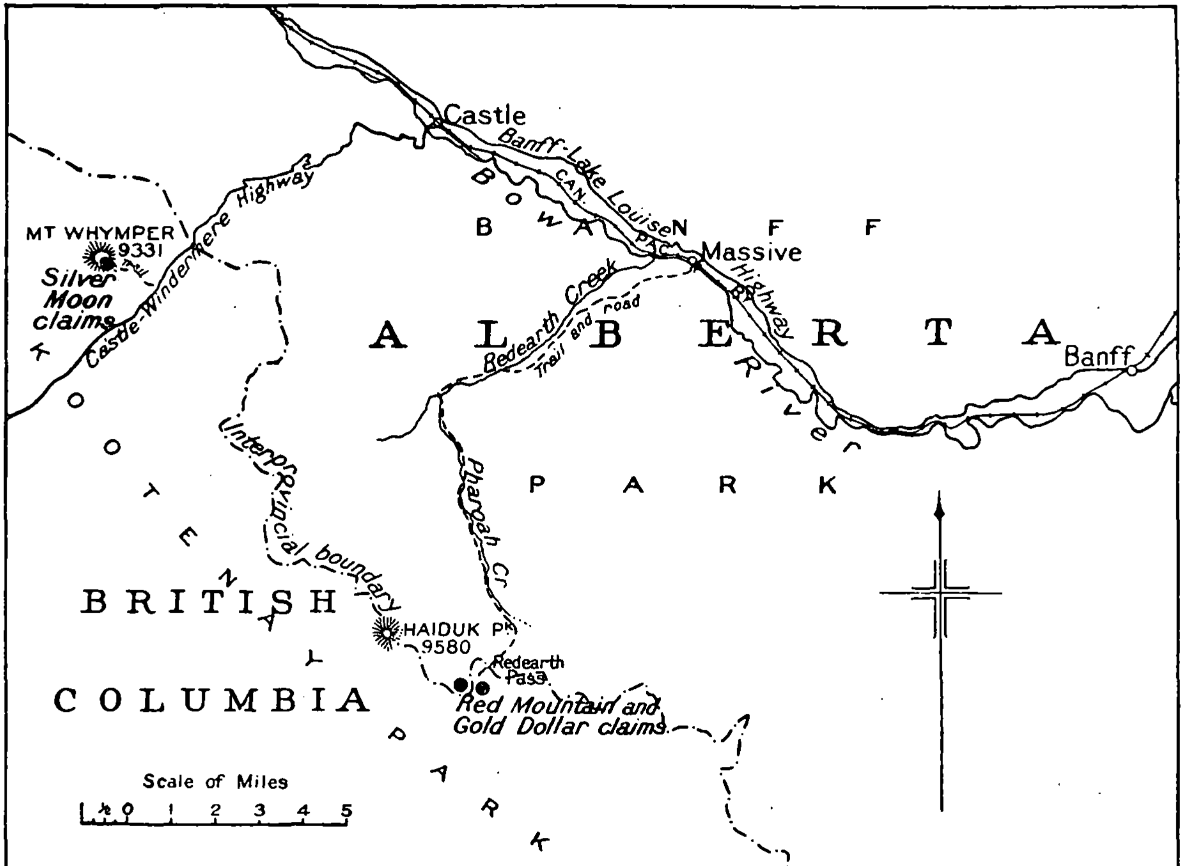


Figure 1. Sketch map showing location of steatitic talc occurrences near Banff, Alberta.

enclosed in a grey, bedded dolomite. These pockets, however, occur at the same horizon along the side of the mountain, and hence are probably part of a single, continuous bedded deposit that pinches and swells erratically.

The crude steatite is uniformly compact and massive, without visible grain, and has a pale yellowish green colour; it grinds to a good white powder. Most of the crude, surface material examined proved to be rather badly flawed, sound pieces over 2 by 3 inches being rare. Test pieces, burned at 1000° C., checked badly in firing; the steatite, therefore, would not appear suitable for lava purposes, though the quality might improve with depth. The steatite is commonly intergrown with coarsely crystallized dolomite, both often associated with quartz, so that considerable cobbing and sorting are required to secure clean talc.

Insufficient exposures exist to enable the extent of the deposit to be estimated; and when visited in 1937 it was found that rock- and snowslides had obliterated some of the workings and made the terrain difficult of examination.

Analyses of selected samples of the clean steatite gave the following:

Talc	—	1	2	3
63.[illegible]	Silica	61·52	64·06	62·91
	Ferrous oxide	0·66	.....	1·68
	Ferric oxide	0·24	.....	.....
	Alumina	Nil	2·10	.....
	Lime	0·10	.....	.....
31.7	Magnesia	32·63	30·13	31·12
	Carbon dioxide	0·07	.....	.....
4.8	Water above 105° C.	4·39	1·41	1·53
	Total	99·61	97·70	97·24

1. Analysis by Bureau of Mines.
2. Partial analysis from Ann. Rept. on Mineral Resources of Alberta, 2, 1920, p. 123.
3. " " " " "

The low iron and lime contents shown by analysis No. 1 indicate that the steatite is exceptionally pure material.

Red Mountain and Gold Dollar Claims. These claims (*see* Plate II, A) lie at an elevation of about 8,000 feet, on the interprovincial divide, at the head of Redearth and Pharoah Creeks, and are approached by a rough wagon-road of 8 miles, followed by a pack-trail of 8 miles, from Massive station, on the main line of the Canadian Pacific Railway. The original discovery of talc was staked on the Red Mountain claim in 1917, and in 1927 the National Talc Company, of Toronto, was formed to undertake development of the deposits. A road and camp were built and some minor prospecting done, by means of stripping and two small tunnels, but work was abandoned without any production being reached. In 1930, the claims were optioned to Western Talc Holdings, of Calgary, who did about 500 feet of drilling on the southeast part of the property, but conducted no further mining, and the claims have since lain idle.

The Red Mountain claim lies to the northwest of the Gold Dollar, and the talc exposures and workings on the two claims are about one-half mile apart. The talc occurs as a bedded deposit, consisting of several talc members from 1 foot to 5 feet thick, toward the base of a grey dolomite formation at least 2,000 feet thick. The dip is variable, but is commonly rather flat, about 15 to 20 degrees northwest. When visited in 1931, many of the exposures were obscured by slides and talus, and few sections could be measured. At the most northwesterly outcrop, however, a talc bed 10 feet thick was exposed immediately above the talus slope, and was overlain by about 60 feet of red-weathering, massive, mottled white and black talc (*see* Plate II B). This latter, upper section is apparently rich in pyrite, the weathering of which produces much surface rust. Above this, again, lie 2,000 feet of dolomite and buff and black shales. Two short drifts have been opened on the talc bed, about 200 feet apart, but were snow-blocked and inaccessible when visited.

On the Gold Dollar claim, about 10 feet of bedded talc is exposed on a shoulder of the mountain. The surface talc here has a fissile character, breaking readily into thin, ½-inch slabs, and is also much cross-jointed, so that only small pieces are obtainable.

The talc on these claims is all of massive, steatitic character, and judging by some of the material taken from the prospect tunnels, should be obtainable in sound blocks of considerable size. In colour it is distinctly unusual, ranging from a deep bluish black to mottled cream and black. The black colour is due to the presence of finely disseminated amorphous carbon, which burns off readily on ignition; in the writer's experience, this is the only recorded instance of talc so coloured. In places, the talc has been brecciated and recemented by narrow veinlets of calcite. An objectionable feature in much of the more massive material is the presence of considerable amounts of pyrite, in the form of crystals up to ½ inch scattered through the talc. Such pyritic steatite would, of course, be quite unsuitable for lava purposes, for which the material would otherwise seem to be well adapted. Samples of selected, clean ore have been pronounced by manufacturers to be of very fine lava quality.

It is reported that five drill-holes were put down on the Red Mountain claim in 1930, with depths of 91, 101, 121, 32, and 155 feet, respectively, but the records are not available. Surface indications, however, tend to show the existence of a persistent steatite body of considerable size but of variable lava quality.

The following analyses show the composition of steatite samples taken from various parts of the property:

—	1	2	3	4	5	6
Silica	52·30	51·84	58·70	58·50	55·50	57·00
Ferric oxide	0·56	1·28	0·40	.....	0·10	.....
Alumina	7·26	7·52	1·26	3·00	3·80	16·00
Lime	Nil	Nil	1·20	Nil	Nil	0·50
Magnesia	31·86	31·55	31·53	31·50	23·50	18·30
Carbon	0·16	0·15	0·40	.....	.....	.....
Carbon dioxide	Nil	Nil	1·38	.....	.....	.....
Sulphur	0·10	0·06	0·05	.....	.....	.....
Water above 105° C	7·69	7·66	5·11	(a) 1·60	(a) 4·40	(a) 2·00
Total	99·93	100·06	100·03	94·60	87·30	93·80

1, 2, and 3. Selected, high-grade black steatite. Analyses by Bureau of Mines.
4. Grab sample from 2-ton stock-pile. Analysis by Provincial Government laboratory Victoria.
5. White steatite from north end of deposit. Analysis as No. 4.
6. Sample from tunnel on Red Mountain claim. Analysis as No. 4.
(a) Reported as loss on ignition.

References. Spence, H. S.: (7), pp. 18–19.
Wilson, M. E.: (15), pp. 51–52.

Other Occurrences

Wilson (15) lists the following additional recorded occurrences of talc in British Columbia, none of which have been worked:

Nanaimo Mining Division. On the Ironclad claim, on Mount Richards, 2½ miles southwest of Crofton, a 3-foot vein of talc is reported to have been cut in a prospect shaft ((15), p. 37).

Lillooet Mining Division. Talc in considerable quantities is stated to occur in the Cadwallader series of the Shulops and Bender Mountains of the Bridge River district. Cairnes[1] mentions talc as an abundant constituent, with about equal amounts of carbonate, in altered serpentine in the upper valley of Cadwallader Creek, thicknesses up to 100 feet of such highly talcose rock having been cut in gold-mining workings in the district. Soapstone and talc are stated to occur at the Bell mine, on Cayoosh Creek (Cayuse River), 5 miles from Lillooet ((15), pp. 40-41).

Greenwood Mining Division. Soapstone of good quality occurs at White's camp and at the head of Goosmus (Koomoss) Creek, adjacent to the Phoenix branch of the Great Northern Railway, in the Boundary district ((15), p. 49).

Revelstoke Mining Division. Steatite is stated to occur in a dolomite formation near Illecillewaet station on the main line of the Canadian Pacific Railway. One deposit, consisting of greenish grey talc mixed with actinolite, is reported to have been traced by outcrops for 2,000 feet ((15), p. 50).

[1] Cairnes, C. E.: "Geology and Mineral Deposits of Bridge River Mining Camp". Geol. Surv., Canada, Mem. No. 213, p. 71, 1937.

Lardeau Mining Division. Serpentinized, and in part talcose, basic igneous rocks occur in extensive bands in this region. On the Asbestos group of claims, east of the Columbia River, near Arrowhead, grey-green talc schist containing a good deal of carbonate has been opened up in a series of test pits ((15), p. 51).

SASKATCHEWAN

Soapstone is stated to occur near Wapawekka (Pipestone) Lake, 50 miles east of Lac la Ronge, in northern Saskatchewan, but no information on the deposits is available.

MANITOBA

As mentioned under Ontario, rocks of soapstone (potstone or pipestone) character have a fairly wide distribution in the region adjacent to the Ontario-Manitoba boundary. Little appears to be on record regarding occurrences of such rocks in Manitoba, but deposits are stated to occur at various unspecified localities along the shores of Lake Winnipeg. There has been no reported attempt at commercial development.

NORTHERN LATITUDES

While of no commercial interest, the occurrence of soapstone at various points along the Arctic coast may be mentioned; a number of such deposits have been quarried by the Eskimos for stone for pots and lamps, and such stone has long been an article of trade or barter among the natives. There is no data on the nature of the stone, and the term soapstone is often used to include any soft, and not necessarily talcose, rock. Among the recorded localities for such "pot stone" are: on Rae and Tree Rivers, flowing into Coronation Gulf, in the western Arctic; and on Committee and Exeter Bays, in southeastern Baffin Island. Bell records[1] that the Eskimos of the east coast and islands of Hudson Bay obtain a tough and durable soapstone from Mosquito Bay, latitude 60° 45′, and that the natives of the Labrador coast obtain their stone from Skynner's Cove, on the north side of Nachyak Inlet.

ONTARIO

The productive talc deposits of Ontario have been confined almost exclusively to the Madoc area, Hastings County, in the southeastern part of the Province, where a steady output of white talc has been maintained for the past thirty years. Small amounts of low-grade talc, in large part of rensselaerite or pyrallolite nature, and representing an alteration product of pyroxenite, were mined many years ago at several scattered localities in eastern Ontario for roofing purposes, and attempts to produce cut

[1] Bell, R.: Geol. Surv., Canada, Rept. Prog., 1877-8, p. 24C; Geol. Surv., Canada, Rept. Prog., 1882-4, p. 15DD.

soapstone for pulp-mill furnace use from deposits in the Lake of the Woods region, western Ontario, were made about ten years ago, but the total output from such operations has been very small. Outside of the Madoc area, there has been no talc or soapstone production in the Province for a number of years.

WESTERN AND NORTHERN ONTARIO

LAKE OF THE WOODS AND RAINY RIVER REGION

The altered volcanic and sedimentary rocks of the extreme southwestern part of the Province, as well as of adjacent sections of Manitoba, are frequently of a soft "soapstone" nature; that is, they are made up in varying proportions of talc and chlorite; and chlorite-rich rock containing little talc, as well as even soft slate, is often loosely termed soapstone. Many of the occurrences of such rocks have attracted attention from the fact that the material was used by the Indians for pots and pipes, and "Pipestone" lakes, portages, points, etc., are common in the region.

In earlier reports of the Geological Survey, occurrences of such stone are recorded at Pipestone Point, south of French portage, Lake of the Woods[1]; near the confluence of the Mattagami and Flat Rivers[2]; on the point between the mouths of the Manitou and Seine River, Rainy River District[3]; and at Red Point Lake, near the confluence of the Mattawa and English Rivers, Keewatin District[4]. Bell mentions[5] soapstone occurrences in the Red Lake district, and also near Falcon Island, Lake of the Woods.

Kenora District

Some interest has been shown at various times in the soapstone possibilities of this region, and several attempts have been made to develop properties, but without sustained success. The main inducement has been a possible market for sawn furnace bricks with the kraft pulp mills at Dryden and Fort Frances. With their mid-continent location, freight considerations are an important factor, and the present nearby market for furnace stone is largely confined to the above two mills. Eastern kraft mills can draw their supply more cheaply from the Quebec mines, and Pacific Coast mills are largely supplied from deposits in the State of Washington. At the moment, therefore, economic considerations appear to be rather unfavourable to development of the soapstone resources of this region.

Pipestone Portage, Moore Bay, Lake of the Woods

Initial work was done at this locality in 1915 by Messrs. Mather and Beveridge, and about twenty years ago, the Dryden Pulp and Paper Company, Dryden, Ont., took out some stone from a small quarry in the face of a low bluff fronting on Moore Bay, at the point where the short

[1] Ann. Rept., I, 1885, pp. 49, 148CC.
[2] Rept. Prog., 1875-6, p. 312.
[3] Rept. Prog., 1873-4, p. 89.
[4] Rept. Prog., 1872-3, p. 103.
[5] Bell, R.: Mineral Resources of the Hudson's Bay Territories, Trans. Amer. Inst. Min. Eng., Feb., 1886.

Pipestone portage crosses to Andrew Bay. Four carloads of stone were shipped by scow to Kenora, and sent to Dryden for trial as furnace stone, but the material was reported too seamy for the purpose and to be of inferior quality.

The stone occurs as a band about 75 feet wide, enclosed in grey slate. It is not a true soapstone, but a soft, chloritic slate. It is rather harsh-textured, with a slaty cleavage, and yields a dirty grey powder having little or no slip.

An analysis, made in the Bureau of Mines laboratory, showed:

Silica	39·14
Ferrous oxide	8·79
Ferric oxide	3·48
Alumina	7·32
Lime	5·92
Magnesia	21·31
Carbon dioxide	7·31
Water above 105° C.	6·68
Total	99·95

Reference. Spence, H. S.: (7), pp. 34-35.

Shoal Lake

Lawson recorded[1] soapstone on the north shore of Shoal Lake, describing it as a grey, fine-grained, but rather hard rock. According to information furnished by F. V. Seibert, Department of Natural Resources, Canadian National Railways, Winnipeg, a band of soapstone occurs both on the mainland and on a small nearby island, the location being 26 miles southwest of Kenora. Two claims, Nos. K3510 and K3511, were staked on the deposit in 1930, but no work appears to have been done.

Wabigoon and Trap Lakes

In 1922, the writer reported[2] on a projected soapstone operation in Zealand Township, one mile west of Wabigoon station, on the main line of the Canadian Pacific Railway. The occurrence lies on a small peninsula on the north side of Wabigoon Lake, 1,500 feet from the track, and is well situated for development. Taken up originally in 1921 by E. G. Pidgeon, of Wabigoon, the deposit was acquired in 1922 by the Wabigoon Soapstone Company, of Toronto, but no development has been undertaken.

In 1923, Mr. Pidgeon discovered outcrops of soapstone on an island in Trap Lake, 8 miles southwest of the Wabigoon deposit and about 9 miles south of Dryden, on which two claims, Nos. K1181 and K1194, were staked. In the same year, a company, Thermo-Stone Quarries, Limited of Toronto, was formed to acquire and develop this property. In 1924, this company and the Wabigoon Soapstone Company were amalgamated. With the exception of a small amount of surface work and the shipping of some test blocks, no further attempt at development of either of these properties has been made.

[1] Lawson, A. C.: Geol. Surv., Canada, Ann. Rept., I, 1885, p. 146CC.
[2] "A New Source of Soapstone in Ontario", Mines Branch, Memorandum Series No. 4, April, 1922.

The Trap Lake deposit is favourably situated as to transportation, water transport being possible to rail at either Dryden or Wabigoon.

On the Wabigoon Lake deposit, two bands of soapstone, one 25 feet wide and the other 75 feet wide, occur, separated by 100 feet of syenite. At Trap Lake, the extent of the soapstone bodies has not been determined, but several small islands are stated to be composed entirely of this rock, and a 10-foot band outcrops also on the shore of the lake 500 feet north of the original discovery island. Outcrops of soapstone have also been located at the southeast corner of Mile Lake, which lies one-half mile north of Trap Lake, as well as on its north side. From the number of surface exposures, it is evident that important quantities of stone exist in this area.

The rocks of the above region have been so highly altered that their original nature is not evident, but the soapstone bodies appear to be altered basic intrusions of peridotite or gabbro type.

The soapstone of the Wabigoon deposit is a dark greenish grey rock, composed largely of talc, with some chlorite and dolomite. It is soft, medium-textured, of uniform grain, with no approach to schistose structure, and can be quarried in sound blocks of large size. In its general appearance and character it closely resembles the Virginia Alberene soapstone.

Analyses of two samples of the stone, made in the Bureau of Mines laboratory, showed as follows:

—	1	2
Silica	41·94	51·44
Ferrous oxide	7·71	7·24
Ferric oxide	2·05	3·68
Alumina	7·57	4·79
Lime	3·42	Nil
Magnesia	25·39	26·43
Carbon dioxide	5·09	0·11
Water above 105° C	6·71	6·56
Total	99·88	100·25

1. Wabigoon soapstone, representative material of north band.
2. " " 18-inch band on contact of above.

Crushing tests made on 2-inch cubes of the stone gave crushing strengths of 10,269 to 12,140 pounds per square inch, with modulus of rupture determined as 1,875 pounds. Corrosion tests showed a weight loss of 9·74 per cent after boiling in hydrochloric acid for 48 hours. Fusion temperature of the stone was determined as 1,400° C.

The above characteristics show that the soapstone of this region is of good commercial quality and well adapted to general industrial purposes, including refractory use. Large tonnages of stone exist, and the deposits are favourably situated for development, should a satisfactory market develop.

The above data have been condensed from the earlier reports cited in the references given below, and these should be consulted for fuller information on the occurrences. The two reports by the writer give details of the laboratory tests made on the Wabigoon stone, and that by Wilson (15) contains a detailed report by J. F. Wright on the geology of the district and nature of the deposits, with sketch maps of the various occurrences.

References. Spence, H. S.: Mines Branch, Memorandum Series No. 4, April 1922.
Spence, H. S.: (7), pp. 35-38.
Wilson, M. E.: (15), pp. 57-66.
Wright, J. F.: "Wabigoon and Trap Lake Soapstone Deposits", Can. Min. Journ., Sept. 5, 1924, pp. 871-72.
Eng. Min. Journ., vol. 117, No. 9, March 1, 1924, p. 379.

Eagle Lake

A band of soapstone, reported to be about 100 feet wide, occurs enclosed in talc-chlorite schist on the southwest shore of Eagle Lake. The location is 21 miles distant by water from either Eagle River or Vermilion Bay station on the main line of the Canadian Pacific Railway, to which water shipment can be made.

In 1924, the Grace Mining Company commenced development of the deposit, erected a camp, and installed a large sawing plant. Work was continued for a few years, and several carloads of cut furnace stone were shipped to nearby pulp mills at Dryden and Fort Frances, Ont. The stone is stated to have proved satisfactory for such use, but, possibly for lack of a sufficient market, work was discontinued about 1927-28 and has not been resumed.

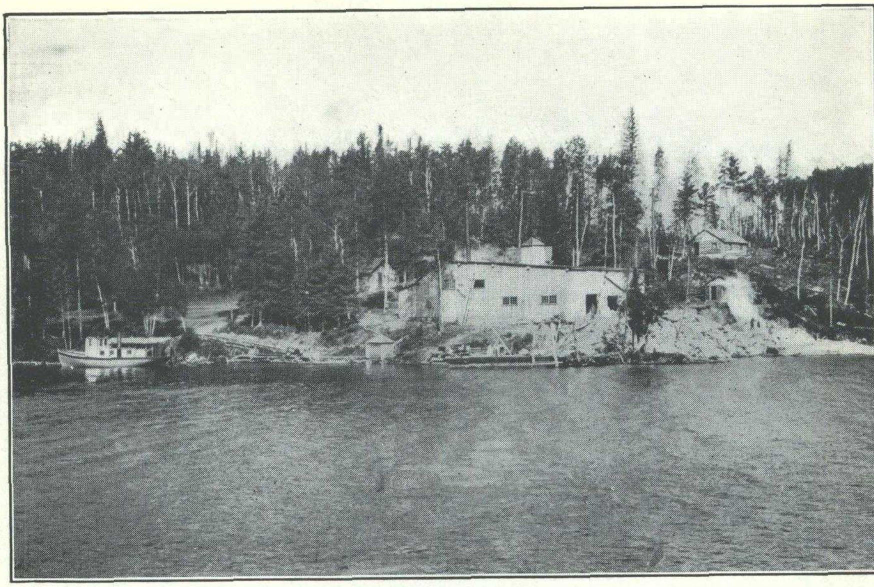
A small quarry (*see* Plate III A and B) was opened close to the edge of the lake, and the stone was cut out in 3-foot benches by means of a Sullivan channeller, working at right angles to the strike of the deposit. Quarry blocks were lifted by derrick and dropped onto small flat-cars, which ran directly to the sawing shed. This was a large, substantial building equipped with three 15-foot gang saws. Sand, obtained locally, was used to feed the saws.

The output consisted entirely of furnace blocks and bricks, the former chiefly of 12 by 12 by 12 inches and 12 by 12 by 18 inches dimensions.

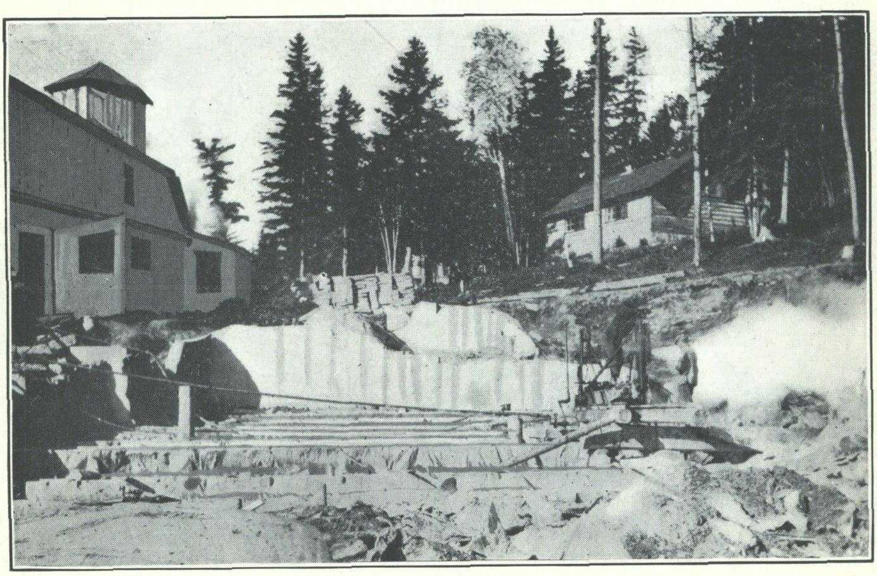
The stone is light green in colour, of medium grain, and inclined to schistose in structure. An analysis of a representative sample, made in the Bureau of Mines laboratory, showed:

Silica	43·20
Ferrous oxide	7·95
Ferric oxide	3·51
Alumina	6·74
Lime	1·30
Magnesia	27·64
Carbon dioxide	1·95
Water above 105°C.	7·80
	100·09

Reference. Spence, H. S.: "The Canadian Soapstone Industry", Invest. Min. Res. and Mg. Ind. 1926, Mines Branch, Dept. of Mines, Canada, p. 21.



A. General view of soapstone quarry of Grace Mining Company, on Eagle Lake, Ontario. Sawing shed is shown at left of pit. (Photo. 1926.)



B. Soapstone quarry of Grace Mining Company, Eagle Lake, Ontario, showing bench method of working. (Photo. 1926.)

Rainy River District

Seine River

In 1926, samples of soapstone were received from J. E. Marks, of Port Arthur, the material being said to come from the north side of the Seine River, about 25 miles west of Atikokan station on the Canadian National Railway, near the Garrett Lake portage. The stone was stated to occur in several beds, having widths from 10 to 25 feet and exposed for distances of 300 to 600 feet.

The stone is a soft, fine-grained rock of fair quality, and when tested, proved to have a fusion point of 1,360°C. A sample of Norwegian standard soapstone tested at the same time fused at 1,450°C.

No work is known to have been done on this occurrence, which is probably that mentioned in Wilson's report as lying "on the west shore of Buttermilk lake, 14 miles west of Atikokan, and 4 miles northwest of Elizabeth station on the Canadian National Railway". The deposit is there stated to consist of schistose stone, containing small crumpled aplite dykes.

Reference. Wilson, M. E.: (15), p. 66.

Pipestone Lake: Rock Island Bay

Soapstone of fair quality is stated to occur at Rock Island Bay, in Watten Township, and near the north end of Pipestone Lake. The stone is of a greenish grey shade, fine-grained, and contains some magnetite and dolomite. Disseminated pyrite crystals are present in some zones. It has been used extensively by the Indians as a pipe material.

Reference. Wilson, M. E.: (15), p. 66.

Sudbury District

Township of May

In an early report[1] of the Ontario Bureau of Mines, reference is made to an occurrence of talc "in the southeast corner of May township, Algoma district, 10 miles from the railway by wagon road". The Spanish River Nickel Mining Company is reported to have sunk a 40-foot shaft on this deposit in 1896, the vein widening from 2½ feet at surface to 11 feet at 40 feet.

In 1910, further work was done on these workings by the Gaugir Talc Company, who deepened the shaft to 50 feet, at which depth the deposit pinched out due to faulting. This company erected a small mill at Lee Valley, 10 miles south of Massey station, and produced a small amount of ground talc for foundry use. The ore is stated to have consisted of an intimate mixture of talc and graphite, which proved an excellent foundry material[2]. Wilson states[3] that the supposed talc is really sericite. No further work has been done on the property.

References. [1]Ann. Rept. Ont. Bur. of Mines, 1896, p. 278.
[2]Personal communication from R. de la B. Girouard, Ottawa, 1938.
[3]Wilson, M. E.: (15), p. 67.

EASTERN ONTARIO

Hastings County

Madoc District

The talc deposits of the Madoc district, in Hastings County, constitute the only important known Canadian occurrences of fine white talc, and from them has been produced probably well over 90 per cent of the entire talc production of the country. Initial development of these deposits commenced about 1900, with opening up of the Henderson mine, close to Madoc, and for some years several hundred tons annually of crude talc were shipped to the United States for grinding. In 1906, a mill was erected at Madoc to grind the ore from this mine, and subsequently two other mills came into operation, one on the adjoining Conley property and the other at Eldorado, a few miles to the north. This latter was closed down about eighteen years ago, but the two Madoc mills have been in steady operation for over twenty years. Although no statistics of production are available, the total output of talc to date from the Madoc area is estimated to have been about 350,000 tons. In recent years, production has been about equally divided between the Henderson and Conley mines.

The Henderson and Conley mines lie only a few hundred feet apart and have worked the westerly and easterly sections. respectively, of the same talc body. This consists of a series of vertical veins or lenses, with widths of from 5 to 65 feet, and extending in an east-west direction for about 1,500 feet. The thickest section lies to the west, on the Henderson property, where a single massive vein has been worked, and this appears to split to the east into a series of more or less parallel, thinner veins. Post-ore faulting and crumpling of the formation have resulted in the ore-bodies following a rather erratic course, with numerous swings away from the main east-west strike.

The talc bodies are of Precambrian age, and are enclosed in a white, crystalline dolomite of the Grenville-Hastings formation. The dolomite contains much secondary tremolite, both as scattered crystals, or aggregates of crystals, and in the form of dense masses or bands. Quartz-rich zones also occur, in which the quartz forms a series of closely spaced, thin veinlets, and narrow quartzite members are also present. Wilson, (15) p. 80, records the occurrence in the mine workings of numerous dykes of a dark-coloured, igneous rock, consisting largely of tourmaline, to which he has given the name "madocite", and which he believes to be derived from the Moira granite batholith that outcrops to the south of the talc deposits. The origin of the latter is thought to be hydrothermal and due to the interaction of siliceous solutions, emanating from this granite by way of channels now occupied by the madocite rock, with the overlying dolomite. Wilson's report, (15) pp. 78-90, deals exhaustively with the geology of these deposits and should be consulted for further details.

Madoc talc is of the foliated type, pale cream in colour in the crude state, and grinds to a pure white powder. Although the pure talc is of excellent quality, the run-of-mine ore contains a considerable proportion of dolomite and tremolite, which pass into the mill products as gritty impurities and impair the grade for the more exacting uses demanding high purity and slip. A certain degree of segregation of this grit fraction into the coarser mesh products is achieved in the air-separation circuit of the mills, but sufficient remains even in the finest powder to lower slip below that of the best grades of Italian, French, and Manchurian talcs. Tests made in the laboratories of the Bureau of Mines, at Ottawa, have shown that the dolomite content can be reduced to almost negligible amount by flotation (*see* page 107), but the product so made still proved to lack slip, possibly owing to the presence of tremolite or quartz. No attempt to beneficiate ore has thus far been made in either of the Madoc mills. The finer grades go largely to the textile (bleaching), paper, and cosmetic trades, with the coarser and more granular product sold for roofing use. Some fine-mesh, but carbonate-rich, talc goes to the rubber trade.

The following analyses, made in the laboratory of the Bureau of Mines, serve to show the average composition of Madoc talc:

—	1	2	3	4
Silica	53·92	51·00	49·48	49·28
Ferrous oxide	0·36	0·32	0·24	0·19
Ferric oxide	Nil	0·13	0·13	0·14
Alumina	0·32	0·62	0·82	0·41
Lime	5·02	6·98	7·02	7·06
Magnesia	29·63	28·76	29·11	29·21
Carbon dioxide	5·51	7·72	9·02	9·26
Water above 105° C	5·05	4·70	4·13	4·55
Total	99·81	100·23	99·95	100·10

1. Crude ore from Henderson mine.
2. No. 1 grade mill product.
3. No. 2 " "
4. No. 3 " "

The figures show a rise in the carbon dioxide content from the No. 1 to No. 3 mill products. Assuming a theoretical 1:1 lime-magnesia dolomite, this would indicate increasing dolomite contents of 16·1, 18·8, and 19·4 per cent from the finest to the coarsest grades, a result due probably to the segregation occurring in sizing, as mentioned above.

Township of Huntingdon

Concession XIV, Lot 14, Henderson Mine. This was the first talc mine opened in the Madoc district, the initial work on the property being done in 1899. In that year, a small shipment of crude talc was made to the United States. Development proceeded slowly until 1906, when the first talc mill in the district was erected at Madoc station by the Geo. H. Gillespie Company. With the erection of the Gillespie mill, mine output grew rapidly, reaching a maximum of over 12,000 tons in 1917. Most of the production has been milled at Madoc, but there have also been exports of several thousand tons of crude talc to the United States. Total mine production to date has probably exceeded 200,000 tons.

The mine (*see* Plate IV) lies 1½ miles southeast of Madoc village, the terminal of a branch of the Canadian National Railway connecting with the main line at Belleville. Operated in the early years by J. E.

Harrison, for the A. H. Robbins Mining Company, of New York, and later by Cross and Wellington, of Madoc, it was acquired in 1918 by Henderson Talc Mines, Limited, a subsidiary of the Geo. H. Gillespie Company. It continued to be worked under that management until November, 1937, when both mine and mill were taken over by Canada Talc, Limited, owners and operators of the adjoining Conley mine. This company has connected the two sets of mine workings, which are now operated as a single mine, and has closed down the Gillespie mill, intending to confine milling operations to the single plant on the Conley property, the capacity of which has been enlarged.

The mine was first worked open-cast, drifts being later run from the bottom of the pit along the strike of the talc body. In 1906, an inclined shaft was sunk to 100 feet on the deposit to the southwest of the open pit, and this was later deepened to 225 feet, with levels opened at 75, 120, and 185 feet. Owing to caving, this shaft was abandoned in 1913, and work has since proceeded from a second, vertical shaft at the east end of the property. Mining has been conducted from six levels, the lowest of which is at 370 feet. Shrinkage stoping is practised, with mill-feed drawn from reserves of broken ore kept in the stopes. In recent years, all mining has been confined to the 370-foot level.

The mill of Geo. H. Gillespie Company, located at Madoc station, about 1½ miles from the mine, was the first Canadian mill to undertake the fine grinding of talc on a large scale, with the production of various grades of fine white talc for different industries. Previous to its establishment, in 1906, practically all of the small amount of talc mined and ground in Canada was impure, off-colour talc and soapstone, used largely in the roofing and foundry trades.

For many years, milling procedure followed closely the lines of a modified flour mill, with coarse crushing and drying, followed by grinding in vertical, emery buhr-mills and screening through silk bolters. With a capacity of 50 tons of finished product per day, this system involved a complicated mill circuit, due to the small capacity of the various units and the return of oversize, but gave adequate service. Later, short tube mills were introduced into the circuit for final fine grinding, but silk bolters continued to be used. In recent years, practice was entirely revised and simplified and consisted in first crushing by jaw crusher to 2 inches, followed by fine crushing to ½ inch in a rotary crusher. The product was then passed through a steam dryer and split to four 8- by 5-foot, silex-lined tube mills in closed circuit with four Sturtevant air separators delivering finished products. Four grades were made, of 200-mesh, 160 mesh, 125 mesh, and 109 mesh, respectively.

References. Spence, H. S.: (7), pp. 25-30.
Wilson, M. E.: (15), pp. 78-84.
Ladoo, R. B.: "Talc Mining and Milling at Madoc, Ont.", U.S. Bur. of Mines, Reports of Investigations, No. 2162, Sept., 1920.

Photo: M. E. Wilson, Geological Survey.

View showing (left) Henderson and (right) Conley talc mines, at Madoc, Ont. The talc forms a series of vertical veins in Precambrian, crystalline dolomite. Originally developed from the open-cast working at left, the deposits have since been worked from the shafts shown. Depth of workings extends to about 400 feet.

325
210,000

Concession XIV, Lot 15, Conley Mine. The workings on this property immediately adjoin those of the Henderson mine to the west, and, as mentioned in the description of that mine, are concerned with an easterly extension of the same deposit (*see* Plate IV). Initial prospecting of the property took place in 1911, and in 1912-13 development was undertaken by the Hungerford Talc Company, who sank a 70-foot shaft and did 75 feet of drifting at that level. This work proved up encouraging amounts of talc, and in 1915 the property was taken over by the Anglo-American Talc Corporation, who commenced active mining and in 1916 erected a mill. In 1921, the property was acquired by the Asbestos Pulp Company, who continued work until 1929, when the company was reorganized and incorporated as the Canada Talc Company. In 1937, the name of this last concern was changed to Canada Talc, Limited. Under various managements, the property has thus been in active production since 1916, and is estimated to have produced about 125,000 tons of talc, making a total for the deposit on this and the adjoining Henderson mine of about 325,000 tons.

Operations on the property have been conducted mainly from a single vertical shaft carried to 431 feet, with seven levels opened. Most of the talc has been mined from a single main vein, having a width up to 13 feet, which has now been worked out from the bottom level to surface over a length of 300 feet. A few years ago, a cross-cut was driven north on the 4th level, at 253 feet, to open up a second vein lying 790 feet north of the shaft which had been proved by diamond drilling. All ore mined since 1935 has been obtained from this vein, by stoping from the 4th level, as well as from several narrower veins cut in the cross-cut. In 1937, a new shaft was put down to the 4th level at 700 feet north of the old one, to serve as an escape and ventilation shaft and from which a cross-cut to the west has been driven to connect up with the workings on the Henderson mine, taken over by Canada Talc, Limited in 1937.

A considerable amount of prospecting by drilling and shallow pits and shafts has been done on this property to the north and east of the main workings, as well as on adjoining ground to the east, but, while talc has been encountered, no bodies of probable commercial extent appear to have been found, and the main talc bodies would seem to be confined to the westerly section worked.

Working force numbers about 17 men, in two shifts, 6 being engaged in mining, 4 on surface, and 7 in the mill. Electric power is used throughout. Detachable bits are used for drilling, and mining is by overhead stoping.

The talc on this property is essentially similar to that of the Henderson mine, and its occurrence the same, except that the ore-bodies are in general narrower. They have been subjected to considerable post-ore rock movement, and, especially in the north workings, follow a rather erratic course, with pronounced local bends. Narrow horses of dolomite country rock are often found enclosed in the talc.

Three analyses of the general mill-run talc showed:

—	1	2	3
Silica	52·62	56·32	51·75
Ferric oxide	0·22	0·20	.....
Alumina	1·66	0·06	1·75
Lime	5·42	2·36	5·70
Magnesia	29·48	31·72	26·58
Carbon dioxide	6·89	3·99	5·90
Water above 105° C	3·41	5·18	7·90
Total	99·70	99·83	99·58

1. Analysis furnished by the company.
2 and 3. Analyses of samples of crude ore, made by Bureau of Mines.

Milling is done by first reducing to 2 inches in a jaw crusher, followed by coarse grinding in a Griffin mill, equipped with a 10-mesh annular screen, the oversize from which is reground to minus 40 mesh for the production of a granular roofing grade. The throughs pass to a 20- by 6-foot, silex-lined, pebble mill, in closed circuit with an 8-foot Gayco air separator, delivering finished products. Seven standard grades of fine talc are made, and sold mainly to the rubber, paper, paint, and textile trades, with two granular grades for roofing use. About 50 per cent of the output finds a domestic market, with 30 per cent exported to the United States and 20 per cent to Great Britain.

References. Spence, H. S.: (7), p. 30.
Wilson, M. E.: (15), pp. 84-89.

Concession XIV, Lot 16. Some prospecting was conducted on this lot, which adjoins the Conley property to the east, between 1917 and 1919, by the International Pulp Company, of Gouverneur, N.Y. Some shallow drilling was done, and three prospect shafts were sunk to depths of 50, 80, and 25 feet, respectively. About 100 feet of cross-cutting was done in the first, and 70 feet in the second, but no commercial talc bodies were struck and no further work has been done.

References. Spence, H. S.: (7), p. 31.
Wilson, M. E.: (15), pp. 89-90.

Township of Madoc

Concession V, Lot 20. This property lies about 2 miles northwest of Eldorado station, on the Trenton-Maynooth branch of the Canadian National Railway, and 8 miles north of the talc mines at Madoc: it formerly produced a small amount of ground talc, but has been inactive since 1920.

Most of the workings lie on the northwest corner of the above lot, close to the bank of the Moira River, but the deposit extends across to lot 20 of concession IV, as well as to lots 21 of concessions IV and V. Mining was commenced in 1911 by the Canadian Talc and Silica Company, who sank a 75-foot inclined shaft and erected a mill on the property. Work was continued intermittently until 1916, the company having been reorganized in 1914 under the name of Eldorite, Limited. During this period, the original shaft was deepened to 90 feet, and a second inclined shaft sunk to 130 feet, with a 200-foot drift run between the two. The property lay idle till 1918, when it was taken over by the Eldorado Mining and Milling Company, who worked up to the end of 1920. Work was then suspended and has not been resumed. At that time, the depth reached in the shafts is stated to have been 200 feet, with considerable stoping between them at the 65-foot level. At the 200-foot level, the connecting drift had been extended 30 feet southwest of No. 1 shaft and 160 feet northeast of No. 2 shaft.

In general, the talc is of similar foliated character to that of the Madoc mines, pale cream to white in colour, and yields a good white powder. It is, however, not nearly such a clean talc as the above, containing more dolomite, and also a considerable amount of quartz, in the form of disseminated grains and thin stringers. These impurities remained in the milled product and lowered the grade. As at Madoc, the deposit lies in a dolomite formation. Wilson, (15) p. 75, classes it as a talc-dolomite schist, and describes it as occurring at the crest of an anticlinal fold, with a pitch to the east. It is far from uniform in character, containing lenses or zones of highly quartzose nature: these latter are too low in talc to be considered commercial ore. A width of 100 feet is indicated for the main talc body in the underground workings.

A short distance to the east of the main deposit, a 20-foot band of crumpled, dark grey, graphitic talc schist outcrops, and in 1919 a separate small mill unit was installed to grind this material for the rubber and foundry trades.

From a planimeter count made on six thin sections of the ore from the main talc body, Wilson determined the average talc content of the deposit to be only 20 per cent, while the dolomite content ranged between 45 and 90 per cent, and quartz 0·5 to 7 per cent. The talc content of the grey talc schist was estimated to be under 30 per cent. It is evident, therefore, that these talcose rocks can hardly be considered other than talcs of very low grade.

Milling of the ore was performed by rotary crusher, followed by drying and reduction in rolls, the product from which was ground in tube mills connected to air separators. As only the finest, air-floated products were marketed, these were probably beneficiated considerably in point of talc content over the crude ore, but the grade was much below that of the average run of commercial talcs. Most of the output was stated to be sold to the paper and paint trades, with the coarse, granular grade going to the roofing trade.

Analyses of the two types of talc, made in the laboratory of the Bureau of Mines, showed as follows:

—	1	2
Silica	30·80	51·86
Ferrous oxide	0·28	0·39
Ferric oxide	Nil	0·60
Alumina	0·65	1·54
Lime	16·68	10·04
Magnesia	24·57	18·19
Carbon dioxide	24·37	13·49
Water above 105°C	2·67	3·33
Total	100·02	99·44

1. Crude white talc.
2. Grey talc schist.

References. Spence, H. S.: (7), pp. 31-32.
Wilson, M. E.: (15), pp. 68-77.

Concession VII, Lot 1. In 1938, a shallow 30- by 8- by 6-foot prospect shaft was sunk on this lot, which lies about one-fourth mile north of the Conley mine, by the Claxton Manufacturing Comany, of Toronto, in a search for talc to supply a grinding mill erected during the same year at the company's Toronto plant. No talc was struck, all of the rock excavated being fine-grained white dolomite.

Concession XI, Lot 15. Wilson, (15) p. 77, states that a 5-foot band of impure talc-dolomite schist is exposed in a shallow prospect pit on this lot. The occurrence is apparently of only small extent, and represents an altered zone in a greenstone lava flow. Such greenstones occupy a considerable area along the boundary between Madoc and Elzevir Townships.

Township of Elzevir

Concession VI, Lot 5; Concession VII, Lots 4 and 5. Several small quarry openings have been made at various times between 1883 and 1908 on these lots for the production of a class of mineral reported as "actinolite". The deposits were first worked by J. James, of the village of Actinolite (formerly Bridgewater), who ground and shipped the output for roofing purposes. Later, in 1908, the properties were acquired by the Actinolite Mining Company, of Bloomfield, N.J., who erected a grinding plant at Actinolite and continued to produce a small tonnage annually of ground roofing material until 1929, since when there has been no further work.

The workings lie about 3½ miles east of Actinolite, and consist of seven small scattered pits opened variously in a rusty talc-dolomite schist or a similar rock mixed with greenstone (serpentine). The latter rock has been highly sheared and jointed, with the development along the cracks of a harsh-fibred, asbestos-like actinolite. The amount of such mineral is relatively subordinate, and the main mass of the rock consists of a heterogeneous mixture of dolomite, talc, serpentine, and actinolite, with talcose greenstone the dominant material. The material milled was the quarry-run of rock, to which, in the last years of operation, an addition of scrap phlogopite mica was made. The market for the product was limited, and is stated to have been mainly confined to a single customer in Chicago, who used it in the laying of tar-roofing compositions. Only a few cars per year were shipped. In addition to the rock mined on the above lots, the Actinolite Mining Company also reported obtaining similar material from a deposit on lot 7 of concession X of the Township of Kaladar, in Lennox and Addington County, to the east. In the same township, Wilson, (15) p. 94, reports several small prospect pits opened on narrow soapstone-talc schist zones in a dolomite formation.

Reference. Wilson, M. E.: (15), pp. 92-94.

Township of Grimsthorpe

Concession V, Lot 9. A very pure foliated talc, of a pale apple-green shade, is found in a narrow, 14- to 18-inch vein on this lot. A couple of small surface pits have been opened on the deposit in a search for mineralogical specimens, but no attempt at development has been made. The occurrence lies in a rather inaccessible location, 11 miles northeast of Cooper P.O. The talc is in the form of aggregates of very large flakes, some of which extend across the entire width of the vein, and is associated with coarsely crystalline dolomite in a serpentine band that is probably an alteration product of amphibolite. Although the talc is of high purity and grinds to a snow-white powder, the deposit is probably too small to be of any commercial importance. An analysis, made in the laboratory of the Geological Survey, showed:

Silica	60·45
Iron oxide	2·82
Alumina	0·27
Lime	0·16
Magnesia	29·84
Water above 105°C	5·42
Total	98·96

The green colour is probably due to a trace of nickel, the content of which was determined as 0·50 per cent (NiO). Similar talc is stated, (15) p. 91, to occur in the northwest portion of the adjoining Township of Elzevir, to the south.

References. Spence, H. S.: (7), p. 25.
Wilson, M. E.: (15), pp. 90-91.
Adams and Barlow: Geol. Surv., Canada, Mem. No. 6, 1910, p. 369.

Township of Cashel

Concession XII, Lots 16 and 17; Concession XIII, Lot 16 S½. In 1937, some prospecting was done on a deposit of talc on these lots by L. S. Reeves, of Madoc, and early in 1938 the Madoc Talc and Mining Company, of Trenton, Ont., was incorporated to proceed with development. The property lies 15 miles northeast of Gilmour station, on the

Trenton-Maynooth branch of the Canadian National Railway, and is reached by a fair gravel road of 12 miles, with 3 miles of rough mine road.

The main talc exposures lie on lot 17 of concession XII, where all of the development work has been done. The company had a small force engaged in shaft-sinking during 1938, and in November the shaft had been carried to a depth of 90 feet, timbered, 2-compartments, to 70 feet. A portable compressor and derrick-hoist comprised the mine equipment. Up to November 1, when the property was inspected, only small trial lots of talc had been shipped. The company reported having leased a building at Trenton, which it is proposed to equip with milling machinery, ore to be trucked to Gilmour, where it will be put on rail for shipment to Trenton.

The shaft has been sunk directly on the talc outcrop, and underground development to date has consisted of a 50-foot cross-cut at the 85-foot level with 125 feet of drifting on the ore-body. Inspection of the workings and material hoisted showed the deposit to consist of a vertical band, apparently at least 50 feet wide, made up of a greenish, rather fine-grained, chloritic talc schist. The band has suffered considerable shearing, with the development of thin layers or sheets of more highly talcose material. Within the schist lie some masses of a hard, dense, black rock, which may be of an intrusive nature, or which are possibly unaltered intercalated members of the original schist complex.

In its general character, the talcose material rather resembles that of the "grit rock" of the talc deposits of the Waterbury district, in Vermont: it is of variable mineral composition, with zones containing considerable carbonate (dolomite) in fairly coarse grains, while semi-chloritized, fibrous hornblende is abundantly present as small knots in some bands. In part, the rock is of a soapstone, rather than a foliated talc, nature, and this type might perhaps serve for sawing into blocks. Selected samples of the cleanest talc yielded a powder having good slip but of off-colour grade: run-of-mine material showed a considerable grit content and would probably only be suitable for the trades employing lower grade, grey talc, such as the rubber and roofing industries.

An analysis of a sample of the crude talc from this deposit, made in the laboratory of the Bureau of Mines, showed:

Silica	40·08
Ferrous oxide	3·70
Ferric oxide	1·87
Alumina	1·75
Lime	4·85
Magnesia	29·81
Carbon dioxide	13·45
Water above 105°C.	4·12
Total	99·63

This would indicate a rather large content of dolomite, and the amount of iron present (in part as magnetite) is much above that of a good commercial talc.

Township of Mayo

Wilson, (15) p. 78, states that a narrow, 18-inch band of compact white to grey talc occurs near Hartsmere, on concession X of this township. The deposit is found along the margin of a diorite dyke, and can be traced by outcrops for 200 feet. No work has been done on the occurrence.

Frontenac County

Township of South Canonto

Concession I, Lots 1, 2, and 4. In 1939, samples of a cream-coloured, compact, platy, steatite-like talc, said to come from this locality, were received by the Bureau of Mines. The samples are stated to have been taken from a series of small prospect pits opened by W. L. Peters, of Maberley, Ont., in the vicinity of Mosquito Lake, and there are reported to be extensive showings of similar material on these lots, as well as on adjacent lots 2 and 3, concessions XIII and XIV of Miller Township, to the west.

No official examination of the occurrences has been made, but the samples received were tested in the laboratories of the Bureau and the material was found to grind to a smooth powder of a pale cream-white colour and possessing moderate slip. A partial analysis showed:

Silica	57·4
Iron and alumina	3·4
Lime	8·3
Magnesia	26·4
Total	95·5

Township of Pittsburgh

Concession III, Lot 35, S½. Dark, soft rock, that appears to be a partly altered pyroxenite, occurs on this lot and was worked about the year 1900 by the Sparham Roofing Company, of Montreal, who used the material in the manufacture of fireproof roofing. There are a few small scattered pits on the property, which lies 5 miles west of Gananoque, about one-fourth of a mile south of the Gananoque-Kingston road. A few hundred tons of material are reported to have been shipped. From its general appearance the rock probably consists largely of rensselaerite or pyrallolite, which is pyroxene in various stages of alteration to steatite, or massive talc.

An analysis of the soft rock that occurs in several of the pits was made in the Bureau of Mines laboratory, and showed:

Silica	50·64
Ferrous oxide	0·79
Ferric oxide	0·55
Alumina	1·06
Lime	4·84
Magnesia	30·49
Carbon dioxide	5·21
Water above 105°C.	6·26
	99·84

The rock is hardly to be classed as true talc, and it is probably mainly composed of mineral substance more closely allied to one of the serpentine group of minerals. The rock grinds to a grey powder possessing fair slip.

According to the Ontario Bureau of Mines Annual Report, XI, 1901, p. 297, 1,800 tons of "serpentine rock" were quarried from a locality two miles west of Gananoque, in Leeds Township, during the six years 1896-1901. This material was taken out by Geo. Jackson, and was shipped to Montreal for roofing purposes.

Lanark County

Township of Lavant

Concession III, Lot 24, E½. Diamond drilling on a talc body on this lot was done around 1918 by the owner, T. B. Caldwell, of Perth, Ont. One 120-foot drill hole was put down, and a few shallow prospect pits were opened.

The property lies 2 miles south of Flower Station, on the Kingston and Pembroke branch of the Canadian Pacific Railway, but is actually distant only one-fourth of a mile from another point on the railway, with which, however, there is no road connection.

The deposit consists of a low, denuded hogsback, about 50 feet wide, and extending 300 feet in a northeast direction. Several small prospect pits have been opened at the base on the west side. The apparent dip is 20 degrees east.

The material of the ridge, as exposed on the surface and in the pits, is a fine-grained, white, siliceous, serpentinized dolomite, representing a band of altered, high-magnesia limestone in the Precambian gneiss-limestone complex. The silica is prominent on weathered surfaces as small nodules or stringers of quartz, that form possibly 5 per cent of the mass. The rock effervesces freely with acid, showing that considerable calcite is present. The magnesium silicate present would appear to be more of the nature of serpentine than talc, as very little talc can be detected under the microscope, and there is not sufficient present to impart more than a slight slip to the powder, which is distinctly gritty.

The following are analyses of the material of this deposit. No. 1 was made in the Bureau of Mines laboratory on a representative sample collected from the various pits and outcrops; No. 2 was made at the School of Mines, Kingston, Ont., and was furnished by the owner:

—	1	2
Silica	52·50	57·70
Ferrous oxide	0·28	.....
Ferric oxide	0·10	1·10
Alumina	0·17	.....
Lime	9·26	4·96
Magnesia	26·04	26·78
Carbon dioxide	6·85	1·90
Water above 105° C	5·13	7·21
Total	100·33	99·65

Township of Pakenham

Concession VI, Lot 6, W½. In 1937, some prospecting was done on this lot by J. Bell, of Almonte, who opened several small surface pits on exposures of steatitized pyroxenite in a white, crystalline dolomite formation. The occurrence lies about 6 miles southwest of Pakenham station, on the Canadian Pacific Railway.

The talc on this lot consists entirely of a soft, yellowish to pale brown rensselaerite-steatite, derived from narrow, dyke-like bodies of pyroxenite enclosed in white, crystalline dolomite. The original pyroxene was in the form of irregular bands of very coarsely crystalline rock, with individual crystals up to 3 by 2 inches, which border on narrow bodies of quartz or quartzite. The original form of the pyroxene crystals has been preserved. The dolomite in contact with the pyroxenite and quartz bodies has been partly serpentinized. None of the exposures indicate any large body of clean steatite, and most of the rock broken consists of a mixture of this material with dolomite, serpentine, and quartz. It grinds to a fairly white powder, which, however, lacks slip on account of the impurities present, but might yield an inferior grade of talc for roofing or rubber purposes. In the more quartz-free zones, the rock cuts fairly easily and can be sawn into small blocks, but these are badly flawed and spall readily.

The original intention was to develop the deposit as a source of stone for the production of cut and turned small ornamental articles, but owing to its coarse, irregular grain and checked character it probably would prove unsuitable for such purpose.

A small shipment of the material was made to the laboratories of the Bureau of Mines in 1937 for a grinding test. Analyses of the Gayco fines (1) and oversize (2) from this test were made in the laboratory of the Bureau; analysis (3) is of a sample analysed by the National Research Council, Ottawa:

—	1	2	3
Silica	59·10	60·92	57·27
Ferrous oxide	0·35	0·39	0·51
Ferric oxide	0·17	0·23	0·72
Alumina	0·52	0·38	0·74
Lime	2·10	0·68	3·20
Magnesia	30·50	30·62	29·34
Carbon dioxide	1·26	0·72	7·94
Water above 105° C	5·78	5·78	0·28
Total	99·78	99·72	100·00

The figures for sample 3 show considerable carbonate to be present, while the low water content indicates only a small degree of talcification of the pyroxene. Samples 1 and 2 are a much better grade of material.

Leeds County

Rideau Lake

Grindstone Island. This island lies 2 miles northwest of Portland village, on the Ottawa-Toronto line of the Canadian National Railway.

Between the years 1893 and 1899, a quantity of rock was quarried on the island and shipped by scow to Montreal, via the Rideau canal, to be used in the manufacture of roofing. The operators were the Sparham Roofing Company, of Montreal. The stone was shipped in the crude state, and was ground in Montreal. No work has been done since 1899.

The workings consist of a single, almost circular, pit, opened in the east face of the low bluff fronting the lake. This pit measures 75 feet across, and has been carried down nearly to lake level, with a depth of about 25 feet.

The material of the deposit is a soft, brown to grey-green, altered pyroxene (rensselaerite). The rock is, variously, medium- to coarse-grained, and varies somewhat widely in the degree of alteration it has undergone. In some parts of the quarry, fairly fresh, unaltered pyroxenite predominates. Pink calcite occurs locally in considerable amount. The rock has all the appearance of a typical mica-bearing pyroxenite, that has undergone pronounced, local metamorphism by solutions from a later pegmatitic intrusion, with complete or partial alteration of the pyroxenite to rensselaerite or pyrallolite. No pegmatite was observed in the pit.

A sample of the stone from the stock-pile near the old loading wharf, ground to pass 100 mesh, yielded a dirty, grey-white powder, having little or no slip. An analysis of this material, made in the Bureau of Mines laboratory, showed:

Silica	54·62
Ferrous oxide	1·41
Ferric oxide	0·88
Alumina	0·09
Lime	4·90
Magnesia	28·56
Carbon dioxide	4·59
Water above 105°C.	5·01
	100·06

Other Talc Occurrences in Eastern Ontario

Small occurrences of talc are not uncommon in the crystalline dolomite of the Grenville-Hastings series in eastern Ontario, where this rock has been intruded by granite or greenstone. The following occurrences are on record but do not appear to be of economic importance.

Lennox and Addington County, Kaladar Township, concession I, lot 5.

Hastings County, Wollaston Township, concession IX, lot 9.

Frontenac County, Clarendon Township, concession II, lot 34.

Frontenac County, Olden Township, southwest of Sharbot Lake.

QUEBEC

The talc and soapstone deposits of Quebec are confined for the most part to occurrences associated with the extensive development of serpentine and altered ultrabasic rocks of the Eastern Townships region, south of the St. Lawrence. These rocks are a northerly extension of the same series extending through Vermont and the southern Appalachians into Virginia, North Carolina, and Georgia, in all of which States talc or soapstone of general similarity to that found in Quebec has been produced on a considerable scale.

Most of such talc, owing to its being derived from rocks composed essentially of ferruginous minerals, is of off-colour grade, yielding a grey or greenish white powder. The colour often is influenced, also, by the varying content of residual chlorite, as well as of other mineral impurities, such as spinel, pyrite, pyrrhotite, etc., all of which are common accessory constituents. A few deposits of rather whiter talc are known in Quebec in the southern and western portion of the above region, but these have remained comparatively undeveloped, and the industry in the Province has been concerned almost entirely in recent years with cut soapstone furnace bricks for kraft pulp mills; ground soapstone waste and soapstone sawdust, sold mainly to the roofing and rubber trades; and small amounts of grey talc found sometimes as bands or lenses in the soapstone bodies.

While the talc deposits of Quebec were among the earliest worked in Canada, various occurrences having been mined in a small way many years ago for the production, mainly, of foundry and paint material, no established industry developed until 1922, when production of sawn soapstone commenced in the Thetford Mines district. A ready market was found for this product with Quebec kraft mills, and a small but steady output has since been maintained.

Argenteuil County

Township of Grenville

Range II, Lots 26 and 27. A deposit of partially altered pyroxenite, of rensselaerite or pyrallolite character, exists on these lots, associated with crystalline dolomite. A small pit was opened on the occurrence many years ago, along the road between Calumet and Pointe au Chene, but no further work has been done. The rock exhibits the grain of the original pyroxene, with a minor development of more compact material on joints and slip faces, is of a greenish brown colour, and contains small mica flakes. It is fairly soft, and grinds to a powder having a strong pinkish shade: a sample, analysed in the laboratory of the Bureau of Mines, yielded:

Silica	58·96
Ferrous oxide	1·01
Ferric oxide	0·58
Alumina	1·03
Lime	1·16
Magnesia	30·96
Carbon dioxide	0·85
Water above 105° C	5·48
Total	100·03

The occurrence is recorded by Logan in an early report[1] of the Geological Survey, and is stated by Ells[2] to extend for 180 feet. Similar rock occurs on lot 16 in the same range of Grenville Township, near the foot of the falls on Calumet Creek, where it was quarried in a small way many years ago for dimension stone.

EASTERN TOWNSHIPS

THETFORD MINES DISTRICT

The whole of the talc and soapstone production of Quebec Province for many years past has been derived from deposits in the adjacent Townships of Broughton, Beauce County, and Thetford and Leeds, Megantic County, where, for the past eighteen years, there has been a small but sustained output. The output of talc has been of minor proportions, consisting of a small tonnage mined from narrow bands of grey talc cutting across the soapstone bodies at the Broughton Soapstone and Quarry Company and Cyr properties, in Broughton and Leeds Townships, and ground locally and in Montreal. Soapstone waste from these same properties has also been shipped to Montreal for grinding, and the sawing dust from some of the various soapstone operations is marketed, mainly for roofing purposes. It is estimated, from reports of operators, that the output of such ground talc and soapstone in 1938 totalled about 1,500 tons. Production could be increased very materially with existing mill equipment if markets could be found for the products.

The soapstone of this district is of somewhat variable character, ranging from a less highly altered, impure, medium-textured rock, in which the form of the original ferromagnesian minerals of the primary pyroxenite or peridotite is preserved, to a more highly talcose, fissile type that might more properly be classed as straight talc. The former type is represented by the stone mined on lot 12 of range XI of Broughton Township; lot 15 of range XV, Leeds Township; and lots 12 and 13 of range III of Thetford Township. The latter type predominates in a belt running through range V of Thetford Township, where the first soapstone operations in the district were conducted and where considerable cut stone was produced. This latter type is softer and structurally weaker than the more granular stone and is more liable to spalling, with resultant higher loss in quarrying, sawing, and handling of the cut shapes. On this account it is not adapted for slab and panel use.

The soapstone of the known and worked deposits occurs in a belt that follows a fairly regular course bordering the north margin of the large serpentine masses with which the asbestos occurrences are associated. This belt has a considerable persistence through range V of Thetford Township, where its trend is northeast-southwest, and possibly continues along the same general strike through Broughton Township as far as East Broughton. A second band strikes northwest through ranges X and XI of Broughton Township into range XV of Leeds Township; and a third band follows a

[1] Geology of Canada, 1863, p. 470.
[2] Geol. Surv., Canada, Ann. Rept., vol. XII, Pt. J, 1899, p. 37.

similar trend north of St. Antoine de Pontbriand across ranges II, III, and IV of Thetford Township. It is possible that these three bands are all different sections of one and the same belt that have been separated by faulting, or whose course has been changed by local thrust movement and drag-folding. H. C. Cooke, who has recently studied the rocks of this area, makes the following observations[1] on the soapstone occurrences:

> All the soapstone of the Thetford district is an alteration product of peridotite dykes. It has been thought that soapstone was mainly an alteration product of pyroxenite, as serpentine is of peridotite, but the writer has found no evidence supporting this conception. The wall rocks of all the known soapstone occurrences are siliceous quartzites or schists. For distances of a few feet from the margin of the soapstone, these schists are converted into a mass of dark green chlorite commonly termed "black-wall." In this, they resemble closely the soapstone deposits of northern Vermont.

Cooke regards the soapstone as having been formed later than the asbestos of the district, but through the medium of the same injection of solutions, and notes that conversion of serpentine to soapstone has only occurred where the dykes of the former rock were comparatively narrow.

The region undoubtedly contains important reserves of a good quality of soapstone, suitable for general refractory use, and the more highly talcose zones, as on lots 4 and 5, range V, of Thetford Township, would yield a good grade of off-colour, substantially lime-free, grey talc, suitable for grinding. The deposits are relatively narrow, 12 to 20 feet being the average, and the dip is sometimes rather flat, factors adverse to large-scale quarry operations by channelling methods.

Universal practice in the mining of soapstone in the district has been to cut the stone out in blocks of, roughly, one cubic yard size by means of light drills fitted with chisel-edged steel. The quarry blocks are lifted by derrick onto small flat-cars, which run to nearby sawing sheds. These are often light, temporary structures, with portable, gasoline-driven sawing and dust-collecting equipment, that can readily be moved from one location to another. Only at the quarry of the Broughton Soapstone and Quarry Company, in Broughton Township, has a more permanent and substantial plant been installed: this concern uses electric power in its operations.

Beauce County

Township of Broughton

Range VII, Lot 14. Soapstone ("steatite") is stated[2 (a)] to occur, and a small quantity to have been mined years ago, on a narrow band north of the workings of the Fraser asbestos mine, near East Broughton. J. A. Dresser reports[2 (b)] that soapstone also occurs on lot 2, range XI, of Broughton Township, as well as on lots 42, 43, and 50, range I of the

[1] Cooke, H. C.: "Thetford, Disraeli, and Eastern Half of Warwick Map-Areas, Quebec"; Geol. Surv., Canada, Mem. No. 211, 1937, pp. 149–153.

[2] (*a*) Geol. Surv., Canada, Ann. Rept., vol. X, 1897, p. 225S; (*b*) Sum. Rept. 1909, p. 198.

Township of Ham, in Wolfe County, and Ells records an occurrence on lot 4 of range XI of Broughton. These last occurrences do not appear ever to have been worked.

Wilson states that the soapstone on lot 14 of range VII occurs as a narrow band, only 1 to 2 feet wide, exposed at intervals in the quarry wall for a distance of 200 feet. The material is highly talcose, fine-grained, and of a grey-white colour, but hardly seems to occur in a body large enough to be of much commercial interest.

References. Geol. Surv., Canada, Ann. Rept., vol. IV, 1888-89, p. 153K.
Geol. Surv., Canada, Ann. Rept., vol. V, Pt. II, 1890-91, p. 26S.
Geol. Surv., Canada, Mem. No. 22, 1913, pp. 68, 96.
Wilson, M. E.: (15), pp. 112-13.

Range IX, Lot 11. A deposit of soapstone is reported[1] to have been worked in 1933-34 on this lot by L. C. Pharo, of Thetford Mines, who installed a small sawing mill and shipped a little cut furnace stone. The occurrence lies about one mile east of the quarry of the Broughton Soapstone and Quarry Company.

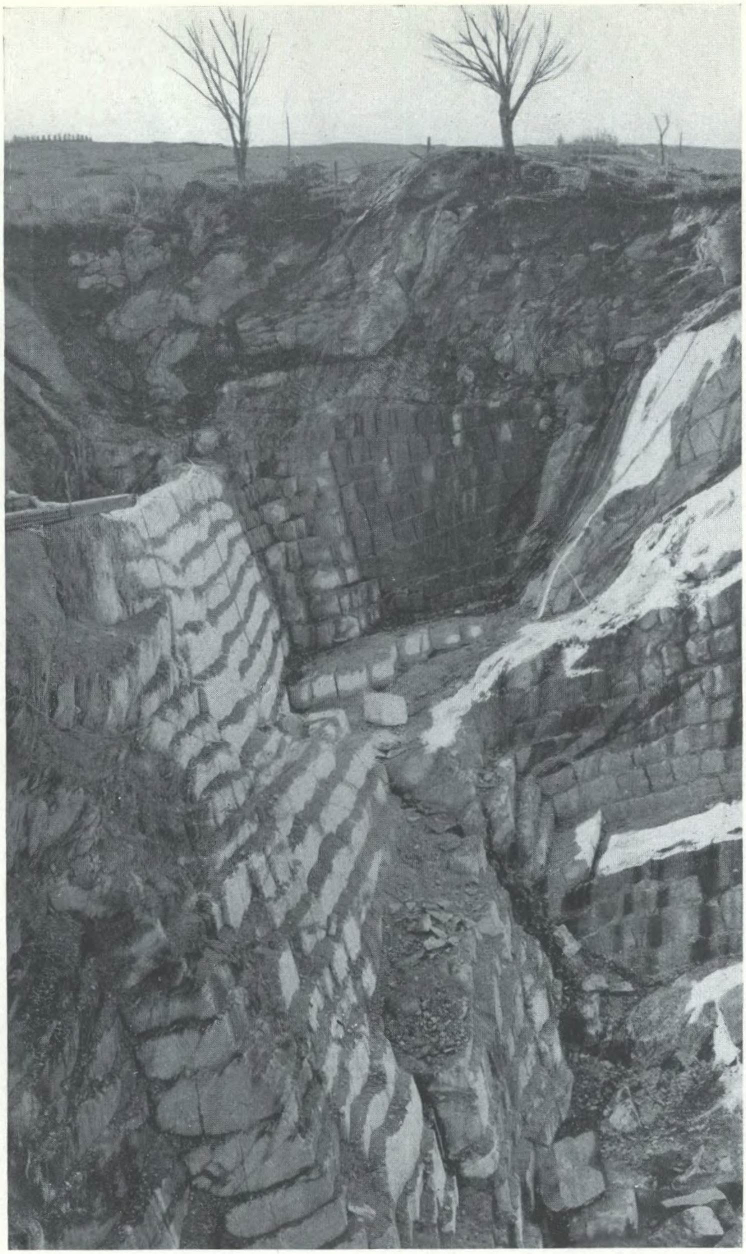
Ranges X and XI, Lot 12. On these lots, and mainly on range XI, is situated the soapstone quarry of the Broughton Soapstone and Quarry Company (formerly the Robertsonville Soapstone Quarry Company), by far the largest soapstone operation in the district. This company was the pioneer concern in the Quebec soapstone industry; it has been in intermittent operation on various properties in the district since 1923, and has produced the bulk of the output.

The workings consist of a single large quarry opening (*see* Plate V), situated along the road leading north from Leeds station, on the Quebec Central Railway, to West Broughton, and about 1½ miles from the railway. The pit, which measures about 250 by 225 feet and 75 feet deep, has been opened on a wide band of soapstone that strikes northwest with a low dip. The band is thought to be a continuation of the band worked farther to the west, in Thetford Township, where several quarries have been opened at various times along an east-west-trending belt in the ridge forming the north side of the valley through which the railroad runs, and to have been separated from it by faulting or drag-folding[2].

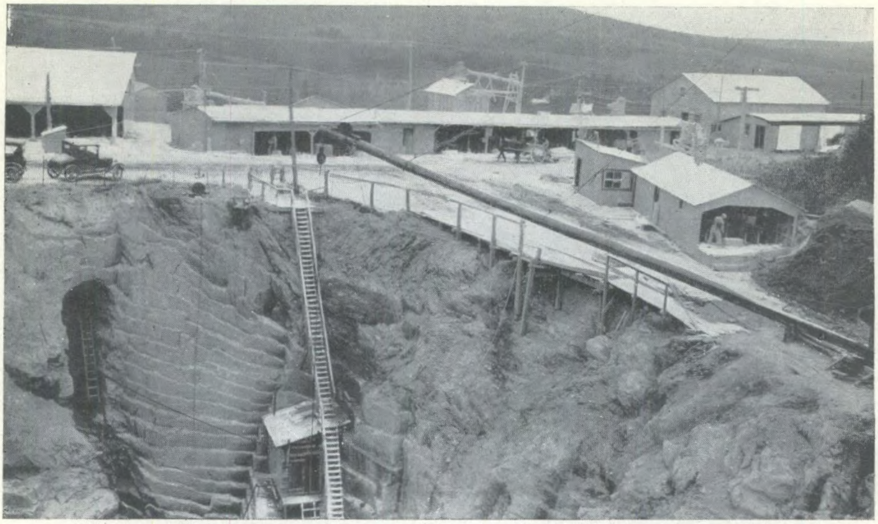
The soapstone on this property is a soft, uniform- and medium-textured, greyish green rock, that Cooke[3] regards as an altered peridotite. It saws easily, has good structural strength, and yields an excellent furnace stone. It also is suitable for monumental and general building use, the local mine office being built entirely of blocks of it, with interior soapstone trim. The company has also fashioned monuments from it, as well as a variety of small shaped and turned ornamental objects. The stone weighs 180 pounds per cubic foot.

The stone is cut from the walls of the quarry, along rough ledges, by means of paving-breaker-type of light, hand drills, fitted with non-rotating steel having a 1¾-inch bevelled chisel edge. Grooves are chiselled in the

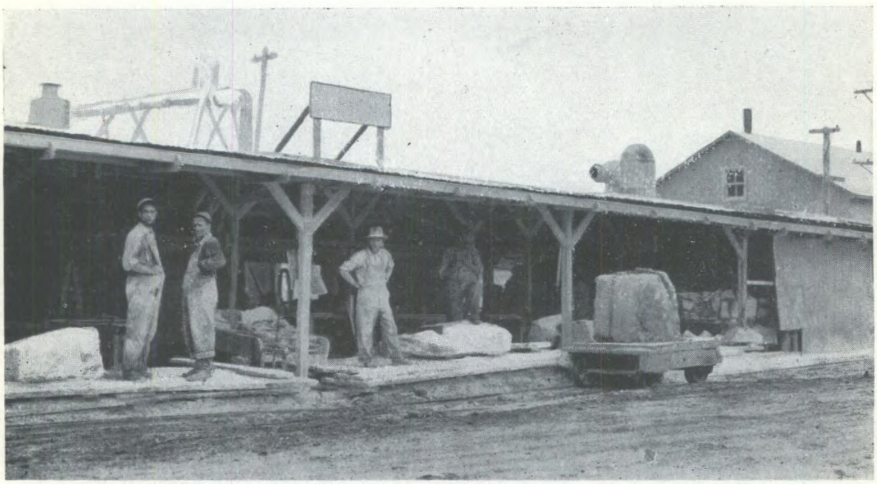
[1] Personal communication from E. Larochelle, Inspector of Mines, Thetford Mines.
[2] Cooke, H. C.: Geol. Surv., Canada, Mem. No. 211, 1937, p. 149.
[3] Op. cit., p. 152.



View of soapstone quarry of Broughton Soapstone and Quarry Company, range XI, lot 12, Broughton Township, Beauce County, Que., showing method of drilling out the stone in blocks along rough benches. The opening measures 250 by 225 feet and is 75 feet deep.



A. General view of soapstone operations of Broughton Soapstone and Quarry Company, range XI, lot 12, Broughton Township, Beauce County, Que., showing portion of quarry opening, range of sawing sheds, and (in background) grinding mill for soapstone waste and talc.



B. Close-up view of portion of sawing-shed installation of Broughton Soapstone and Quarry Company, showing size of blocks quarried, and (above roof at right) part of cyclone system for collection of sawing dust.

rock along three sides of the individual blocks, which are then broken out with bars. Size of blocks is roughly 42 by 36 by 36 inches. The blocks are lifted by derrick onto small flat-cars which run directly to the sawing sheds.

Midway of the pit, a narrow band within the soapstone mass has been more highly altered and converted largely to a pale grey, translucent, foliated talc, which, however, contains a considerable amount of impurities, largely dark chlorite. This talc is ground in part in a small mill on the property and in part shipped to the grinding plant of Pulverized Products, Limited, in Montreal. It, together with the soapstone dust from the sawing benches, is marketed chiefly to the roofing trade, some going also to the paper and rubber industries. Some is also utilized for sawing into crayons.

Sawing of the soapstone is done in a range of small open-fronted sheds (*see* Plate VI A and B). Rough sawing into slabs of the desired thickness is done by horizontal, cam-driven, coarse-toothed steel rip-saws, having a 40-inch blade. Some slab stone, in pieces up to 36 by 30 by 1¼ inches, is sold for building purposes, but the great bulk of the sales has consisted of furnace blocks and bricks. These may be of any dimensions, according to the specifications of individual pulp mills, but the principal sizes made are the following:

2½ x 4½ x 9 inches	12 x 12 x 12 inches
6 x 6 x 12 "	8 x 12 x 18 "
6 x 12 x 12 "	12 x 12 x 18 "

Furnace stone finds its chief market with the pulp mills of the Province, but is also shipped as far west as Dryden, Ont. and to Bathurst, N.B.

The blocks and bricks are cut from the slab stone by means of steel-toothed circular saws, with diameters ranging from 18 inches to 40 inches. Care has to be taken in sawing to ensure that the long diameter of the finished piece is parallel to the natural grain of the stone, so as to obtain adequate structural strength. This is particularly important in furnace stone, which, if cut across the grain, tends to spall out from the walls, with resultant disruption and short life.

Sawing dust is collected by cyclone dust-collectors, for sale to the roofing trade. Air-dried talc from the band in the quarry is ground in a small mill having a capacity of about one-half ton of minus 200-mesh product and 2 tons of coarse, roofing-grade oversize per hour. The material is first broken in a jaw crusher and is then fed to an Allis Chalmers Pulverator hammer-mill, with final reduction in a Raymond No. 00 hammer-mill in closed circuit with an air separator. Soapstone waste is ground in the Pulverator, followed by sizing over a 3-deck screen of 40-mesh, 80-mesh, and 150-mesh. The plus 40-mesh is further reduced in the Raymond mill, the coarse reject of the air separator being returned to the screen; the minus 40 plus 80-mesh forms a coarse (S1) roofing grade, and the minus 80 plus 150-mesh a finer (S2) grade for the same purpose; while the minus 150-mesh (T3) constitutes a rubber grade of talc. These products sell for $6 to $8 per ton, f.o.b. rail. Formerly, cut stone sold at $4 per cubic foot, but in the last few years, owing to competition in the industry and slackened demand, the price has dropped to $2, and even less. Crayons are cut by means of small, 15-inch, circular saws, the chief sizes made being $\frac{3}{16}$ by $\frac{1}{2}$ by 5 inches and $\frac{1}{4}$ by $\frac{1}{4}$ by 5 inches; these sell at about $1.10 per gross.

A few years ago, a drying kiln was installed for drying of the cut furnace stone before shipment, with the idea that removal of the 4 per cent moisture content would give longer life, and also might enable the stone to replace imported fire-brick for general refractory use, but results did not prove satisfactory and the practice has been discarded.

Two samples of the stone from this quarry, analysed in the laboratory of the Bureau of Mines, yielded:

—	1	2
Silica	58·70	35·60
Ferrous oxide	5·40	5·77
Ferric oxide	Nil	0·74
Alumina	1·16	1·41
Lime	Nil	0·76
Magnesia	29·36	33·14
Carbon dioxide	0·23	16·88
Water above 105° C	5·48	3·63
Total	100·33	97·93

References. Rowe, R. C.: "Soapstone Mining in the Province of Quebec", Can. Min. Journ., Dec. 6, 1927, pp. 1003-4; Concrete and Quarry, April, 1930, p. 15.
Rowe, K. C.: "Broughton Soapstone", Concrete and Quarry, April, 1936, pp. 8-9.

Rigaud-Vaudreuil Seigniory

An occurrence of soapstone is recorded[1] by B. R. MacKay, on the St. Victor River, 3 miles west of the Chaudière River. The deposit is described as a belt 30 feet wide, forming the northern rim of the St. Victor 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 is regarded as an alteration product of the dunite. Numerous veinlets of magnesite and fibrous serpentine cut the dunite and soapstone. The soapstone is much jointed and fractured, and for this reason is considered unsuitable for cutting into slabs or blocks.

Megantic County

Township of Leeds

Range IV, Lot 12a. In 1938, this lot was prospected by stripping and trenching by L. Pharo, of Thetford Mines, who, in September, installed a mining and sawing plant on the property and started to produce cut soapstone. In addition, a small mill was built to produce ground talc. Mill equipment consists of a jaw crusher and hammer-mill, the latter of the operator's own design, in closed circuit with an air separator. Power is furnished by a 42 h.p. Diesel engine.

[1] Geol. Surv., Canada, Mem. No. 127, 1931, p. 87.

The deposit lies 2½ miles from Kinnear's Mills, and 9 miles from rail at Pennington Siding, between Robertsonville and Thetford Mines. It is stated to consist of a 50-foot band of soapstone, bordered on each side by about 8 feet of grey talc. From its location, it seems probable that it may be a northerly extension of the same soapstone belt worked at different points in the neighbourhood of St. Antoine de Pontbriand, in ranges II, III, and IV of Thetford Township.

Range XV, Lot 15. A considerable amount of cut soapstone was produced from this lot between 1925 and 1927 by the Broughton Soapstone and Quarry Company. In 1927, this company transferred its operations to its present quarry-site in Broughton Township, and the property remained idle till 1937, when L. Cyr resumed work on it and has produced a further small amount of cut stone. The location is on the top of the hill 2 miles north of the village of St. Pierre de Broughton, and about 8 miles from Leeds station.

A number of small shallow pits have been opened on what appears to be a considerable body of soapstone that outcrops on level ground on the top of the hill, but most of the stone mined has come from a single larger opening measuring 50 by 20 feet and 30 feet deep. The stone here is fairly coarse-grained and resembles that of Broughton Township. Thin quartz seams occur, and small ankerite crystals are common, with occasional small pockets of coarsely crystalline calcite. With the latter are sometimes associated small amounts of apple-green talc, in large flakes. Talc of good grinding quality also occurs as a 3-foot vein cutting or bordering the soapstone body, and is shipped to a Montreal plant for pulverizing.

The stone was cut out by drills, and the blocks swung by derrick to sawing sheds located close to the pit. During 1925 and 1926, 37,000 cubic feet of cut stone was reported produced from the property.

Two samples of the stone from this quarry analysed in the laboratory of the Bureau of Mines, yielded:

—	1	2
Silica	32·16	31·10
Ferrous oxide	5·25	5·18
Ferric oxide	0·63	0·74
Alumina	0·94	2·32
Lime	Trace	Nil
Magnesia	34·74	34·49
Carbon dioxide	22·20	22·80
Water above 105° C	2·75	3·29
Total	98·67	99·92

Reference. Spence, H. S.: "The Canadian Soapstone Industry", Invest. Min. Res. and Mg. Ind. 1926, Mines Branch, Dept. of Mines, Canada, pp. 23-24.

Township of Thetford

Range II, Lot 12; Range III, Lots 11, 12, and 13; Range IV, Lot 12. A northwest-trending band of soapstone traverses the above lots, which lie along the valley running north from St. Antoine de Pontbriand.

It has been worked intermittently since 1924 by various operators, who have opened several small quarries along its course. The workings lie about 4 miles north of Robertsonville station, or 7 miles from Thetford Mines, both places serving as shipping points.

The character of the stone is similar at all the quarries, being a soft, light grey, medium-textured rock. Locally, considerable crushing has taken place, with thin chlorite seams and small quartz or calcite stringers cutting the stone. The band is from 15 to 20 feet wide and evidently has considerable persistence. It is possibly a continuation of the same band that runs for several miles through range V of the same township, and which takes a northwest swing at its westerly end. Its course is concealed for the most part by a rather heavy mantle of drift that covers the hillside, entailing considerable stripping.

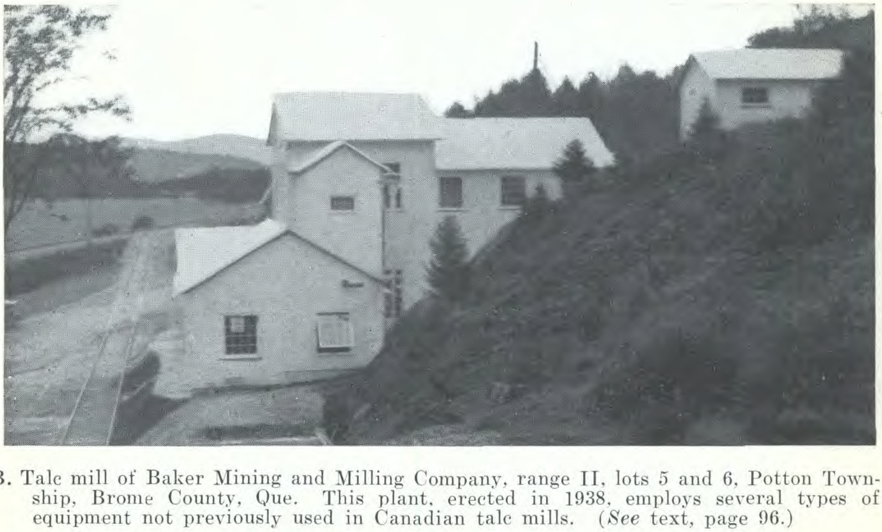
From lot 12 of range II, about eighteen cars of cut furnace bricks were reported to have been shipped in 1924. The stone was taken from a pit 25 feet deep, by 40 feet wide and 175 feet long, following the strike of the band along the flank of the ridge. The deposit exhibits considerable crushing and is locally seamed by chlorite and quartz. No further work has been done on the property since the above.

Most of the recent work on this belt has been done on lots 12 and 13 of range III, where L. C. Pharo, of Thetford Mines, has taken out a few hundred tons of soapstone since 1934. The property, as well as lot 12 on range IV, was first worked in 1925 by J. Houlle, of St. Antoine, who shipped a couple of cars of cut stone. The stone is mined by the same methods as used at the quarry of the Broughton Soapstone and Quarry Company, in Broughton Township, and is cut in a small sawing plant on the property. Some of the more compact material is used for cutting into crayons. The soapstone is a rather fine-textured, soft rock with a tendency to fissile structure, and occurs as a 20-foot band having a rather steep dip. The hanging-wall consists of a weathered talc-chlorite schist that is highly slickensided and squeezed. Serpentine forms the foot-wall, with a 3-foot mashed zone along the contact. The quarry opening is a narrow pit 90 by 30 feet, and about 65 feet deep, and lies about half-way up the hillside, one-quarter mile above the valley road. A shipment of cut stone from this mine was made to Australia in 1937, for kraft mill use. At the end of 1937, operations are stated to have been moved to lot 11 of the same range, with plans projected to install a grinding plant.

A sample of the stone from the quarry on lots 12 and 13 on range III, analysed in the laboratory of the Bureau of Mines, gave the following:

Silica	58·84
Ferrous oxide	4·82
Ferric oxide	0·20
Alumina	1·33
Lime	0·26
Magnesia	28·48
Carbon dioxide	0.50
Water above 105°C.	4·83
Total	99·26

A. View of soapstone quarrying operation along north side of old open pit of Kitchener asbestos mine, range V, lot 2, Thetford Township, Megantic County, Que. Illustrates the occurrence of a band of soapstone as a marginal deposit bordering a body of asbestos-bearing serpentine.



B. Talc mill of Baker Mining and Milling Company, range II, lots 5 and 6, Potton Township, Brome County, Que. This plant, erected in 1938, employs several types of equipment not previously used in Canadian talc mills. (*See* text, page 96.)

Range V, Lot 2 E ½. Soapstone has been mined intermittently since 1933 on this lot by Charles Fortin, of Robertsonville, who has shipped a few hundred tons of cut furnace stone. The working is the most easterly of the various openings made on the belt of soapstone running through range V of Thetford Township, and is the only one now in operation.

The occurrence consists of a band of fine-grained, rather fissile grey stone lying along the north wall of the old pit of the Rumpel, or Kitchener, asbestos mine, 3 miles east of Robertsonville station (*see* Plate VII A). The stone is cut out in rough blocks up to 30 by 30 by 50 inches by means of paving-breaker type drills along rough benches in the side of the old quarry opening. The blocks are lifted by derrick onto small flat-cars and sawn in a small cutting shed on the property, using the same type of saws as described for the operation of the Broughton Soapstone and Quarry Company, in Broughton Township. Power is furnished by portable gasoline engines. Sawing dust is collected by a cyclone dust collector, and is sold to the roofing trade. A small amount of soapstone waste is shipped to Montreal for grinding.

The property is owned by the Asbestos Corporation, of Thetford Mines, and is worked under royalty.

An analysis of a sample of the sawing dust from the stone on this lot, analysed in the laboratory of the Bureau of Mines, is shown below under 1, while under 2 is shown an analysis of the crude stone:

—	1	2
Silica	59·22	58·42
Ferrous oxide	3·72	4·42
Ferric oxide	0·13	0·05
Alumina	2·56	2·44
Lime	1·62	0·90
Magnesia	28·04	28·28
Carbon dioxide	0·06	0·02
Water above 105° C	5·01	4·99
Total	100·36	99·52

Range V, Lots 4, 5, and 6. The occurrence on these lots is the first one operated for talc and soapstone in the Thetford district. It was first worked as a source of foundry talc many years ago, and in 1922 was the site of the initial operations for cut soapstone by L. Cyr, who in 1923 formed the Robertsonville Soapstone and Quarry Company (now the Broughton Soapstone and Quarry Company). A few cars of cut stone were produced on lot 4, but most of the output came from lot 5, where work was continued until 1926, when the operations of the above company were transferred to Leeds Township, and later to Broughton Township. The property has lain idle since that time.

The soapstone on these lots differs from that at most of the other occurrences in the district in that it is more highly talcose. It is a highly fissile rock, composed of paper-thin layers of finely foliated talc, with no approach to granular texture, and might more properly be termed talc. Although it can be sawn into bricks, it lacks the structural strength of ordinary soapstone and tends to spall readily. It would yield a good grade of grey, off-colour grinding talc, rather high in iron but substantially lime-free and possessing good slip. Chlorite and minute disseminated grains of spinel are the principal impurities. When worked, blasting methods were used, which caused high loss of sound stone for cut furnace use, and only small bricks could be sawn.

The deposit forms a band about 12 feet thick, having an apparent rather flat dip of about 45 degrees to the south, with serpentine on the hanging-wall. It is, therefore, hardly adapted to working by open-cut methods and would probably best be developed by drifts from an inclined shaft. Present workings consist of a few shallow open cuts, following the strike, and one short drift run to cross-cut the body.

Two analyses of samples of the stone from lot 5, made in the laboratory of the Bureau of Mines, showed as follows:

—	1	2
Silica	59·66	56·80
Ferrous oxide	4·12	5·65
Ferric oxide	0·37	.....
Alumina	1·67	0·66
Lime	Nil	0·06
Magnesia	29·96	29·36
Carbon dioxide	Nil	1·40
Water above 105° C	4·90	6·20
Total	100·68	100·13

In 1932 and 1936, several lots of talc and soapstone from these occurrences were sent to the laboratories of the Bureau of Mines, at Ottawa, for tests to determine whether the grade and colour of the powdered material could be improved. Microscopic examination showed the presence in the talc of numerous dark specks, and these were determined spectrographically as probably being mainly iron-magnesia spinel (pleonaste). The talc enclosing the specks was found to be of a cloudy grey colour, due either to iron stain or possibly to the presence of residual chlorite. Magnetic, tabling, and flotation tests were run on this material, but proved to effect very little useful separation. In the magnetic separation tests it was found that much of the talc, as well as the iron-bearing impurity, behaved magnetically and passed over with the latter. Although by tabling and flotation considerable dark impurities were removed, with some improvement in colour of the talc product, the iron content of the latter was found not to be lowered greatly over that of the feed sample, the best result attained (by flotation) showing 4·79 per cent Fe_2O_3, as against 5·52 per cent in the feed sample. By magnetic means, the best result achieved was 5·09 per cent Fe_2O_3 in the non-magnetic fraction. These results would indicate that little improvement in grade and colour is possible by the above means on the talc-soapstone of this district.

The occurrence lies one-quarter mile north of the highway between Thetford Mines and Robertsonville, and about 2½ miles east of Robertsonville station on the Quebec Central Railway.

References. Spence, H. S.: (7), p. 43: Mines Branch, Dept. of Mines, Canada, Rept. No. 687, 1928, pp. 22-23.
Wilson, M. E.: (15), pp. 110-112.

Range V, Lots 7 and 9. West of the workings on lots 4 and 5, the same soapstone band has been worked in a small way at a couple of points. On lot 7, about 100 tons of crude stone were mined in 1920 by T. Demers, of Thetford Mines, and shipped to a rubber firm in the United States. On lot 9, two cars of cut stone were produced in 1924 from a small pit opened on a 10-foot band exposed a short distance north of the workings of the old Federal asbestos mine; the stone here is rather more massive and granular than that farther to the east. Little further work has been done on either lot. This last occurrence is the most westerly exposure of the soapstone belt running for about 3 miles through range V of Thetford Township, and it is possible that the band takes a swing from here to the northwest and is the same as that worked north of St. Antoine de Pontbriand. Assuming an average width of about 10 feet, and that the band is continuous, as seems probable, the total reserves indicated are very considerable.

Two analyses (1) of a sample of the talc (soapstone) from lot 7, and (2) of a sample from lot 9, both made in the laboratory of the Bureau of Mines, are shown below:

—	1	2
Silica	54·88	59·62
Ferrous oxide	4·63	4·25
Ferric oxide	1·44	1·21
Alumina	3·59	1·40
Lime	1·10	Nil
Magnesia	27·22	28·49
Carbon dioxide	1·52	Trace
Water above 105° C	5·86	4·61
Total	100·24	99·58

Township of Inverness

Range I, Lot 1. Several small surface pits were opened on this lot a number of years ago on outcrops of whitish talc that forms a narrow band, from 2 to 6 feet wide, in green talcose and chloritic schist. The band has been opened up over a distance of 100 feet along its strike, but the amount of talc visible is small, and the occurrence would not appear to have commercial importance. Most of the property is heavily drift-covered. Wilson states that the talc body borders on a mass of soapstone having an exposed width of 80 feet. The property lies 10 miles northwest of Thetford Mines station, and is stated to be owned by Mrs. R. J. Briggs, of Clapham.

Reference. Wilson, M. E.: (15), pp. 108-110.

Township of Ireland

Craig's Road Range, Lot 2. A little work, mainly stripping and surface blasting, was done on this lot about thirty years ago by W. J. Porter, of Clapham, for the Megantic Talc Company, of Toronto, a concern organized to develop the property. Little further work has been done.

The occurrence consists of a number of narrow veins or seams of pale green talc, in the form of aggregates of large flakes or crystals, often associated with large crystals of brown ankerite (ferruginous dolomite). In some zones, talc predominates, while in others, ankerite is the principal mineral. Maximum vein-widths exposed are about 12 inches. The veins occur in talcose and chloritic schist, in part of soapstone character and probably an altered serpentine, which is often rich in disseminated crystals of magnetite and ankerite. Owing to the narrowness of the talc veins and the considerable amount of ankerite present, the deposit probably has little economic interest, though the clean talc itself is of high quality and yields a very white powder having high slip. An analysis of a selected sample of the clean talc, made in the laboratory of the Bureau of Mines, yielded:

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
Total	99·29

The largest opening on the property is a small pit, 30 by 20 feet and 5 to 15 feet deep, located on the largest talc vein exposed. The occurrence lies 1½ miles south of Clapham village, and 13 miles northwest of Black Lake station on the Quebec Central Railway.

References. Spence, H. S.: (7), p. 42.
Wilson, M. E.: (15), pp. 106-108.

Brome County

Township of Bolton

A number of talc and soapstone occurrences are on record in this township, as described below, and many of them were mentioned in the "Geology of Canada," one of the earliest reports of the Geological Survey, published in 1863. On checking the locations given in this and later reports, including those of Wilson and the writer, with recent maps of the region (Standard Topographical Map No. 11 S.E., Sherbrooke Sheet, 1929, and Department of National Defence Map No. 65, Memphremagog Sheet, 1924), it becomes obvious that the lot numbers are in many instances at variance with the positions as shown on the maps mentioned. This discrepancy is evidently due to an error in the numbering of the lots of the township when these maps were draughted, the numbers being shown as running from south to north, whereas they actually run from north to south.

In this report the lot numbers of the various properties are as given in the original records, and conform to those shown on the Provincial maps. For convenience in using the above-mentioned maps, however, the position thereon of the properties is indicated by the lot number in brackets following the correct number. No claim for accuracy in such adjustment is made, the position indicated being merely the estimated one.

Range I, Lot 23 (*Lot 6*). Some prospecting for talc was conducted on this lot between 1911 and 1913 by L. Greer and L. N. Benjamin, on land owned by J Pibus, of Knowlton. The openings made include a shaft said to be about 30 feet deep, an adit driven into the hillside for a distance of 140 feet, and several small prospect pits and trenches. All of these workings have now either caved in or are filled in, and are inaccessible. The occurrence lies 5 miles southeast of Knowlton station, on the Foster-Sutton branch of the Canadian Pacific Railway[1].

According to Wilson the talc here forms a marginal deposit on the east side of a belt of serpentine in a schist-crystalline limestone complex, with the greatest width exposed about 10 feet. The adit is stated to have followed the strike of the deposit and to have been in talc for the whole 140 feet of its length. The talc is described as a grey talc schist, which yields an off-colour powder.

Reference. Wilson, M. E.: (15), pp. 100-101.

Range II, Lot 26 (*Lot 3*). A deposit of yellowish grey, schistose talc occurs on this lot, and was worked many years ago in a small way by the owner, George R. Pibus, of Knowlton. Two small pits, a few hundred feet apart, have been opened on the deposit, and disclose a band of about 7 feet of talc of good quality. In common with the talc of many of the other deposits in the Eastern Townships, the material is thinly laminated and breaks up rather readily into thin sheets. The colour is lighter than that of the material of many of the other deposits examined, and the alteration of the original rock to talc seems to have been more pronounced in this case.

Beyond the pits referred to above, little work has been done on the property; and, owing to the heavy overburden, few outcrops are to be seen. Considerable trenching would have to be done to prove the deposit. The owner reports traces of talc for a distance of 400 feet along the strike of the band exposed in the pit.

[1] In 1939, some further prospecting was done on this property by L. Roberts and J. E. Ball, of Knowlton, who opened a few small surface pits in the neighbourhood of the original workings. These disclosed widths up to 30 inches of pale, greenish white, foliated talc, apparently bordering a body of rather compact soapstone. The clean talc grades off into undetermined widths of a talc-dolomite mixture.

A sample of the talc from the main pit gave a powder of a cream shade, possessing excellent slip. An analysis, made in the laboratory of the Bureau of Mines, yielded:

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
Total	100·06

As with most of the talcs of the Eastern Townships, the iron oxide content is rather high, and the powdered material is not pure white.

The property lies 6 miles southeast of Knowlton station on the Foster-Sutton branch of the Canadian Pacific Railway, about one-quarter mile off the road between Knowlton and Bolton.

References. Geol. Surv., Canada, Ann. Rept., vol. IV, 1888-89, p. 154K.
Geol. Surv., Canada, Sum. Rept., 1911, p. 292.
Wilson, M. E.: (15), pp. 101-102.

Range IV, Lot 4 (Lot 25). A body of steatite (probably soapstone) is stated by Wilson to occur on the west side of the Missisquoi River, deposit is reported as having a width of about 75 feet, and to consist of steatite containing disseminated magnesite crystals and patches of dolomite. No work has been reported on this occurrence.

Range VI, Lot 24 (Lot 4). The occurrence of talc on this lot was recorded by Logan in the Geology of Canada, 1863, p. 797, who described it as consisting of two bands of "steatite", respectively 3 feet and 5 feet thick, separated by a few feet of dolomite and chloritic rock. The deposit is stated by Wilson to occur on the west side of the Missisquoi River, about 1 mile north of the village of South Bolton, and 9 miles from Knowlton station. It was worked many years ago, 300 tons of talc being recorded as produced in 1871[1], but nothing further has been done.

The workings are long since overgrown and difficult to find, but can be approached by an old logging road that follows the creek valley a few hundred feet south of the deposit. Wilson describes them as consisting of two trenches, respectively 60 by 25 feet and 5 feet deep, and 160 by 15 feet and 10 feet deep, which come together at their south ends. The material exposed consists of impure, grey-green talc schist, containing a great deal of carbonate in disseminated crystals, and occurring in two bands having widths of from 5 to 15 feet. The bands are separated by 10 feet of dolomite and chloritic schist.

References. [1] Geol. Surv., Canada, Rept. Prog., 1871-72, p. 148.
Wilson, M. E.: (15), pp. 102-104.

Range VI, Lot 26 (Lot 3). A small pit is stated by Wilson to have been opened on the northwest corner of this lot in 1876, and to show an occurrence of dark green soapstone, containing disseminated small crystals of magnetite, bordering the north margin of a mass of serpentine. The exposures are insufficient to indicate the extent of the deposit.

Reference. Wilson, M. E.: (15), p. 104.

Range VII, Lot 5 (Lot 24). The occurrence of talc on this lot was recorded in a Geological Survey publication[1] of 1911, which states that the mineral also extends over to lot 24 in range VI, to the west. The material is there stated to be "dark-coloured and very impure, containing numerous crystals of magnesium carbonate." The deposit on range VI is reported to have been worked in 1871, with 300 tons of talc shipped[2].

The occurrence on range VII lies on the farm of A. Lecours, 2 miles southwest of the village of Eastman, and 1 mile south of Eastray station on the Quebec Central line of the Canadian Pacific Railway. In 1935, L. Cyr, of St. Pierre de Broughton, installed a small mining plant on the property and sank a 12- by 12-foot shaft to a depth of 40 feet, at which depth a short drift was carried to the north. This work is stated to have disclosed two 4-foot bands of talc, separated by 2 feet of black slate. A small tonnage of talc was mined, but only a sample shipment of a few tons was made.

The talc of this deposit is of very finely foliated type, grey-white in colour, and yields a grey powder, which, however, is whiter than that of the talc from deposits of the Thetford district. In some of the stock-piled crude ore, considerable pyrite in the form of disseminated crystals was noted. The talc forms an irregular band in a slate formation, the entire assemblage having been subjected to intense squeezing and crumpling. From its character and association, which differ from the main features exhibited by the talcs of the Thetford region, this deposit would seem to have originated from a dolomitic band in the slates. It may, however, represent a very highly altered ultrabasic intrusive, in which the conversion to talc has been more complete than in the case of the Thetford deposits, where considerable residual chlorite remains.

An analysis of a representative sample of the crude talc, taken from the stock-pile on the property and analysed in the laboratory of the Bureau of Mines, yielded:

Silica	58·44
Ferrous oxide	3·95
Ferric oxide	1·20
Alumina	1·09
Lime	Nil
Magnesia	29·30
Carbon dioxide	0·17
Water above 105°C.	5·25
Total	99·40

Range IX, Lot 1 (Lot 28). A band of soapstone 40 feet wide is recorded as occurring in a cutting of the Canadian Pacific Railway a short distance west of Orford Lake and between Orford Lake and Eastman stations.

Reference. Geol. Surv., Canada, Ann. Rept., vol. VII, 1894, p. 62J.

Range IX, Lot 17 (Lot 12). A deposit of impure, grey, magnesitic talc, containing disseminated pyrite grains, is stated by Wilson to occur on the east side of the road following the shore-line of Nick Lake, and 3½ miles

[1] Geol. Surv., Canada, Sum. Rept., 1911, p. 292.
[2] This location may really be range VI, lot 4; *see* introductory remarks on page 92.

by road from Bolton Centre. The material forms a band about 20 feet wide, bordering serpentine, and is exposed for a length of 200 feet. The band has suffered considerable crushing, and is seamed by numerous small veinlets of talc, with, in one place, an irregular vein up to 3 feet wide of quartz and carbonate.

References. Geology of Canada, 1863, pp. 797-8.
Geol. Surv., Canada, Ann. Rept., vol. IV, 1888-89, p. 152K.
Wilson, M. E.: (15), pp. 104-105.

Township of Brome

Range XI, Lot 6, S½[1]. A little surface prospecting was done on this lot in 1939 by J. E. Ball, of Knowlton. One shallow trench has exposed an apparent width of about 25 feet of grey, fissile talc, similar to that on range I, lot 23, of Bolton Township. The property is owned by A. E. Kimball of Knowlton, and lies 2½ miles from Knowlton Station.

Township of Potton

Range II, Lots 5 and 6[2]. A deposit of talc occurs on these lots, which were taken up in 1935 by the Baker Mining and Milling Company, of Montreal. This company has carried out considerable surface stripping and trenching which has exposed several bodies of talc, or what may, perhaps, be different portions of a single, large contorted deposit. In 1938, the company proceeded with the erection of a mill on the property, and in October, this had been completed and was ready to run (*see* Plate VII B). At the same time, work was proceeding on an adit close to the mill-building, to tap the lower talc outcrops, and from which development of the deposit is planned to proceed.

The deposits lie on the north side, and near the base, of a high ridge forming the south side of the Missisquoi River valley, a few hundred feet from the tracks of the Montreal-Newport, Vt., branch of the Canadian Pacific Railway, and 1½ miles west of Highwater station. The occurrence is well situated for development by means of adits, drifts, and stoping, with loading direct from mill to cars.

Stripping and trenching over an area of about 500 by 1,000 feet have exposed what are thought to be two approximately parallel bands of talc, striking diagonally up the hillside. The bands pinch and swell irregularly, with no definite strike, and the supposed two bands may really be a single band folded back on itself. The country rock is a highly crushed and deformed, soft, green, and fine-grained talc-chlorite schist which possibly represents a highly altered ultrabasic intrusive. The structure is difficult to determine owing to the heavy overburden over most of the area. Widths of talc up to 40 feet are said to have been found in some of the trenches, and in the most westerly opening a bed 25 feet thick is exposed. The apparent dip of the main body exposed in the easterly pit is about 70 degrees.

[1] Cadastral lot 1343.
[2] Cadastral lots 111 and 112.

The talc is of fine-textured, foliated type, exhibiting a rather variable range of colour, from greenish grey to nearly white. The colour of the ground product is similarly variable: it possesses fair slip. The deposit, while consisting in the main of fairly clean talc, contains zones rich in large acicular crystals of actinolite, and in the west pit a 12-inch band containing large crystals of dolomite occupies the middle of the band. Traces of brittle asbestos occur locally on seams and joints.

A shipment of 15 tons of talc, taken from the various surface workings on the property was made to the laboratories of the Bureau of Mines in 1936 for grinding tests. The shipment comprised a number of different samples consisting of rather varied material, as shown by analyses 1 to 4 below, which are of four different lots. Analysis 5 was made on a composite sample of the ground products from three lots selected as yielding the cleanest and whitest material:

—	1	2	3	4	5
Silica	58·48	35·04	57·76	39·56	51·52
Ferrous oxide	4·49	4·49	4·26	4·58	4·37
Ferric oxide	0·07	0·57	0·61	0·96	0·38
Alumina	2·01	0·93	2·40	1·61	1·96
Lime	Nil	20·00	Nil	1·50	1·12
Magnesia	29·11	31·91	29·37	32·67	29·63
Carbon dioxide	Nil	3·63	Nil	14·65	5·77
Water above 105° C.	5·40	3·05	5·50	4·16	5·32
Total	99·56	99·62	99·90	99·69	100·07

The mill flow-sheet provides for the tramming of ore to two crude storage bins of 50 tons capacity each. From these, it proceeds by link-belt conveyer, which can also be used as a picking-belt, to a jaw crusher breaking to 3 inches. It is then reduced in a Jeffrey hammer-mill to ½-inch, followed by screening on a Traylor vibrating screen having two decks of 60 mesh and 65 mesh. The plus 60 mesh is returned to the hammer-mill; the minus 60 plus 65 mesh forms a roofing-granule product; and the minus 65 mesh serves as the feed for a Williams roller-mill combined with air separator and dust collector. The coarse product of the separator may constitute a grade for the rubber and roofing trades or may be returned to the Williams mill, while the fines and dust form the highest grade shipping product. Planned capacity is 5 tons per hour of finished talc. Power is supplied by a 200 h.p., M.A.N. Diesel engine. A Redler chain elevator is used for the roller-mill feed, and a novel feature of the latter is an "electric eye" device. This is connected to a small air vent-pipe leading from the top of the separator: should the air-ports at the base of the mill become choked through excess feed, a vacuum is created in the air-chamber and vent-pipe, thus raising the level of the liquid in a U-tube connection, which interrupts a light-beam and actuates a feeder cut-out. (Compare the " electric ear " used in a Vermont mill, page 46.)[1]

[1] NOTE.—When the property was visited in November, 1939, a tunnel had been carried 180 feet into the hill, with a side-drift 70 feet long run to the south at 150 feet from the portal. The drift showed a width of 25 feet of talc, dipping 45 degrees east, with the west face still in ore. About 150 tons of talc had been milled, and some shipments made to the roofing trade. Mill performance was stated to deliver ½ ton of minus 325 product per hour, 1 ton of 95 per cent minus 325 mesh, and 3 tons of mixed fine and coarse (roofing grade).

Range IV, Lots 17 and 18; Range V, Lots 18 and 19. Some diamond drilling of talc occurrences on these lots is reported to have been done in 1920 by the Talc Development Company of Canada, a subsidiary of the Eastern Talc Company, of Boston, which was formerly engaged in talc mining in Vermont. A considerable body of talc is stated to have been proven, but no development has ever taken place. The locality lies just west of the Missisquoi River road from South Bolton to Mansonville, and 6 miles from Highwater station on the Montreal-Newport branch of the Canadian Pacific Railway.

Wilson states that the deposit on lot 19 of range V, where most of the drilling was done, consists of a narrow band of grey schistose talc, about 4 feet wide, following the west contact of a mass of serpentine which on its east margin has been altered to rusty soapstone.

Talc was recorded from this area many years ago, two analyses of material from Potton Township, and probably from this or the following occurrence on lot 28 of range V, having been recorded in the Geology of Canada, 1863, p. 470, as follows:

—	1	2
Silica	59·50	51·60
Ferric oxide	4·50	7·38
Alumina	0·40	3·50
Magnesia	29·15	22·36
Lime	Nil	11·25
Volatile (water)	4·40	3·60
Total	97·95	99·69

Reference. Wilson, M.E.: (15), pp. 98–99.

Range V, Lot 28. A deposit of talc and soapstone, having a combined width of about 8 feet, and following the easterly margin of a band of serpentine, occurs on a hillside about 1½ miles west of South Bolton village. Wilson describes the occurrence as consisting of 4 feet of grey talc schist in contact with 4 feet of broken talcose serpentine. The talc is of off-colour grade, and the soapstone is regarded as too highly fractured to be suitable for sawing purposes. Only two small surface pits have been made on the deposit.

Reference. Wilson, M.E.: (15), p. 100.

Township of Sutton

Range V, Lot 10. Wilson records an occurrence of grey talc schist banded with talcose serpentine and pale grey magnesitic talc in the bed of a brook one-quarter mile east of the road leading south from Sutton village. The entire talcose zone is estimated to be about 20 feet wide, with magnesitic talc forming the greater part of the material. Small, disseminated grains of chromite and millerite (nickel sulphide) occur in this last. No work has been done on the deposit, which lies 3 miles from Sutton station on the Farnham-Newport branch of the Canadian Pacific Railway.

In the same township, soapstone is reported to occur in the bed of a creek on lot 11 of range VIII, close to Sutton village; and on lot 12, range VII, impure talc containing magnesite, pyrite, and chromite is recorded (Geology of Canada, 1863, p. 797).

Reference. Wilson, M. E.: (15), pp. 97-98.

Richmond County

Township of Melbourne

Range IV, Lot 23. About 200 tons of soapstone were reported to have been mined on this lot in 1918 and 1920 by the Canada Paper Company, of Windsor Mills, Que., the material being used for furnace-lining in its kraft pulp plant. The occurrence lies about 1 mile from Kingsbury station, on the Eastray-Windsor Mills branch of the Canadian Pacific Railway, not far from the large quarry of the New Rockland Slate Company.

The stone is grey-white in colour, highly talcose, and of massive texture, but is much squeezed and traversed by slip planes. It is rather friable, and would not cut blocks of any size. It occurs as a narrow band, about 12 inches wide, in a highly altered igneous rock, and has been worked by stripping along the face of a low bluff along which the deposit runs. An analysis of a sample of the material, made in the laboratory of the Bureau of Mines, showed:

Silica	61·12
Ferrous oxide	3·16
Ferric oxide	0·20
Alumina	0·54
Lime	Nil
Magnesia	30·48
Carbon dioxide	Nil
Water above 105°C.	4·58
Total	100·08

Reference. Spence, H. S.: (7), p. 44.

Wolfe County

Township of Wolfestown

Range II, Lot 20. According to a report[1] of the Geological Survey, about 3,000 tons of soapstone were mined on this lot by the Wolfestown Mining Company prior to 1897. In an earlier report[2], it is stated to have been worked in 1888 and 1889, with a production of about 300 tons. In 1912, J. Martel, of Belmina, took out a small tonnage, since when no further work has been done. All of the material was used for grinding, being consumed mainly in the paint and lubricant trades, grinding being done in Montreal. The last lot mined was ground in a local grist mill, and sold for foundry use at Thetford Mines.

The deposit lies close to the bank of White River, near its crossing by the Coleraine-Wolfestown road, and 6 miles from Coleraine station on the Quebec Central Railway. The old workings have long since caved in, and no examination of the deposits is possible. Ells[2] states that the band of soapstone lies near the contact of crystalline schist and black Cambrian slate and has a width of from 1 to 10 feet. Wilson[3] gives the thickness as 25 feet, of which the lower 6 feet is grey talc schist and the remainder chlorite schist. The material is of off-colour grade and grinds to a brownish grey powder having fair slip An analysis, made in the laboratory of the Bureau of Mines, showed:

Silica	58·48
Ferrous oxide	3·64
Ferric oxide	1·04
Alumina	2·33
Lime	Nil
Magnesia	29·50
Carbon dioxide	Nil
Water above 105° C.	4·97
Total	99·96

References. [1] Geol. Surv., Canada, Ann. Rept., vol. X, 1897, p. 225S.
[2] Geol. Surv., Canada, Ann. Rept., vol. IV, 1888-89, p. 152K.
Spence, H. S.: (7), p. 44.
[3] Wilson, M. E.: (15), p. 106.

Other Recorded Occurrences in Quebec

In view of the great development of altered ultrabasic rocks in the Eastern Townships, occurrences of talc and soapstone, which commonly occur along the margins of such rocks, are widespread in the region. The following localities are recorded in early reports of the Geological Survey, but have never been worked, and they are not known to possess any economic importance:

Brome County, Township of Brome, range VIII, lot 2; range IX.
Sherbrooke County, Township of Hatley, range V, lots 19, 20, and 21.
Stanstead County, Township of Stanstead, range IX, lot 13.
Wolfe County, Township of Ham, range I, lots 22 and 25.
Gaspé County, Ste. Anne River, near Mt. Albert.

NEW BRUNSWICK

An early report of the Geological Survey (Rept. Prog., 1870-71, p. 238) records the occurrence of talc or soapstone near the Narrows of the St. John River, and near Musquash village, in St. John County. The deposits would appear to be small and not to possess any economic value; they have never been worked.

NOVA SCOTIA

A few occurrences of talc in Nova Scotia are recorded in early reports of the Geological Survey, most of them in Cape Breton Island, but they all appear to be of very limited extent and of doubtful economic importance. They are found mostly as narrow beds along sheared zones in slates, gneiss, dolomite, or quartzite. Wilson, (15) p. 114, lists five such occurrences, with the report references in each case.

Inverness County

A small deposit of massive, cream-coloured talc of steatite character occurs close to Fraser's mill, on the north side of Brigend Brook, near Whycocomagh. It was worked in a small way about thirty years ago by R. P. Fraser, of Pictou, to which point a few tons are reported to have been shipped for grinding. Only a few small surface pits were opened, these disclosing several narrow bands of talc up to 12 inches in width, separated by quartzite, in a dolomite formation. What talc there is seems to be of fair quality, low in iron, and yields a good white powder having high slip. A sample of selected material picked from the mine dumps, and analysed in the laboratory of the Bureau of Mines, yielded:

Silica	58·88
Ferrous oxide	0·46
Ferric oxide	0·04
Alumina	0·81
Lime	1·80
Magnesia	31·74
Carbon dioxide	1·32
Water above 105° C	5·00
Total	100·05

Reference. Spence, H. S.: (7), p. 23.

Cape Breton County

There are a number of old records relating to the occurrence of talc or pyrophyllite at several places along the southeast coast of Cape Breton Island, including Eagle Head, Kennington Cove, and Landing Cove, all in the vicinity of Gabarus Bay, near Louisburg. It is probable that in all these instances the supposed talc or pyrophyllite is really sericite, and the occurrences are only mentioned here to correct a false impression.

In a provincial report[1], there is a detailed report on talc occurrences at Landing Cove, which describes the deposits as extending for about 1,800 feet with a width of 12 to 20 feet, upon which two shafts, respectively 25 feet and 60 feet, were opened about forty years ago, with short drifts run from their bottoms. The material taken out was shipped to the United States for grinding. The concluding section of the report, however, states that the mineral present is not talc, but a silicate of alumina, though three quoted analyses, the average of which is as given below under (1), are those of a talc. A. O. Hayes describes[2] the occurrence as consisting of a band of sericite schist, associated with stratified volcanic rocks. A sample of material from the same locality was kindly furnished to the writer by J. P. Messervey, of the Provincial Mines Department, in 1938. This was found to consist partly of massive and partly of more foliated or shaly, pale cream-coloured rock. Outwardly, it resembles steatitic talc or massive pyrophyllite, but is considerably harder than either of these minerals. The sample was divided into three parts, representing, respectively, (2),

[1] "Talc and Soapstone in Nova Scotia", Monograph Pamphlet No. 27, Nova Scotia Dept. Public Works and Mines, 1926, pp. 13–17.
[2] Geol. Surv., Canada, Sum. Rept. 1918, pp. 18–20F.

selected shaly material; (3), a mixture of shaly and massive material; and (4), a composite of (2) and (3). These fractions were analysed in the laboratory of the Bureau of Mines and yielded the results shown below. In addition, specimens of these materials were submitted to the Mineralogical Section of the Geological Survey for examination, and were reported by E. Poitevin to consist of sericite schist. These determinations, therefore, definitely establish that the Louisburg occurrence consists mainly of silicate of alumina, and is of a sericite nature.

—	1	2	3	4
Silica	54·75	78·82	80·16	78·36
Ferrous oxide	1·40 (ferrous and ferric oxide together)	0·07	0·21	0·07
Ferric oxide		Nil	0·15	0·29
Alumina	5·83	16·62	14·44	16·04
Lime	Trace	Nil	Nil	0·09
Magnesia	32·14	0·48	0·31	0·43
Soda	.....	0·28	0·76	0·48
Potash	.....	1·08	1·97	1·79
Carbon dioxide	.....	0·04	0·06	0·04
Water above 105° C	6·19	2·69	2·33	2·60
Total	100·31	100·08	100·39	100·19

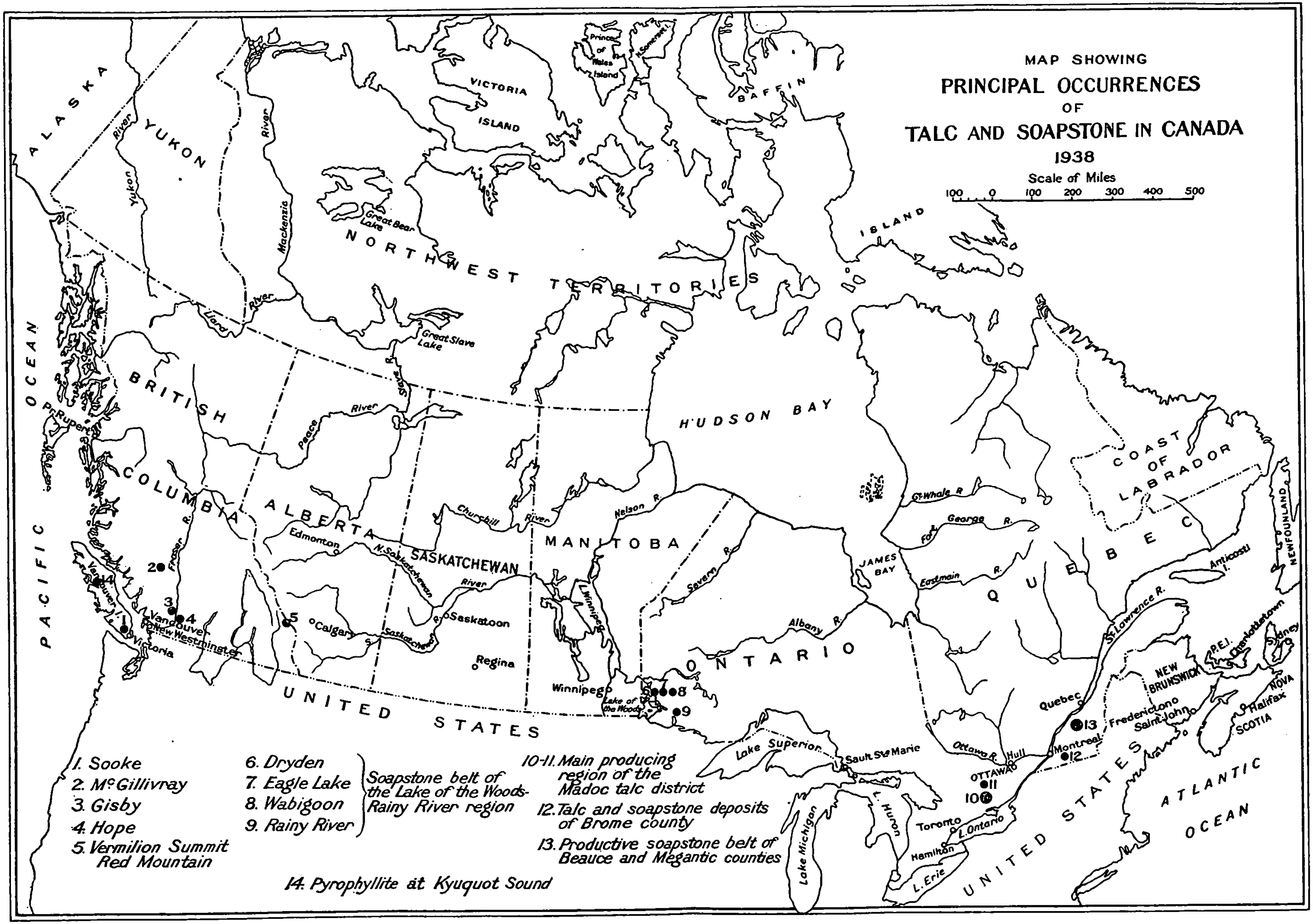

MAP SHOWING
PRINCIPAL OCCURRENCES
OF
TALC AND SOAPSTONE IN CANADA
1938
Scale of Miles
100 0 100 200 300 400 500
1. Sooke
2. McGillivray
3. Gisby
4. Hope
5. Vermilion Summit
Red Mountain
6. Dryden
7. Eagle Lake
8. Wabigoon
9. Rainy River
Soapstone belt of the Lake of the Woods-Rainy River region
10-11. Main producing region of the Madoc talc district
12. Talc and soapstone deposits of Brome county
13. Productive soapstone belt of Beauce and Megantic counties
14. Pyrophyllite at Kyuquot Sound
ALASKA
YUKON
NORTHWEST TERRITORIES
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
COAST OF LABRADOR
NEW BRUNSWICK
NOVA SCOTIA
P.E.I.
NEWFOUNDLAND
VICTORIA ISLAND
BAFFIN ISLAND
Prince of Wales Island
HUDSON BAY
JAMES BAY
PACIFIC OCEAN
ATLANTIC OCEAN
UNITED STATES
Great Bear Lake
Great Slave Lake
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
Lake of the Woods
Lake Superior
Sault Ste Marie
Lake Michigan
L. Huron
Toronto
Hamilton
L. Ontario
L. Erie
OTTAWA
Hull
Montreal
Quebec
Fredericton
Saint John
Halifax
Charlottetown
Sydney
Anticosti I.
Vancouver
New Westminster
Victoria
Pr. Rupert

Figure 2.

CHAPTER V

MINING AND PREPARATION FOR MARKET

TALC

Mining

Talc is mined, variously, from open quarry excavations and by underground methods, largely dependent on the terrain in which the deposits are situated. When the ground is moderately level, and the deposit steeply inclined, initial operations often start from an open pit, followed by sinking of a vertical or inclined shaft, from which levels are run and stopes opened.

Talc bodies, in general, owing to their origin, which commonly is due either to ascending hydrothermal solutions or to intense dynamic disturbance of the rocks in which they occur, and often to both, usually have rather steep dips, though in mountainous regions they may be found squeezed or tilted into irregular lenses of almost any attitude. Such lenses sometimes pinch and swell in erratic fashion, often with pronounced change of dip and strike, which may complicate mining, but as a rule development is a relatively simple and cheap operation.

Commercial talc bodies may consist, variously, of one or several relatively narrow, closely spaced beds or bands, only a few feet thick, mining of which can proceed from cross-cuts run from a shaft, with stoping of the individual bands on a series of levels; or, as in the case of the Luzenac deposits, in France, they may be immense lenses, with widths up to as much as 200 feet.

Steeply inclined deposits in mountainous regions are often mined from adits run in along the ore-body, from which raises are put up and a series of levels opened, the talc being won by overhead stoping and shot down to the adit level, which serves as a main haulage-way.

Owing to the soft, slippery nature of talc, and particularly where deposits have suffered squeezing and deformation, talc bodies are often intensely slickensided, with the development of weak slip-faces; these, especially in wet ground, are liable to cause caving of older workings unless close attention is paid to spacing and size of pillars and to timbering. For the same reason, shafts should be put down in solid rock adjacent to a deposit, rather than in the ore-body itself, and permanent mine structure should be located with due regard to possible caving of surface over or adjacent to worked-out sections.

It is customary, especially in deposits associated with altered intrusives, such as serpentines, pyroxenites, etc., to find irregular horses or lenses of the host-rock within the talc mass, and these may have to be removed as waste to avoid danger from spalling or slipping. Where such horses are of large size, they can usually be left standing and the talc worked out around them with little danger. There is usually a sharp line of demarcation between talc bodies and their enclosing rocks, and the walls generally stand well: hence relatively little contamination of ore by waste arises in mining.

Dynamite is commonly used for blasting. When the talc is to be used for cutting into crayons, or for lava purposes, a minimum of explosive is employed, to avoid shattering, and as large blocks as possible are broken out with bars. In smaller operations, a considerable proportion of the talc raised may often be won by straight pick and shovel methods.

Preparation for Market

Ground talc is supplied to the consuming industries in a variety of grades, dependent on colour, purity, physical character, and fineness. Some industries, as, for example, cosmetics, demand a talc of high purity, grit-free, pure white in colour, and ground to 300-mesh or finer. Such talcs command a high price, $50 to $80 per ton. At the other extreme are the impure, off-colour talcs, used in the roofing trade, where fineness is not required: these sell at around $5 to $8 per ton, and often are the coarser products resulting from air-separating devices used in mill circuits and containing a considerable amount of gritty impurities. Practically all ground talc is produced by dry-grinding.

Drying

In the case of wet mines, or in winter, it may be necessary to dry the coarsely broken talc before grinding. Lower grade, off-colour talcs are dried in coal- or coke-fired, shell dryers, but for white talcs, steam-heated dryers are preferred. Sometimes, broken ore is allowed to remain in mine stopes until drained of surplus water. In summer, sufficient dryness is often attained by air-drying of the crude block talc in storage sheds, after screening out the mine-fines over a grizzly, only the latter being artificially dried. Considerable heat is generated in the fine-grinding operation, and usually suffices to drive off any moisture remaining in the ore.

In Italy[1], where fuel is dear, labour cheap, and sunshine abundant, the practice has been to use sun-heat for drying in the summer months. The crude, lump talc is first broken to 1 inch, and is then dumped to open-front storage sheds surrounding a large open, concrete-paved yard, which serves as the drying floor. The talc is spread by hand each morning, raked over during the day, and moved back into the sheds at night. Quarry fines are separately dried in a similar fashion, and only in winter is artificial drying resorted to.

Milling

Coarse crushing is performed by jaw crushers or gyratory crushers, often followed by further reduction in rolls, rotary, or disk-type crushers. Fine-grinding of the higher grade talcs, in which colour and uniformly fine powder are prime requisites, is usually done in silex-lined tube-mills, some-

[1] Spence, H. S.: "Talc in Italy", Can. Min. Journ., Oct. 8, 1926, pp. 971-2.

times preceded by Hardinge mills, or in Raymond high-side roller mills, in closed circuit with air separators of Raymond, Gayco, or Sturtevant type. Large-capacity mills, as in New York State (*see* page 43), may employ one or more units of several tube mills in series, the individual mills being of large size—up to 26 by 8 feet. Williams roller mills and Sturtevant ring-roll mills are also sometimes employed for fine grinding. For lower grade talcs, where fineness and colour are not so essential, mills of the high-speed, disintegrator, or hammer-mill type, are sometimes used, in conjunction with air separators. Formerly, buhrstones were extensively employed for grinding, but these are now seldom used. Sizing of the ground product is almost universally performed by air separators, in closed circuit with the grinding units, this method having superseded the former system of bolting through silk bolting trommels. The finest cosmetic grades, however, are still prepared by bolting. Screens are seldom used in the milling of talc, except for scalping in the crusher circuit, and for sizing of coarser grades. More modern mills usually have dust collectors connected to crusher equipment, elevators, etc., both to reduce dust nuisance and health hazard and to recover an ultra-fine talc product. Talc mill workers have been claimed to be extremely liable to silicosis risks, though there is nothing definite on this score, and some local authorities enforce dust prevention as a precautionary measure[1].

A recent development in talc-milling practice, in order to obtain an exceedingly fine powder, is the use of so-called "micronizing" machines, which reduce by the agency of dry steam. The steam is introduced under high pressure through nozzles around the periphery of a steel chamber, into which the feed drops through a central opening, and where the particles are subjected to an intense mutual bombardment. Particle size attained by this method is measured in microns. Devices of similar type, but using a single jet of compressed air, impingeing on a baffle plate, have recently come on the market. Such ultra-fine talc is little in demand, but may find special uses, as, for instance, in plastics. Micronizing equipment is not used to any extent in talc mills on the American continent, though two mills, one each in Vermont and New York States, employ it to a limited degree for special-product grades (*see* pages 43 and 46). Micronizing of talc, as well as of a number of other industrial minerals, is practised by one of the larger Norwegian producers: standard particle sizes of from 5 to 20 microns are attained, and the products are stated to command an active market with the paint and paper trades[2].

Particle size of commercial talcs ranges from the relatively coarse, 40- to 125-mesh grades, sold mainly to the roofing trade, to the finer sizes demanded by the paint, paper, and cosmetic trades, which may run as fine as 99 per cent through 325 mesh. Many trades are satisfied with a minus 200-mesh product.

According to Gillson, (10) p. 881, there is a current trend toward the preparation of ground talc by wet-grinding methods, using pebble mills in

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[1]Cunningham, J. G.: "Chemical Health Hazards in Industry", Chemistry and Industry, vol. 53, 1934, pp. 707-10.
Dreeson, W. C. and Dalla Valle, J. M.: "The Effects of Exposure to Dust in Two Georgia Talc Mills and Mines", U.S. Public Health Reports, vol. 50, No. 5, Feb. 1, 1935, pp. 131-43.
[2]Trade Literature ("Micro-Minerals") of A/S Norwegian Talc, Bergen.

closed circuit with wet classifiers and hydroseparators. Such a system offers the advantage, in the case of lower grade ores, of being operable in conjunction with wet concentrating flotation equipment, to obtain a cleaner product (*see* below), as well as to reduce dust losses and hazards. Wet

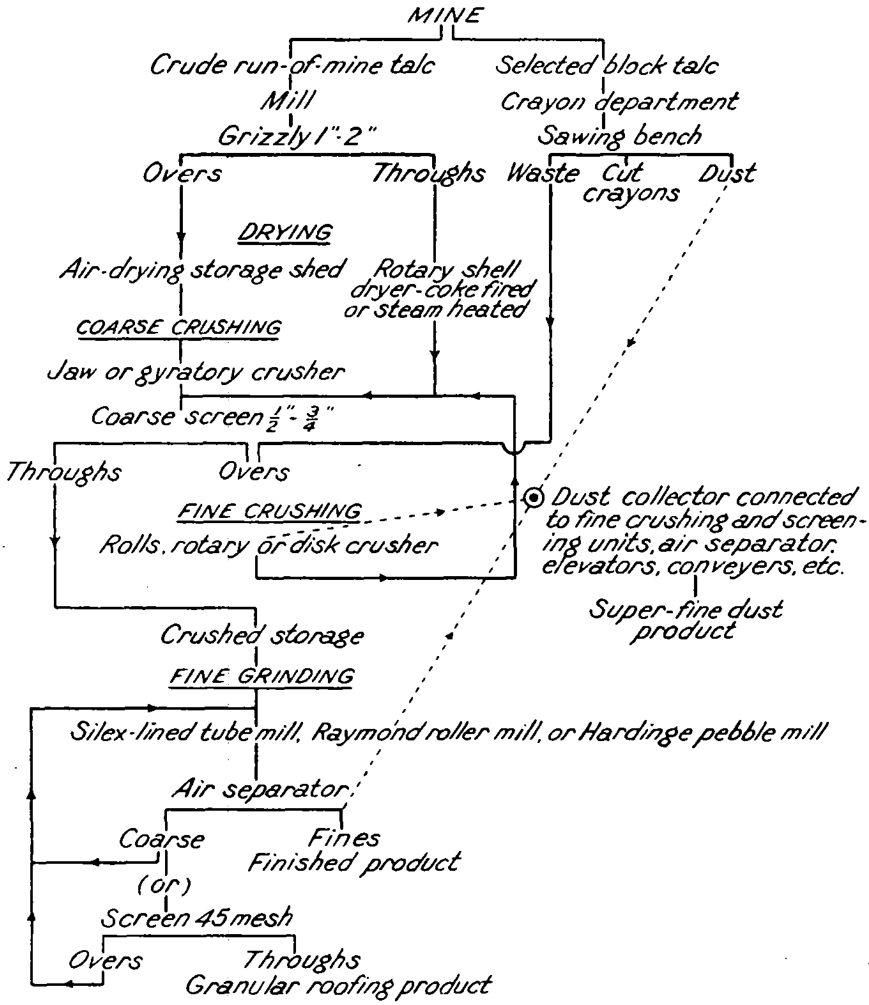

Figure 3. Simplified outline of talc-milling procedure, showing alternative types of equipment in general use.

grinding is stated to have been introduced recently in a North Carolina talc plant, but does not appear to have been adopted as yet elsewhere. Drying of the finished product would probably add materially to production costs by this method.

Figure 3 shows, in simple form, the main outline of a modern talc mill, indicating the various types of equipment in general use. So much variation exists in type of ore and products made that each plant or region usually lays out its mill to suit its own particular needs, with the result that many modifications of the circuit shown exist. Elevators, conveyers, and incidental equipment have been omitted for the sake of clarity. Publications (6) and (7) listed in the Bibliography at the end of this report give detailed flow-sheets of a number of talc mills on the American continent, and both the text and footnote references in Chapter III, dealing with the World Talc Industry by countries, give additional information. Many of the cited articles in American trade publications, e.g. "Pit and Quarry," "Rock Products" etc., as well as the report by Ladoo (6), contain illustrations of talc-milling operations, and these may be consulted to advantage.

Beneficiation

Most talc is milled as mine-run material without any attempt at selection into grades, and until very recently no efforts to beneficiate natural grade by ore-dressing methods have been made, so that any impurities present in the ore passed into the mill products. In some mills a certain proportion of such impurities, in the form of coarse, harder particles, is removed from the finer talc in the air separators, and instead of being returned to the circuit is marketed as a low-grade roofing product, the grade of the fine talc being proportionately improved.

Some years ago, flotation tests on a sample of crude dolomitic talc from the Madoc district, Ontario, were made in the Ore Dressing Laboratories of the Bureau of Mines, at Ottawa, and it was demonstrated that the lime (CaO) content could be reduced from 5·7 per cent in the sample to 0·32 per cent in the concentrate[1]. Air separation of a portion of the same sample, ground in a Raymond pulverizer and separated by Gayco separator, also resulted in removal of carbonate, the lime content being reduced to 3·03 per cent. Wet concentration by Wilfley table gave a talc tailing with 2·5 per cent CaO in the finer sizes. It was reported, however, that the flotation product, although substantially lime-free, proved deficient in slip, as compared with the cosmetic grades of commercial talcs.

Flotation methods of cleaning talc have also been investigated by the United States Bureau of Mines, in co-operation with two leading producers in Vermont and New York State[2]. The Vermont ore came from a deposit operated by the Eastern Magnesia Talc Company, at Johnson, Vt., (*see* page 46), and contained as principal impurities magnesite, pyrite, pyrrhotite, and a nickel arsenosulphide (gersdorffite). It was found that a good grade of talc flotation concentrate (94·82 per cent talc), with

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[1] Carnochan, R. K. and Rogers, R. A.: Investigations in Ore Dressing and Metallurgy, 1932, Mines Branch, Dept. of Mines, Canada, Rept. No. 736, 1934, pp. 231-34.

[2] Clemmer, J. B. and Cooke, S. R.: "Flotation of Vermont Talc-Magnesite Ores", U.S. Bur. of Mines, Reports of Investigations, No. 3314, Oct., 1936.

Ralston, O.: Ann. Rept. Non-Metals Div., 1937. U.S. Bur. of Mines, Inf. Circ. No. 6974, Oct., 1937, p. 8. "Flotation and Agglomerate Concentration of Non-Metallic Minerals", U.S. Bur. of Mines, Reports of Investigations, No. 3397, May, 1938, pp. 21-22.

Norman, J. E., O'Meara, R. G., Baumert, F. X.: "Froth Flotation of Talc Ores from Gouverneur, New York", Bull. Amer. Ceram. Soc., vol. 18, No. 8, August, 1939, pp. 292-97.

greatly improved slip and colour, could be made, as well as a commercial magnesite tailing (80·21 per cent $MgCO_3$). A sulphide middling was also made, from which, by tabling, a concentrate with 27·84 per cent nickel and 1·63 per cent cobalt was recoverable. As a result of this work, a pilot flotation unit was installed in 1937 at the above company's mill, and this was being increased to five times the original capacity in 1938.

The New York talc tested was from the W. H. Loomis Talc Corporation, Gouverneur, N.Y. (*see* pages 43 and 44), and contained fibrous tremolite as the chief impurity. The objective of the test was to recover purer foliated talc for special markets, as well as to discover means of controlling the talc-tremolite ratio during milling: both objectives were reached. It was found that, for best results, some method of cleaning the grit particles of their adherent talcose coating should be employed, so that they can be more readily depressed in the flotation operation. No commercial application based on this work has yet been made.

Some work on methods of separating the talc and magnesite contents of a soapstone has been done in England[1], and the same separation is being made in commercial practice on a talc-magnesite ore from the Anglo-Egyptian Sudan[2] (*see* page 37).

STEATITE

Steatite, being essentially only a textural modification of ordinary talc, and occurring in deposits of similar character, its mining is carried out similarly to that of talc. As the material, when desired for lava purposes, requires to be won in block form, suitable for sawing, care has to be taken in mining to avoid shattering of the crude steatite as far as possible, only sound, unflawed pieces being usable (*see* page 9). A minimum of explosive is used, in order to merely loosen the ore, which is then barred down as far as possible in large pieces. The manufacture of lava shapes from steatite is briefly described on page 10.

SOAPSTONE

Mining

Mining of soapstone on the American continent is almost universally by open quarry methods. A single pit, or a series of pits, is opened on a band of soapstone, which usually has a vertical or steep dip, and the stone is channelled out in successive tiers or benches. The general procedure is described[3] in the section dealing with the Virginia soapstone deposits (*see* page 48), and need not be repeated here. The Virginia operations sometimes are carried down to a considerable depth by such methods, some of the excavations reaching 200 feet (*see* Plate VIII, A and B).

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[1] British Patent No. 425,362, March 12, 1935 (General Electric Company and A. B. Jackson, Concentrating Soapstone).

[2] Ceramic Age, "Talc Flotation", Aug. 28, 1936, p. 41; U.S. Bur. of Mines, Mineral Trade Notes, vol. 1, No. 3, Sept. 20, 1935, p. 31.

[3] Hughes, H.: "Soapstone", U.S. Bur. of Mines, Inf. Circ. No. 6563, Feb., 1932.

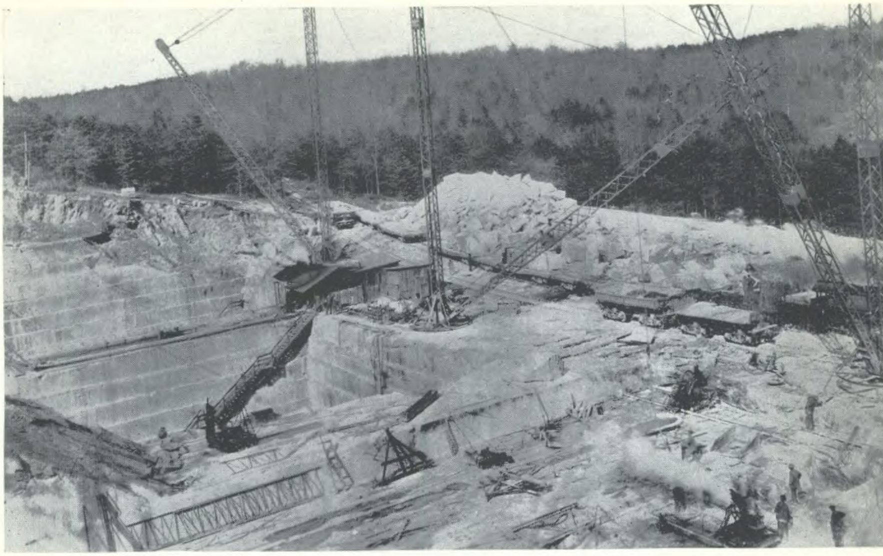

Photo: Alberene Stone Corporation

A. General view of soapstone quarrying operations of the Alberene Stone Corporation of Virginia, at Schuyler, Va. This company is the world's largest producer of soapstone and soapstone products. The photograph shows the series of individual pits opened along a wide belt of stone, and the large derricks used for hoisting. The stock-pile behind illustrates the size of the individual blocks raised.

Photo: Alberene Stone Corporation

B. View of bottom of one of the quarries of the Alberene Stone Corporation of Virginia, at Schuyler, Va., showing method of cutting out the stone in successive tiers of blocks by means of channelling and undercutting machines. The cuts are run at right angles to the strike of the soapstone body. *See* text, page 48.

In the Quebec soapstone belt, similar open pit methods are followed, but light plugger, or paving-breaker, type drills are used in place of channelling machines. The drills employ non-rotating steel, sharpened to a chisel-edge of special design, with which grooves are cut along and across rough benches, and the stone is then broken out by bars into blocks of roughly 30 by 36 by 36 inches size. The blocks are hoisted by derrick onto small flat-cars, which run on tracks to the sawing sheds and on which the blocks are cut into slabs. (*See* Plates V and VI.)

At a now-idle soapstone quarry operation at Eagle Lake, in western Ontario, stone was formerly taken out by a channelling machine, as in the Virginia practice. (*See* Plate III.)

From the literature, it would appear that in some European countries soapstone (in part block talc) is won underground, the larger and more solid masses broken out in mining operations for grinding ore being used for sawing into furnace stone. A soapstone operation in Washington (*see* page 50) is probably unique in that the stone is mined underground by means of coal-cutter equipment. An adit is run in on the deposit, which is about 100 feet wide, and a succession of individual rooms or chambers is opened by the cutters, from which monolithic blocks or bars of stone measuring 8 feet by 40 inches by 18 inches are cut out by a circular saw fitted with carborundum teeth and mounted on a carriage.

Preparation for Market

Soapstone is marketed chiefly in the form of dimension stone, as slabs, blocks, and bricks, which are cut to size out of the crude quarry stone by saws of various types. In larger operations, as in Virginia (*see* page 48), the quarry blocks are first sliced to the required width by gang saws, followed by cutting to size with circular saws, either toothed or faced with carborundum, depending on the character and hardness of the stone. Smaller operations, as in Quebec, employ coarse-toothed, 40-inch, steel rip-saws for the longitudinal cuts, followed by a series of 18-inch to 40-inch diameter, steel-toothed circular saws for cutting to size. In Washington, all sawing is done by carborundum-toothed circular saws.

Care has to be taken in sawing to ensure that the long dimension of the finished article is parallel to the natural grain of the stone, in order to give maximum strength. This is of added importance in the case of furnace stone, so as to ensure that the bricks are set end-grain to the furnace walls; this reduces spalling and attack, with resultant wall-disintegration and short life.

Furnace bricks require no finishing except, perhaps, smoothing with a steel plane, but strict adherence to size and taper specifications is essential. For use as panels, decorative trim, laboratory equipment, etc., varying degrees of finishing are demanded, including shaping, grooving, drilling and polishing. This procedure will be found outlined in the section on the Virginia deposits.

A considerable amount of the softer grades of soapstone waste is ground for the production of low-grade powder for various industrial uses, a large proportion going to the roofing and rubber trades, and the sawing dust collected by exhaust fans is similarly utilized.

CHAPTER VI

ANALYSES OF TALCS, STEATITES, AND SOAPSTONES

Below are assembled analyses of a number of talcs, steatites, and soapstones, both Canadian and foreign. The Canadian materials analysed include, in addition to actual commercial products, samples from a number of undeveloped prospects, as well as from certain old, long-inactive properties.

Except where otherwise indicated, all of the analyses were made in the laboratories of the Bureau of Mines, on material either collected by the writer or furnished by operators or others.

Where a map number follows a Canadian locality reference, this relates to the deposit or district number shown on Figure 2, index map of Canadian talc and soapstone occurrences, page 102. Similarly, a page number following a reference indicates the page of this report where the source of the sample is mentioned or described.

CANADIAN

—	1a	1b	2a	2b	3
Silica	33·68	34·38	57·62	58·06	59·88
Ferrous oxide	4·97	4·59	5·31	4·91	4·54
Ferric oxide	.....	0·45	0·80	0·11	.....
Alumina	1·65	0·83	2·46	2·25	1·18
Lime	15·32	8·68	0·10	Trace	0·10
Magnesia	22·68	26·94	28·53	28·82	29·51
Carbon dioxide	18·23	19·30	.....	0·09	0·02
Water above 105° C	3·20	3·10	4·75	5·46	4·73
Total	99·73	98·27	99·57	99·70	99·96

1a. } Talc, Wolfe Creek, Sooke, Victoria Mining Division, Vancouver Island, B.C. Figure 2,
1b. } No. 1; page 53. Sample 1a analysed 1920. Sample 1b analysed 1938.
2a. } Talc, McGillivray, Lillooet Mining Division, B.C. Figure 2, No. 2; page 55. Sample 2a
2b. } analysed 1920. Sample 2b analysed 1938.
3. Talc, Gisby claims, Keefers, Yale Mining Division, B.C. Figure 2, No. 3; page 56.

CANADIAN—*Continued*

—	4	5a	5b	5c	6a
Silica	32·50	61·52	64·06	62·91	52·30
Ferrous oxide	.....	0·66	.....	1·68	.....
Ferric oxide	6·50	0·24	.....	.....	0·56
Alumina	3·10	.....	2·10	.....	7·26
Lime	.....	0·10	.....	.....	.....
Magnesia	33·53	32·63	30·13	31·12	31·86
Carbon dioxide } Water above 105° C. }	22·20	0·07	.....	.....	.....
Water above 105° C.		4·39	1·41	1·53	7·69
Total	97·83	99·61	97·70	97·24	99·67

4. Soapstone, Jessica, near Hope, Yale Mining Division, B.C. Figure 2, No. 4; page 57. Analysis by Provincial Department of Mines, Victoria, B.C.

5a. 5b. 5c. Steatite, Silver Moon claims, Mount Whymper, Windermere Mining Division, B.C. Figure 2, No. 5; page 57. Analysis 5b and 5c by Alberta Mines Department.

6a. Black steatite-talc, Red Mountain and Gold Dollar claims, Windermere Mining Division, B.C. Figure 2, No. 5; page 59. Analysis showed also 0·16 per cent carbon and 0·10 per cent sulphur.

—	6b	6c	6d	6e	6f
Silica	51·84	58·70	58·50	55·50	57·00
Ferrous oxide	.....	.....	.....	.....	.....
Ferric oxide	1·28	0·40	.....	0·10	.....
Alumina	7·52	1·26	3·00	3·80	16·00
Lime	.....	1·20	.....	.....	0·50
Magnesia	31·55	31·53	31·50	23·50	18·30
Carbon dioxide	.....	1·38	.....	.....	.....
Water above 105° C.	7·66	5·11	1·60(*)	4·40(*)	2·00(*)
Total	99·85	99·58	94·60	87·30	93·80

6b. Black steatite-talc, Red Mountain and Gold Dollar claims, Windermere Mining Division, B.C. Figure 2, No. 5; page 59. Analysis showed also 0·15 per cent carbon and 0·06 per cent sulphur.

6c. Black steatite-talc. Same source as above. Analysis showed also 0·40 per cent carbon and 0·05 per cent sulphur.

6d. Grab sample as above. Analysis by Provincial Department of Mines, Victoria, B.C.

6e. White steatite, as above. Analysis by Provincial Department of Mines, Victoria, B.C.

6f. Sample from tunnel on Red Mountain claim. Analysis by Provincial Department of Mines, Victoria, B.C.

NOTE.—Nos. 6d, 6e, and 6f only partial analyses. (*) Reported as ignition loss.

CANADIAN—*Continued*

—	7	8a	8b	9	10
Silica	39·14	41·94	51·44	43·20	54·62
Ferrous oxide	8·79	7·71	7·24	7·95	1·41
Ferric oxide	3·48	2·05	3·68	3·51	0·88
Alumina	7·32	7·57	4·79	6·74	0·09
Lime	5·92	3·42	.....	1·30	4·90
Magnesia	21·31	25·39	26·43	27·64	28·56
Carbon dioxide	7·31	5·09	0·11	1·95	4·59
Water above 105° C	6·68	6·71	6·56	7·80	5·01
Total	99·95	99·88	100·25	100·09	100·06

7. Soapstone (chloritic slate), Pipestone Portage, Kenora, Lake of the Woods, Ont. Figure 2, No. 6; page 63.

8a. Soapstone, north band, Wabigoon Lake, Lake of the Woods, Ont. Figure 2, No. 8; page 64.

8b. Soapstone, contact zone, Wabigoon Lake, Lake of the Woods, Ont. Figure 2, No. 8; page 64.

9. Soapstone, Eagle Lake, Lake of the Woods, Ont. Figure 2, No. 7; page 66.

10. Rensselaerite or pyrallolite talc (altered pyroxenite), Grindstone Island, Rideau Lake, Leeds County, Ont. Page 80.

—	11	12	13a	13b	13c
Silica	52·50	50·64	51·00	49·48	49·28
Ferrous oxide	0·28	0·79	0·32	0·24	0·19
Ferric oxide	0·10	0·55	0·13	0·13	0·14
Alumina	0·17	1·06	0·62	0·82	0·41
Lime	9·26	4·84	6·98	7·02	7·06
Magnesia	26·04	30·49	28·76	29·11	29·21
Carbon dioxide	6·85	5·21	7·72	9·02	9·26
Water above 105° C	5·13	6·26	4·70	4·13	4·55
Total	100·33	99·84	100·23	99·95	100·10

11. Dolomitic talc, Caldwell prospect, Lavant Township, concession II, lot 24 E½, Lanark County, Ont. Page 78.

12. Rensselaerite or pyrallolite talc (altered pyroxenite), Pittsburgh Township, concession III, lot 35, Frontenac County, Ont. Page 77.

13a. Talc, No. 1 grade mill product, Geo. H. Gillespie Company, Madoc, Ont. Figure 2, No. 10; page 69.

13b. Talc, No. 2 grade mill product, Geo. H. Gillespie Company, Madoc, Ont. Figure 2, No. 10; page 69.

13c. Talc, No. 3 grade mill product, Geo. H. Gillespie Company, Madoc, Ont. Figure 2, No. 10; page 69.

CANADIAN—*Continued*

—	13d	14a	14b	14c	15a
Silica	53·92	56·32	51·75	52·62	30·80
Ferrous oxide	0·36	0·20	.....	.....	0·28
Ferric oxide	.....	.....	.....	0·22	.....
Alumina	0·32	0·06	1·75	1·66	0·65
Lime	5·02	2·36	5·70	5·42	16·68
Magnesia	29·63	31·72	26·58	29·48	24·57
Carbon dioxide	5·51	3·99	5·90	6·89	24·37
Water above 105° C	5·05	5·18	7·90	3·41	2·67
Total	99·81	99·83	99·58	99·70	100·02

13d. Crude talc, Henderson mine, Huntingdon Township, concession XIV, lot 14, Hastings County, Ont.: mill-feed for Gillespie Company products. (*See also* 13a, 13b, 13c.)

14a. Crude talc, Conley mine, Huntingdon Township, concession XIV, lot 15, Hastings County, Ont. Figure 2, No. 10; page 71.

14b.}
14c.} Mill-run talc, from same source as No. 14a. Analysis of No. 14c by Canada Talc Company.

15a. Crude dolomitic talc, Eldorado Mining and Milling Company's mine, Madoc Township, concession V, lot 20, Hastings County, Ont. Figure 2, No. 10; page 72.

—	15b	16	17	18a	18b
Silica	51·86	60·45	40·08	59·10	60·92
Ferrous oxide	0·39	.....	3·70	0·35	0·39
Ferric oxide	0·60	2·82	1·87	0·17	0·23
Alumina	1·54	0·27	1·75	0·52	0·38
Lime	10·04	0·16	4·85	2·10	0·68
Magnesia	18·19	29·84	29·81	30·50	30·62
Carbon dioxide	13·49	.....	13·45	1·26	0·72
Water above 105° C	3·33	5·42	4·12	5·78	5·78
Total	99·44	98·96	99·63	99·78	99·72

15b. Grey talc schist, Eldorado Mining and Milling Company's mine, Madoc Township, concession V, lot 20, Hastings County, Ont.

16. Large flake, green talc, Grimsthorpe Township, concession V, lot 9, Hastings County, Ont. Page 75. Analysis by Geological Survey, Canada.

17. Schistose greenish talc, Madoc Talc and Mining Company's mine, Cashel Township, concession XII, lot 16, Hastings County, Ont. Figure 2, No. 11; page 75.

18a.}
18b.} Rensselaerite or pyrallolite talc (altered pyroxenite), Pakenham Township, concession VI, lot 6, Lanark County, Ont. Page 79. 18a, milled product, Gayco fines. 18b, milled product, Gayco oversize.

CANADIAN—*Continued*

—	18c	19a	19b	20a	20b
Silica	57·27	58·70	35·60	32·16	31·10
Ferrous oxide	0·51	5·40	5·77	5·25	5·18
Ferric oxide	0·72	.....	0·74	0·63	0·74
Alumina	0·74	1·16	1·41	0·94	2·32
Lime	3·20	.....	0·76	Trace	Nil
Magnesia	29·34	29·36	33·14	34·74	34·49
Carbon dioxide	7·94	0·23	16·88	22·20	22·80
Water above 105° C	0·28	5·48	3·63	2·75	3·29
Total	100·00	100·33	97·93	98·67	99·92

18c. Rensselaerite or pyrallolite talc (altered pyroxenite), Pakenham Township, concession VI, lot 6, Lanark County, Ont. Analysis by National Research Council, Ottawa. (*See also* 18a and 18b.)

19a.}
19b.} Soapstone, Broughton Soapstone and Quarry Company's mine, Broughton Township, range XI, lot 12, Beauce County, Que. Figure 2, No. 13; page 84.

20a.}
20b.} Soapstone, Broughton Soapstone and Quarry Company's old mine, Leeds Township, range XV, lot 15, Megantic County, Que. Figure 2, No. 13; page 87.

—	21	22a	22b	23a	23b
Silica	58·84	59·22	58·42	59·66	56·80
Ferrous oxide	4·82	3·72	4·42	4·12	5·65
Ferric oxide	0·20	0·13	0·05	0·37	.....
Alumina	1·33	2·56	2·44	1·67	0·66
Lime	0·26	1·62	0·90	.....	0·06
Magnesia	28·48	28·04	28·28	29·96	29·36
Carbon dioxide	0·50	0·06	0·02	.....	1·40
Water above 105° C	4·83	5·01	4·99	4·90	6·20
Total	99·26	100·36	99·52	99·98	100·13

21. Soapstone, L. C. Pharo mine, Thetford Township, range III, lots 12 and 13, Megantic County, Que. Figure 2, No. 13; page 87.

22a. Soapstone (sawing dust), Charles Fortin quarry, Thetford Township, range V, lot 2 E½, Megantic County, Que. Figure 2, No. 13; page 89.

22b. Soapstone (crude stone), from same source as above.

23a.}
23b.} Soapstone (thinly laminated grey talc), old Robertsonville Soapstone Quarry Company's mine, Thetford Township, range V, lot 5, Megantic County, Que. Figure 2, No. 13; page 89.

CANADIAN—*Continued*

—	24	25	26	27	28
Silica	54·88	59·62	60·86	59·78	58·44
Ferrous oxide	4·63	4·25	1·11	3·96	3·95
Ferric oxide	1·44	1·21	0·24	0·44	1·20
Alumina	3·59	1·40	0·22	1·82	1·09
Lime	1·10	.....	0·08	0·02	Nil
Magnesia	27·22	28·49	32·19	29·23	29·30
Carbon dioxide	1·52	Trace	0·09	0·02	0·17
Water above 105° C	5·86	4·61	4·50	4·79	5·25
Total	100·24	99·58	99·29	100·06	99·40

24. Soapstone, Thetford Township, range V, lot 7, Megantic County, Que. Figure 2, No. 13; page 91.
25. Soapstone, Thetford Township, range V, lot 9, Megantic County, Que. Figure 2, No. 13; page 91.
26. Large flake, green talc, Ireland Township, Craig's Road range, lot 2, Megantic County, Que. Figure 2, No. 13; page 92.
27. Grey, schistose talc, Bolton Township, range II, lot 26 (3), Brome County, Que. Figure 2, No. 12; page 93.
28. Compact grey-white talc, Bolton Township, range VII, lot 24(5), Brome County, Que. Figure 2, No. 12; page 95.

—	29a	29b	29c	29d	29e
Silica	58·48	35·04	57·76	39·56	51·52
Ferrous oxide	4·49	4·49	4·26	4·58	4·37
Ferric oxide	0·07	0·57	0·61	0·96	0·38
Alumina	2·01	0·93	2·40	1·61	1·96
Lime	.....	20·00	.....	1·50	1·12
Magnesia	29·11	31·91	29·37	32·67	29·63
Carbon dioxide	.....	3·63	.....	14·65	5·77
Water above 105° C	5·40	3·05	5·50	4·16	5·32
Total	99·56	99·62	99·90	99·69	100·07

29a., 29b., 29c., 29d., 29e. } Fine-textured, grey-white talc, property of Baker Mining and Milling Company, Potton Township, range II, lots 5 and 6, Brome County, Que. Figure 2, No. 12; page 96. (29e was a composite of four samples of best colour.)

CANADIAN—*Concluded*

—	30	31	32	33a	33b
Silica	61·12	58·48	58·88	78·82	78·36
Ferrous oxide	3·16	3·64	0·46	0·07	0·07
Ferric oxide	0·20	1·04	0·04	Nil	0·29
Alumina	0·54	2·33	0·81	16·62	16·04
Lime	.....	.....	1·80	Nil	Nil
Magnesia	30·48	29·50	31·74	0·48	0·43
Carbon dioxide	.....	.....	1·32	0·04	0·09
Water above 105° C	4·58	4·97	5·00	2·69	2·60
Total	100·08	99·96	100·05	97·72	97·88

30. Grey-white, fine-textured talc (soapstone), Melbourne Township, range IV, lot 23, Richmond County, Que. Page 99.

31. Grey-brown talc schist, Wolfestown Township, range II, lot 20, Wolfe County, Que. Page 99.

32. Cream-coloured steatitic talc, Fraser's mill, Whycocomagh, Inverness County, Cape Breton, N.S. Page 101.

33a. Sericite (recorded as "talc"), selected schistose type, Landing Cove, Louisburg, Cape Breton, N.S. Page 101. Contained also 0·28 per cent soda and 1·08 per cent potash.

33b. Same as 33a. Composite of massive and schistose types. Contained also 0·48 per cent soda, 1·79 per cent potash

FOREIGN

—	34a	34b	34c	34d	35
Silica	55·66	57·50	56·86	60·52	43·80
Ferrous oxide	.....	.....	0·06	0·14	5·58
Ferric oxide	0·17	0·17	0·08	0·08	0·34
Alumina	0·30	0·27	0·67	0·82	1·64
Lime	7·19	5·24	4·12	4·12	0·24
Magnesia	30·24	30·20	31·12	28·05	31·35
Carbon dioxide	0·71	0·38	0·88	1·44	12·50
Water above 105° C	5·20	5·13	4·67	3·06	4·86
Total	99·47	98·89	98·46	99·23	100·31

34a. 'Tremoline' talc, W. H. Loomis Talc Corporation, Gouverneur, N.Y. Analysis furnished by company. Page 43.

34b. Fibrous talc, W. H. Loomis Talc Corporation, Gouverneur, N.Y.

34c. Fibrous talc, W. H. Loomis Talc Corporation, Gouverneur, N.Y. Analysis by U.S. Bureau of Mines.

34d. Fibrous talc, International Pulp Company, Gouverneur, N.Y. Page 43.

35. Grey talc, Eastern Talc Company, Rochester, Vt.

FOREIGN—*Continued*

—	36	37	38	39	40a
Silica	56·33	42·73	59·15	54·14	59·30
Ferrous oxide	5·39	4·93	3·36	3·59	4·42
Ferric oxide				1·33	0·64
Alumina	3·19	1·17	0·26	1·66	1·81
Lime	0·41	0·10	0·15	0·46	0·20
Magnesia	27·89	33·16	31·34	30·16	29·42
Carbon dioxide	0·36	4·74	1·76	2·90	0·18
Water above 105° C	5·68	12·95	4·30	5·25	4·67
Total	99·25	99·78	100·32	99·49	100·34

36. Grey talc. Eastern Magnesia Talc Company, Waterbury, Vt. Company's analysis. Page 46.

37. Grey talc, standard mine-run product, Eastern Magnesia Talc Company, Johnson, Vt. Company's analysis. Page 46.

38. Talc, do do mill-product cleaned by flotation (*see* page 46). Company's analysis.

39. Crude, mill-run talc, Vermont Talc Company, Chester, Vt. Page 47.

40a. Crude, mill-run talc, Vermont Mineral Products Company, Chester, Vt. Page 47.

—	40b	40c	41	42	43
Silica	45·95	58·96	60·80	58·50	61·90
Ferrous oxide	4·70	3·78	.....	.....	.....
Ferric oxide			0·82	.....	0·85
Alumina	1·70	3·43	1·62	1·10	0·45
Lime	1·59	1·43	1·20	8·00	.....
Magnesia	32·39	28·54	31·08	27·90	31·30
Carbon dioxide	.....	.....	4·36	4·50	5·30
Water above 105° C	12·19	2·15			
Total	98·52	98·29	99·88	100·00	99·70

40b. Fine mill-product, Vermont Mineral Products Company, Chester, Vt. Analysis by the company. Page 47. (*See also* 40a.)

40c. Flake mill-product, roofing grade, from same source as above.

41. Mill product, Sierra Talc Company, Inyo County, California. Company's analysis. Page 41.

42. }California talc (locality not stated). Analyses quoted by Geller and Creamer, Journ.
43. } Amer. Ceram. Soc., vol. 18, No. 9, Sept. 1935, p. 259.

FOREIGN—*Continued*

—	44	45	46	47	48
Silica	63·07	61·35	41·75	44·10	62·44
Ferrous oxide	0·67	1·68	14·04	.....	.....
Ferric oxide	.....	.....		6·96	1·24
Alumina	1·56	4·42	4·80	0·50	.....
Lime	0·30	0·82	4·19	2·00	Trace
Magnesia	28·76	26·03	25·56	30·60	31·99
Carbon dioxide	.....	.....	10·22	15·10	.....
Water above 105° C	4·36	5·10			5·07
Total	98·72	99·40	100·56	99·26	100·74

44. Talc from Kinsey mine, N. Carolina. Analysis from Economic Paper No. 3, Geol. Surv., N. Carolina, p. 14. Page 44.

45. Talc from Hewitt mine, N. Carolina. Analysis from Economic Paper No. 3, Geol. Surv., N. Carolina, p. 14. Page 44.

46. Soapstone (Alberene Stone), Alberene Stone Corporation, Va. Company's analysis. Page 47.

47. Soapstone, Skagit Talc, Inc., Wash. Analysis from Wilson and Pask, Amer. Inst. Min. Met. Eng., Contribution No. 99, 1936, p. 4. Page 50.

48. Crude talc, Colonia, Uruguay. Analysis from Stutzer (1), p. 358. Page 51.

—	49	50	51	52	53
Silica	58·93	61·83	61·54	61·83	56·78
Ferrous oxide	3·29	0·15	.....	0·85	1·20
Ferric oxide	0·29	0·22	0·76	.....	.....
Alumina	3·59	0·26	1·74	2·97	9·17
Lime	0·72	0·18	1·81	1·04	1·47
Magnesia	29·27	31·50	30·09	30·56	28·33
Carbon dioxide	0·50	0·06	3·65	.....	.....
Water above 105° C	3·08	4·71		3·62	4·60
Total	99·67	98·91	99·59	100·89	101·55

49. Grey talc (soapstone), mill products, Miass, U.S.S.R. (Russia). Average of four analyses from Z. f. p. G., vol. 37, April, 1929, p. 61. Page 51.

50. Talc from Cerisor, Rumania. Analysis from Stutzer (1), p. 338. Page 36.

51. Talc, best white, Mautern, Austria. Average of five analyses from H. Rosenberg, Talkum-Brevier, 1914. Page 29.

52. Talc, best white, Mautern, Austria. Average of three analyses from Stutzer (1), p. 330. Page 29.

53. Talc, grey, do do

—	54	55	56	57	58
Silica	53·45	63·09	65·10	62·35	61·24
Ferrous oxide	1·36	.....	1·66	.....	.....
Ferric oxide		0·94		0·05	0·02
Alumina	7·42	.....	5·50	0·17	1·42
Lime	0·33	.....	.....	.....	.....
Magnesia	30·94	31·55	27·32	32·10	32·42
Carbon dioxide	6·43	.....	.....	.....	.....
Water above 105° C		4·38	.....	4·37	4·90
Total	99·93	99·73	99·58	99·04	100·00

54. Talc, mill-products, Rabenwald, Austria. Naintsch Company's figures: average of eight analyses. Page 29.
55. Lava-grade steatite, Göpfersgrün, Germany. Average of two analyses from Stutzer (1), p. 327. Page 32.
56. Lava-grade steatite, fired body, Göpfersgrün, Germany. Analysis from L. E. Thiess, Journ. Amer. Ceram. Soc., vol. 20, No. 9, Sept., 1937, p. 311. Page 32.
57. Lava-grade steatite, China. Analysis furnished by American Lava Corporation, Chattanooga, Tenn. Page 30.
58. Lava-grade steatite, India. Analysis furnished by American Lava Corporation, Chattanooga, Tenn. Page 33.

—	59	60	61	62a	62b
Silica	61·40	47·60	38·40	40·90	38·68
Ferrous oxide	.....	2·75	5·21	5·22	4·86
Ferric oxide	0·45	8·50	0·91	0·79	0·47
Alumina	0·56	1·35	1·74	5·15	2·87
Lima	0·14	3·70	1·22	8·84	9·80
Magnesia	32·50	26·40	31·98	22·41	24·14
Carbon dioxide	4·98	9·50	16·26	12·82	14·58
Water above 105° C			3·58	4·27	4·77
Total	100·03	99·80	99·30	100·40	100·17

59. Lava-grade steatite, Manchuria. Analysis furnished by American Lava Corporation, Chattanooga, Tenn. Page 30.
60. Soapstone, Handoel, Sweden. Analysis from Handoel Soapstone Company. Page 37.
61. Grey talc, mill-products, composite of six mesh sizes, Norwegian Talc Company, Bergen, Norway. Page 35.
62a. White talc, best (P1) grade, Luzenac, France. Page 31.
62b. White talc, second (P2) grade, Luzenac, France. Page 31.

FOREIGN—*Concluded*

<table>
<tr><th>—</th><th>63a</th><th>63b</th><th>63c</th><th>64a</th><th>64b</th><th>65</th></tr>
<tr><td>Silica</td><td>59·70</td><td>61·30</td><td>62·64</td><td>57·59</td><td>60·34</td><td>63·50</td></tr>
<tr><td>Ferrous oxide</td><td>.....</td><td>.....</td><td>0·23</td><td>0·66</td><td>0·85</td><td>.....</td></tr>
<tr><td>Ferric oxide</td><td>0·50</td><td>.....</td><td>0·02</td><td>.....</td><td>0·23</td><td>.....</td></tr>
<tr><td>Alumina</td><td>1·10</td><td>0·70</td><td>0·35</td><td>3·64</td><td>1·77</td><td>.....</td></tr>
<tr><td>Lime</td><td>0·30</td><td>.....</td><td>Nil</td><td>.....</td><td>0·64</td><td>.....</td></tr>
<tr><td>Magnesia</td><td>34·01</td><td>32·30</td><td>32·16</td><td>31·04</td><td>31·14</td><td>31·70</td></tr>
<tr><td>Carbon dioxide</td><td rowspan="2">4·30</td><td rowspan="2">5·80</td><td>0·19</td><td rowspan="2">5·96</td><td>0·78</td><td>.....</td></tr>
<tr><td>Water above 105° C</td><td>4·72</td><td>5·20</td><td>4·80</td></tr>
<tr><td>Total</td><td>99·91</td><td>100·10</td><td>100·31</td><td>98·89</td><td>100·95</td><td>100·00</td></tr>
</table>

63a. White talc, Manchuria. Analysis from E. H. Lintz, Journ. Amer. Ceram. Soc., vol. 21 No. 6, 1938, p. 229. Page 30.

63b. White talc, Manchuria. Analysis from Geller and Creamer, Journ. Amer. Ceram. Soc., vol. 18, No. 9, 1935, p. 259. Page 30.

63c. Crude white talc, Manchuria, as imported by B.C. Refractories, Vancouver.

64a. White talc, mill-products, Val Chisone, Italy. Average of two analyses from E. Ridoni, "Il Talco", 1918, p. 47. Page 33.

64b. Superfine Italian talc, cosmetic grade, as imported by Schofield Donald, Ltd., Montreal.

65. Theoretical analysis of pure talc.

PART II

PYROPHYLLITE

INTRODUCTORY

The mineral pyrophyllite bears a close outward resemblance to talc in its softness, colour, feel, lustre, and structure. It is commonly of a cream-white shade, has a foliated or fibrous texture, with, less commonly, an approach to massive, cryptocrystalline form (like steatite). On account of the above similarity, it is often difficult to distinguish pyrophyllite from talc without resorting to chemical analysis.

Chemically, pyrophyllite is a hydrous silicate of aluminium, with the theoretical formula H_2Al_2 $(SiO_3)_4$, corresponding to 66·7 per cent silica, 28·3 per cent alumina, and 5·0 per cent water. It may thus be regarded as the alumina analogue of talc, with alumina in place of magnesia.

Pyrophyllite occurs in much the same way as talc, forming bedded deposits, usually in areas of profound metamorphism, and is thought to have originated, like talc, through hydrothermal alteration of original sedimentary or volcanic rocks. Whereas the source rock in the case of talc was of an ultrabasic type (pyroxenite, peridotite, serpentine), or dolomite, in the case of pyrophyllite it was of acidic character (andesite, rhyolite, or clastic derivatives of such rocks, such as tuffs, slates, or schists). The term "pinite" is sometimes applied to such altered, pyrophyllite-rich rocks (*see* page 138). Sericite is commonly an important accessory mineral in pyrophyllite deposits.

Pyrophyllite is a much rarer mineral than talc, and comparatively few occurrences are known. However, due to the close resemblance of the two minerals, pyrophyllite sometimes has been mined and sold as talc, as for example in North Carolina, and doubtless also at other less well-known localities; it is recorded[1] that an occurrence at Tschistaya-Gora, in the southern Urals, Russia, was so worked.

The massive, compact form of the mineral, termed agalmatolite, or pagodite, and similar to steatite in character, is stated[2] to occur in China and Korea, and to be worked at Kasato, in Chinto-gun, and at Ogmesan and Ibam, in Kainan-gun, in the latter country, for the production of carved ornaments. Doubtful occurrences of agalmatolite are also reported at Sailik, in Turkestan, and in Burma, the material of which, however, may actually be jade. Much of the so-called steatite used in China and the Orient generally for similar purposes may be pyrophyllite. Recorded, but not commercial, occurrences of pyrophyllite are known at Nagyag and Schemnitz, in Hungary; near Bockau, in Saxony; and in Sutherlandshire, Scotland. Dana[3] records occurrences, also probably of mineralogical interest only, in Vermland and Christianstad, Sweden; near Ottré, Luxemburg; at Spa and Malmédy, Belgium; at Valais, Switzerland; in the Ural Mountains, Russia; and at Ouro Preto, Brazil; similar

[1] Gillson, J. L.: (10), p. 875.
[2] Dammer und Tietze: (2), p. 413.
[3] Dana, E. S.: Textbook of Mineralogy, 4th Ed., 1932, p. 683.

occurrences in the United States are given as at Graves Mountain, in Lincoln County, Georgia; at the Kellog lead mine, near Little Rock, Arkansas; in the Chesterfield district, South Carolina; in Mariposa County, California; and, as thin seams, in some of the coal measures of Pennsylvania. Pyrophyllite is also reported[1] to occur in important amount in Tasmania, but there has been no development of the deposits.

The following occurrence in South Africa may also be mentioned. Near Ottosdal, in the Lichtenburg district, western Transvaal, pyrophyllite occurs as the chief constituent (90 per cent) of a rock thought to be a metamorphosed tuff, or clay (possibly bentonite) derived from volcanic ash[2]. The remaining constituents are chloritoid (9 per cent) and rutile (1 per cent). The average of the analyses of six samples from this occurrence showed as follows:

Silica	55·83
Alumina	33·75
Ferric oxide	1·08
Titanium oxide	2·53
Lime	0·15
Magnesia	0·25
Loss on ignition	6·78
	100·37

The material, which is of a bluish grey colour and exceedingly dense and fine-grained, is found in the form of a sedimentary, bedded deposit dipping at about 35 degrees and having a proven thickness of 200 to 300 feet. Enormous quantities are said to be available, with an easily accessible tonnage of 5 million tons in one exposure alone. The rock is locally termed "Wonderstone" and has been quarried in recent years on a small scale by Messrs. Wonderstone Industries, Ltd., as well as by other smaller operators. Most of the production has been used in the form of cut stone for building and ornamental purposes, but it is stated that the stone has properties that fit it for electrical insulation and other uses. The powdered stone is non-plastic and is only moderately refractory (fusion point, cone 28 or 1,630° C.), so that it possesses little or no ceramic value.

Occurrences of pyrophyllite are known in Canada, at Kyuquot Sound, Vancouver Island, B.C., and in Beauce and Stanstead Counties, Que., as described on pages 131 to 137.

In Newfoundland (page 129) important deposits exist in the Conception Bay area, Avalon Peninsula, in the southeastern part of the island, where some development took place about thirty-five years ago, with shipments totalling several thousand tons. Further shipments have recently been made.

As far as known, however, the sole world source of pyrophyllite on an important scale is in the United States, where, in the Deep River region of Moore, Chatham, and Randolph Counties, North Carolina, there is an important and growing production[3].

[1] Information from F. Palmer, Canadian Government Trade Commissioner, Melbourne, August, 1938.

[2] Nel, L. T., Jacobs. H., and Bozzoli, G. R.:" Wonderstone", Geol. Series, Bull. No. 8, Dept. Mines, South Africa, 1937: a 44-page report describing the occurrence and physical properties of the stone.

[3] It is reported in 1939 that development is currently under way upon an occurrence of pyrophyllite near Victorville, San Bernardino County, California, and that a few hundred tons have been shipped to Los Angeles for grinding. (Information from Kennedy Minerals Company, Los Angeles, September, 1939.)

The close similarity between pyrophyllite and talc in their general physical characteristics enables them to substitute for each other for many industrial uses, and ground pyrophyllite may satisfactorily replace talc for many purposes, such as in textile bleaching, paper, paints, rubber, roofing, etc. The growing interest in the mineral, however, is largely due to its possibilities in the ceramic industry, where, due to recent extensive research, it is finding rapidly increasing use.

OCCURRENCES IN NORTH CAROLINA

General

Important amounts of pyrophyllite (reported as talc) have been produced in North Carolina for a number of years past, the output finding similar uses to talc. Most of the earlier production came from the Glendon district, in Moore County, where, in 1928, there was one small plant in operation. In the last decade there has been a growing interest in the mineral, and at the end of 1937 six plants were reported[1] to be grinding pyrophyllite for market. Most of this recent development is due to growing outlets for the mineral in the ceramic industry, which now takes a large part of the production. Since, for statistical purposes, pyrophyllite is lumped with talc, it is not possible to state the tonnage produced, but it is estimated that the 1937 ouput fell not far short of 20,000 tons. Most of the production comes from the operations of the following three companies: Standard Mineral Company, Hemp, Moore County; Pyrophyllite Talc Products Company, Glendon, Moore County; Carolina Pyrophyllite Company, Staley, Randolph County; and in addition, the Pomona Terra Cotta Company produces for its own use in refractory kiln brick near Snow Camp, in Alamance County[2]. The North Carolina Natural Products Corporation, with plant at Glendon, was also reported[3] to be producing pyrophyllite in 1937.

Evidence of the confusion sometimes existing in the correct designation of pyrophyllite and talc, respectively, is seen in the name of one of the above-mentioned companies, which combines both minerals, although its product is pyrophyllite (*see* footnote, page 45), and the point is further illustrated by the fact that this company took over the mine and plant of the United Talc and Crayon Company, which, in turn, succeeded a former concern, the Talc Products Company.

North Carolina pyrophyllite found early use for monumental purposes, as well as for cut fire-bricks, hearth-stones, etc., and the first recorded production dates from 1850, the material being considered talc or soapstone. The first report that definitely classes it as pyrophyllite is that of Pratt[4], who describes the various deposits and mining operations prior to 1900, and who mentions that the first correct determination of the material was made by G. J. Brush, in 1862. More recent reports dealing

[1] Milliken, W. A.: Ceramic Age, vol. 31, January, 1938, pp. 18–19.

[2] Personal communication from J. L. Stuckey, August, 1938.

U.S. Minerals Yearbook, 1938, p. 1189.

[4] Pratt, J. H.: "Talc and Pyrophyllite Deposits of North Carolina", North Carolina Geol. Surv., Economic Paper No. 3, 1900, pp. 24-29.

with the geology of the occurrence have been written by J. L. Stuckey[1], who includes numerous text references to earlier publications on the subject. The details given below are taken mainly from Stuckey's report of 1928.

Location, Nature, and Origin of the Deposits

The productive pyrophyllite deposits occur mainly in the Deep River region, in the central and south central parts, respectively, of adjoining Moore and Chatham Counties, about 60 miles southwest of Raleigh, and within a belt about 8 miles wide and 30 miles long. Glendon and Hemp in Moore County are important centres of production. Other deposits occur in Randolph County, where development is now proceeding near Staley; near Troy, in Montgomery County; south of Graham in Alamance County; and in Granville and Orange Counties. All of these occurrences lie within a northeasterly-trending belt in the Piedmont Plateau region of the central part of the State. The region is one of medium relief, with elevations ranging from 300 to 500 feet above sea-level; it has a mature topography, with a number of easterly flowing rivers. Hills and ridges are well rounded, and the valley slopes gentle, with the result that rock outcrops are rare and prospecting difficult, owing to the deep weathering that has taken place and the generally heavy soil cover. The district is well served in respect to railroad transportation.

In general, the geologic occurrence of the pyrophyllite throughout the above region is similar. The host rocks consist of highly metamorphosed shales, altered to slates, alternating with similarly highly altered volcanic tuffs, flows, and breccias of predominantly acid type, mainly rhyolites and dacites. The entire series has suffered profound regional deformation, with the rocks highly folded and mashed. The tuffs vary from fine- to coarse-grained, the latter often grading into a breccia and having, variously, a massive or schistose texture. Flows and breccias of more basic andesitic type also occur, and diabase dykes are found in some local areas.

All of the pyrophyllite bodies lie in the acid volcanics, and chiefly in the coarse tuffs and breccias. They form irregular lenses, with widths up to 500 feet and lengths up to 2,000 feet, and usually with steep dips; they grade both laterally and longitudinally into the enclosing tuffs, but have considerable downward persistence, with no limit reached as far as development has gone. The intensive post-ore crushing and crumpling that the bodies have suffered is evidenced by the heavy slickensiding and variation in dip and strike of parting and cleavage planes.

The origin of the deposits is thought to be due to alteration of the enclosing volcanic tuffs and breccias through ascending hydrothermal solutions derived from some deep-seated intrusive, the presence of which, however, has not yet been established. The pyrophyllite has, thus, an origin similar to that of talc, being, however, derived from acid, aluminous rocks, whereas talc originates from basic, magnesian types. The placement

[1] Stuckey, J. L.: "The Pyrophyllite Deposits of the Deep River Region of North Carolina", Economic Geology, vol. 20, No. 5, August, 1925, pp. 442-63; "The Pyrophyllite Deposits of North Carolina", North Carolina Dept. Conservation and Development, Bull. No. 37, 1928.

of the bodies would appear to have been dictated by zones of weakness developed along the limbs of folds, as a result of shearing or drag-folding, accompanied by mashing of the less competent tuffs, whereas the slates suffered folding without disruption. The resultant mashed zones probably afforded the necessary entrance channels for the ascending hydrothermal solutions that caused pyrophyllitization of the tuffs.

The principal mineral impurities present in the pyrophyllite are quartz, sericite, chloritoid, chlorite, and feldspar. Quartz is the most abundant mineral, forming large cherty masses, or veins and stringers, within the ore-bodies or along the walls. The other minerals occur in disseminated form through the pyrophyllite, and commonly in the less highly altered portions of the deposits. Pyrite and iron oxide (magnetite or hematite) also are found in limited amount, chiefly along the walls and around lenses or horses of included silicified wall-rock. The iron oxides are thought to be derived mainly from alteration of the chloritoid, with which they usually occur. In addition, epidote, zircon, titanite, rutile, and apatite have been identified, but are of slight import and probably represent mainly residual accessory minerals in the original tuff. Pyrophyllite appears to have been the last mineral formed, and, with sericite, is held to have replaced quartz and chloritoid. The latter minerals are considered to have been the first minerals to form under the conditions of original silicification of the tuff.

Development and Production

In 1928, Stuckey (loc. cit.) recorded two major pyrophyllite operations in North Carolina, namely that of the Standard Mineral Company (subsidiary of the R. T. Vanderbilt Company), at Hemp, and that of the United Talc and Crayon Company, at Glendon, both in Moore County, with a third property being considered for development at Staley, in Randolph County. This latter has since been brought into production by the Carolina Pyrophyllite Company, while, as noted above, the Pyrophyllite Talc Products Company has recently taken over the holdings of the United Talc and Crayon Company. In addition, Stuckey notes a total of about seventeen other localities within the pyrophyllite-bearing belt where prospecting or mining operations for the mineral had been undertaken at various times, none of which, however, had come into production. The three concerns listed above comprise the present main operations and account for most of the production, though Milliken (loc. cit.) states that at the end of 1937 there were six mills producing ground pyrophyllite in the State.

The operations of the Pyrophyllite Talc Products Company, at Glendon, have recently been described[1]. The deposit being mined consists of a single lens-shaped body having a length of 1,500 feet, with widths up to 60 feet. Drilling is said to have proved a depth of at least 300 feet, with an estimated amount of 1½ million tons of commercial ore. Initial operations are by open-pit methods, following down on the hanging-wall side of the body, which has a dip of 35 to 45 degrees. Due to deep

[1] "Pyrophyllite Talc Mining Booms in North Carolina", Eng. Min. Jour., vol. 139, No. 1, Jan., 1938, pp. 36–37. Milliken, W. A.: "Pyrophyllite Development in North Carolina", Ceramic Age, vol. 31, Jan., 1938, pp. 18–19.

weathering, drilling is easy and little powder is required. In the purer pyrophyllite zones, holes are put down by hand auger. Owing to the presence of streaks and bands of quartzose material, as well as of bands containing too large an amount of iron-bearing chloritoid to be of commercial grade, considerable hand-sorting has to be done in the pit. Later, it is planned to install a picking-belt for this work. Considerable sericite is present in some zones, and, being difficult to distinguish from the pyrophyllite, entails extra care in sorting milling-grade ore. Grinding is done in a mill at Glendon, about one mile distant, to which the ore is trucked and delivered to four 300-ton crude storage bins. Two grades of mine-run ore are furnished, and milled separately. After air-drying, the ore is first coarsely crushed, elevated to crushed storage bins, and then fed to a Raymond 3-roller mill, in closed circuit with an air separator, delivering a finished product.

Operations of the Carolina Pyrophyllite Company (associated with the Tennessee Mineral Products Corporation) at Staley have recently been described by Burgess[1] and Trauffer[2]. The property of this company is located 4 miles west of Staley, in Randolph County, on a small hill known as Soapstone Mountain. The occurrence is exposed on the top of the hill over an area of about one-quarter acre, with little overburden. It was originally opened up by Gerhardt Bros., a number of years ago, for material to be used in the manufacture of an aluminium-silicon alloy. Mining was originally conducted from a tunnel driven near the base of the hill, which has a height of about 150 feet, with drifts run along the strike of the deposit. A raise was later put up to surface and opened out into a glory-hole. These operations have disclosed a width of ore-body of about 280 feet, and float indications point to a length of at least 1,500 feet. The dip of the deposit is about 70 degrees. Indicated ore reserves in the present workings total over 150,000 tons, while estimates of as high as one million tons have been suggested as probable.

As in most of the pyrophyllite deposits of the region, quartz and sericite are associated with the material of the Gerhardt mine, but they both tend to occur in well defined lenses or bands, rather than disseminated through the pyrophyllite, and thus can readily be removed by selective mining and sorting. Most of the pyrophyllite is of compact, massive (agalmatolite) type, though some radiated, fibrous material also occurs. Both types grind to a powder composed of platy particles and of pure white colour.

Ore is trucked to the company's new mill at Staley for grinding and placed in crude storage bins. It is first reduced in a jaw crusher and then goes to crushed storage, from which it is fed to a Hardinge mill in closed circuit with a Gayco air separator, the fines from which make the shipping product[3]. Six mesh sizes are produced, from 80 mesh to 325 mesh. Much of the output goes to the ceramic trade.

The Standard Mineral Company[3], at Hemp, operates two mills. At the older mill, ore is first reduced in a gyratory crusher and is then ground in a Raymond roller mill, the product of which goes to a Gayco separator.

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[1] Burgess, B. C.: "Pyrophyllite, a New Development—The Gerhardt Deposit", Bull. Amer. Ceram. Soc., vol. 15, Sept., 1936, pp. 299–302.
[2] Trauffer, W. E.: "Pyrophyllite Mining Undergoes Revival", Pit and Quarry, vol. 31, April, 1939, pp. 42–3.
[3] Milling data supplied by R. K. Carnochan, Industrial Minerals Division, Bureau of Mines, 1938.

The Gayco fines constitute the shipping product, and the coarse goes to a pebble mill in closed circuit with the Gayco separator. The output goes mainly to the rubber and cosmetic trades. At the new mill, the crushed ore passes first to a vibrating screen in closed circuit with the crusher, the throughs going to crushed storage, from which they are fed to an 8-foot Hardinge mill in closed circuit with a Gayco separator. The Gayco fines pass to a Dings magnetic machine which removes iron-bearing impurities, the product being used chiefly in the ceramic industry.

Composition of North Carolina Pyrophyllite

As already noted, much of the earlier production of pyrophyllite in North Carolina found similar industrial markets to talc, and was often sold as talc. For most of such uses, physical character, rather than chemical composition, was, and still is, the determining factor. With the growing use of pyrophyllite for ceramic products, however, chemical composition becomes of prime importance, with low-iron and high-alumina contents the chief considerations. Sericite (also a hydrous silicate of alumina, with alkalis) and quartz are the impurities found in greatest amount in the North Carolina pyrophyllites, and, indeed, in pyrophyllites in general. For general industrial uses, a moderate sericite content is not seriously objectionable, but in pyrophyllite for ceramic use the amount requires to be kept to a minimum, in order to maintain uniform firing behaviour, the alkalis acting as fluxes and reducing fusion temperatures. Quartz introduces gritty material and reduces slip, and so is objectionable for many uses: for ceramic purposes, it is mainly objected to as a low-priced impurity that lowers the alumina content of the product.

Below are listed a number of analyses of North Carolina pyrophyllites, taken from the sources shown, together with two analyses of the associated sericite:

—	1	2	3a	3b	3c
Silica	57·58	64·68	64·54	76·32	73·50
Alumina	33·31	28·34	28·88	19·80	22·53
Ferrous oxide	.....	.....	.....	} 0·18	0·09
Ferric oxide	0·33	0·60	0·45		
Magnesia	Trace	Trace	Trace	.....	.....
Lime	Trace	0·72	0·36	0·14	0·08
Soda	0·06	0·38	0·12	0·07	0·06
Potash	3·90	0·01	0·18	0·27	.....
Water above 105° C	5·56	5·54	5·40	3·44	3·95
Total	100·74	99·93	99·93	100·22	100·21

1. Pyrophyllite from mine of Standard Mineral Company, Hemp. Analysis from J. L. Stuckey, Bull. No. 37, p. 36. (*See* footnote, page 124.)
2. Pyrophyllite from the old Womble mine, near Glendon. Analysis as above.
3a. Pyrophyllite, crude ore, from Gerhardt mine, Staley. Analysis as above.
3b. Pyrophyllite, crude ore, from Gerhardt mine, Staley. Analysis from B. C. Burgess, loc. cit., p. 302. (*See* footnote, page 126.) Sample calculated as 66 per cent pyrophyllite, 31 per cent quartz, and 3 per cent sericite.
3c. Pyrophyllite, crude ore, from Gerhardt mine, Staley. Analysis as 3b. Sample calculated as 79 per cent pyrophyllite and 21 per cent quartz.

—	3d	3e	3f	3g	3h
Silica	70·26	69·90	69·38	75·30	75·40
Alumina	24·95	25·13	26·02	20·50	20·30
Ferrous oxide }	0·08	0·07	0·08	.....	.....
Ferric oxide }				0·10	0·30
Magnesia	.....	.....	.....	.....	.....
Lime	0·16	0·16	0·14	0·16	0·20
Soda	0·31	0·08	0·24	0·28	0·20
Potash	0·13	Nil	Nil		
Water above 105° C	4·32	4·67	4·50	3·60	3·60
Total	100·21	100·01	100·36	99·94	100·00

3d. Pyrophyllite, crude ore, from Gerhardt mine, Staley. Analysis from B.C. Burgess loc. cit., p. 302. (*See* footnote, page 126.) Sample calculated as 85 per cent pyrophyllite, 12 per cent quartz, and 3 per cent sericite.

3e. Pyrophyllite, crude ore, from same source as 3d. Analysis as 3d. Sample calculated as 88 per cent pyrophyllite, 11 per cent quartz, and 1 per cent sericite.

3f. Pyrophyllite, crude ore, from same source as 3d and 3e. Analysis as 3d. Sample calculated as 89 per cent pyrophyllite, 9 per cent quartz, and 2 per cent sericite.

3g. Pyrophyllite, standard grade mill-product made by Carolina Pyrophyllite Company from ore from Gerhardt mine. Company's analysis.

3h. Pyrophyllite, No. 3 (filler grade) mill-product, from same source as 3g. Company's analysis.

—	3i	3j	4a	4b	5a
Silica	71·70	76·40	64·53	63·50	70·15
Alumina	24·10	20·05	29·40	28·73	23·84
Ferrous oxide	.....	.....	0·67	0·84	.....
Ferric oxide	0·10	0·13	.....	.....	0·07
Magnesia	.....	Trace	Trace	Trace	0·02
Lime	0·10	Trace	Trace	Trace	0·06
Soda }	0·20	0·21	0·28	0·37	0·20
Potash }		0·05	Trace	Trace	1·54
Water above 105° C	3·80	3·33	5·45	5·85	4·00
Total	100·00	100·17	100·33	99·69	99·88

3i. Pyrophyllite, No. 24 (enamel grade) mill-product, made by Carolina Pyrophyllite Company from ore from Gerhardt mine. Company's analysis.

3j. Pyrophyllite, No. 24 (ceramic grade) mill-product, Carolina Pyrophyllite Company. Analysis from Bull. No. 12, Engineering Experiment Station, State College, Raleigh, N.C., 1937, p. 29.

4a. Cream-coloured pyrophyllite from mine of Roger's Creek Mining Company, Glendon. Analysis from J. H. Pratt, Economic Paper No. 3, North Carolina Geol. Surv., 1900, p. 26.

4b. Green pyrophyllite from mine of Roger's Creek Mining Company, Glendon. Analysis as 4a.

5a. Pyrophyllite, "Pyrax" grade mill-product of Standard Mineral Company, Hemp. Analysis from E. H. Lintz, Journ. Amer. Ceram. Soc., vol. 21, No. 6, June, 1938, p. 235.

—	5b	6	7	8	9	10
Silica	78·05	65·70	70·26	47·07	77·22	66·70
Alumina	17·56	28·32	24·94	36·89	15·95	28·30
Ferrous oxide	.....	.....	.....	.....	} 0·35	.....
Ferric oxide	0·09	0·12	0·08	0·42		.....
Magnesia	0·04	.....	.....	0·20	.....	.....
Lime	0·16	0·12	0·12	0·55	Trace	.....
Soda	0·20	0·36	0·31	1·34	0·93	.....
Potash	1·39	0·06	0·13	8·21	3·54	.....
Water above 105° C	2·35	5·37	4·32	5·05	2·08	5·00
Total	99·84	100·05	100·16	99·73	100·07	100·00

5b. Pyrophyllite, "Pyrax" grade mill-product of Standard Mineral Company, Hemp. Company's analysis (courtesy of J. L. Stuckey).

6. North Carolina pyrophyllite (source not stated) "needle" type. Analysis from A. F. Greaves-Walker and C. W. Owens, Bull. Amer. Ceram. Soc., vol. 15, Sept., 1936, p. 304.

7. North Carolina pyrophyllite (source not stated), radiated granular type. Analysis from A. F. Greaves-Walker and C. W. Owens, Bull. Amer. Ceram. Soc., vol. 15, Sept., 1936, p. 304.

8. Sericite, Standard Mineral Company's mine, Hemp. Analysis from J. L. Stuckey, Bull. No. 37, p. 36. (*See* footnote, page 124.)

9. Sericite, Gerhardt mine, Staley. Analysis from B. C. Burgess, loc. cit., p. 302. (*See* footnote, page 126.)

10. Pyrophyllite, theoretical composition.

OCCURRENCES IN NEWFOUNDLAND

After the North Carolina deposits, the occurrences of pyrophyllite in Newfoundland would appear to rank next in point of size and possible economic importance, as far as recorded data go. These occurrences have been described in a recent report[1] of the Geological Survey of Newfoundland, from which the following details are largely taken. The geology of the district has also been described in an earlier paper by Buddington[2].

The deposits lie within a narrow belt extending for about 6 miles south of Manuels, a small town on Conception Bay, Avalon Peninsula, in the southeastern part of the island. They consist mainly of quartz-pyrophyllite schists, containing scattered lenses of nearly pure pyrophyllite, and have been formed by hydrothermal alteration of sheared rhyolite flows, breccias, and conglomerates, lying close to an intrusion of granite. A large tonnage of material classed as high-grade and medium-grade schist is said to be available, particularly in the neighbourhood of Johnny's Pond, but such material would probably have to be treated for the removal of the contained quartz in order to obtain a product of commercial quality. Air separation and froth flotation have been suggested for this purpose, but are not known to have been tried, even experimentally, and all of the material mined and shipped has consisted of clean pyrophyllite obtained by hand-sorting from the lenses within the schist.

The deposits are favourably located for development, lying within 2 miles of a railroad. They were worked by a quarry at Johnny's Pond

[1] Vhay, J. S.: "Pyrophyllite Deposits of Manuels, Conception Bay", Bull. No. 7, Geol. Sect., Department of Natural Resources, Newfoundland, 1937.

[2] Buddington, A. F.: "Pyrophyllitization, Pinitization and Silicification of Rocks around Conception Bay, Newfoundland", Journ. Geology, vol. 24, No. 2, 1916, pp. 130–152.

from 1903 to 1905, when an aerial tramway was installed to the railroad and a loading pier built at Seal Cove, 8 miles west of Manuels. In 1904, 1,750 tons were shipped, and in 1905, about 6,000 tons, the whole of which was consigned to an unstated destination in the United States. High cost of hand-sorting clean mineral from large quantities of mined schist is suggested as a reason for closing down of the operations. In 1935, a small shipment of 30 tons is reported to have been made through the Canadian Alliance Corporation to a Montreal plant for an experimental grinding test, and the material is understood to have been marketed as talc. It was proposed to ship another 500 tons the following year, but the plan did not materialize, and nothing further has been done[1]. A large part of the pyrophyllite-bearing area is understood to be held by M. Bishop, Bishop Sons and Company, Ltd., St. John's, Newfoundland, but considerable ground still remains open for staking.

The pyrophyllite is predominantly of a cream to pale green colour, and usually has a massive to finely foliated texture; less commonly it exhibits a radiated fibrous structure. Quartz is the principal associated mineral, followed by zoisite in small amount. Chlorite, pyrite, and sericite occur sparingly in disseminated form, but mostly in the less highly pyrophyllitized portions of the deposits.

Most of the production has come from Mine Hill, close to Johnny's Pond, where an open-cut quarry has been opened to a depth of 45 feet, from the floor of which a shaft was sunk a further 70 feet. These openings have been made on a band of quartz-pyrophyllite schist containing irregular lenses and bands of clean pyrophyllite, the whole having a steep dip. A few small pits have also been opened on similar occurrences at Trout Pond and Dog Pond, to the south of the above.

The largest reserves of pyrophyllite are considered to occur in the Mine Hill area and in the section lying to the north of Johnny's Pond. At Mine Hill, the following estimates of tonnage of various grades of material available to a depth of 80 feet have been made:

Pyrophyllite content	Tons
75 per cent	52,700
55 "	140,500
45 "	207,400
30 "	200,000
Total	600,600

A large proportion of the material averaging 75 per cent contains pyrophyllite in the form of large masses of relatively pure mineral. Material below 30 per cent in grade greatly exceeds in quantity all the other grades combined.

[1] A recent report (Foreign Metals and Minerals, Minerals Circular No. 17, Aug. 29, 1938, U.S. Bur. Foreign and Domestic Commerce, p. 35) states that in June, 1938, 25 tons of "talc" was shipped from the Manuels deposit to the United States, and that the occurrences have recently been under examination by American interests (Clinchfield Sand and Feldspar Corporation, Baltimore, Md.) with a view to further development. According to an official report of the Newfoundland Government, shipments for 1938 totalled 1,000 tons, consigned to the above company.

Several partial analyses are given in the report by Vhay (footnote 1, page 129) and show as follows:

—	1	2	3	4
Silica	58·00	72·10	87·90	86·40
Alumina	29·03	21·51	9·16	9·26
Potash	.....	2·21	.....	.....

1. Best grade of pyrophyllite, from Mine Hill quarry.
2. Pyrophyllitized rhyolite. Calculated composition: pyrophyllite, 61 per cent; quartz, 18 per cent; feldspar, 19 per cent.
3. Channel sample of quartz-pyrophyllite schist. Estimated to contain 30 per cent pyrophyllite.
4. Grab sample of quartz-pyrophyllite schist. Estimated to contain less than 12 per cent pyrophyllite.

In 1938, through the courtesy of Mr. Howse, Department of Mines of Newfoundland, the writer received a representative sample of crude, lump pyrophyllite from the Manuels deposits (exact locality not stated). This sample was analysed in the laboratory of the Bureau of Mines and showed as follows:

Silica	65·02
Alumina	28·67
Ferrous oxide	Nil
Ferric oxide	0·23
Lime	Nil
Magnesia	0·17
Carbon dioxide	0·02
Soda	0·28
Potash	0·42
Water above 105°C	4·98
Total	99·79

From the above data, it appears that while the total amount of pyrophyllite present in these deposits is large, the great bulk of it is contained in low-grade rock that would require concentration to make a commercial product. The fact, however, that several thousand tons have been shipped and apparently found an acceptable market suggests that further prospecting and development might disclose commercial amounts of clean mineral of milling grade requiring only selective mining and hand-sorting, requirements that also obtain in the North Carolina field.

OCCURRENCES IN CANADA

BRITISH COLUMBIA

Kyuquot Sound, Vancouver Island

The pyrophyllite at this locality occurs on a group of four Crown-granted claims, close to tide-water, in the northwestern portion of Kyuquot Sound, a large inlet on the west coast of northern Vancouver Island. Two of the claims lie on the north side of a small peninsula between Kokshittle Arm and Easy Cove, and two on the south side of the latter. The distance from Victoria is about 200 miles, and the locality may be reached by biweekly coastal steamer service of the Canadian Pacific Railway. The deposits are well situated for development. The present owner is reported to be Mrs. H. P. White, 851 Fort Street, Victoria.

The occurrence has been known for about thirty years, and one of the claims (the Monteith) on the peninsula was worked in a small way around 1910 to supply a refractory material for the British Columbia Pottery Company, of Victoria. In 1911, material was mined from an adjoining claim (the Deertrail) by the San Juan Mining and Manufacturing Company, who used it in the manufacture of polishing powders, soaps and cleansers in a small plant in Esquimalt. Little further has been done. Around 1920, some activity was shown by Vancouver interests looking to the possibility of utilizing the material (pyrophyllite and alunite) of the deposits as a source of potash: a company, the Alunite Mining and Products Company, of Vancouver, was formed, and a number of additional claims were staked. A little material (quartz-alunite rock) was shipped at that time, in an effort to develop a use for it for fertilizer purposes, but this came to nothing[1]. Around 1925, the possibilities of using material from claims on Easy Cove for ceramic products were investigated by M. D. White and associates, of Victoria, but no development resulted[1]. In 1937, it was reported that an effort was being made by Vancouver interests to work the deposits as a source of ground pyrophyllite for Coast paper mills, but to date no results appear to have developed.

The fertilizer (potash) possibilities of the deposits were examined by the Provincial Mines Department in 1920, analyses being made of a number of samples from the various claims. The conclusion was reached[2] that "as far as the potash content of the rock is concerned, it is of too low a percentage to be considered as a commercial possibility for fertilizing purposes".

The above-cited report[2] gives some details of the occurrences, but the only comprehensive descriptions ever given are those by Clapp, who examined the area in 1913. The following notes are taken mainly from his reports[3].

The rocks with which the pyrophyllite and alunite deposits are associated are chiefly volcanics of Triassic and Lower Jurassic age, consisting of porphyritic and fragmental andesites and dacites. The pyrophyllite and alunite occur in separate and well defined masses as replacements of the volcanic rocks along their contacts with intrusive diorite and andesite. Four distinct types of such replacement have been recognized: quartz-sericite-chlorite rock; quartz-sericite rock; quartz-pyrophyllite rock; and quartz-alunite rock.

The alunite and pyrophyllite are considered to have been formed through the agency of sulphurous hydrothermal solutions accompanying the accumulation of the fragmental volcanics, these latter being still further altered (pyritized and silicified) under deep-seated conditions by the later intrusive diorite. Finally, still further and recent alteration has been caused by

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[1] Ann. Rept., Dept. Mines, British Columbia, 1925, p. 274.
[2] Ann. Rept., Dept. Mines, British Columbia, 1921, pp. 198–202
[3] *Clapp, C. H.: "The Geology of the Alunite and Pyrophyllite Rocks of Kyuquot Sound, Vancouver Island"*, Geol. Surv., Canada, Sum. Rept. 1913, pp. 109–26; "Alunite and Pyrophyllite in Triassic and Jurassic Volcanics at Kyuquot Sound, British Columbia", Econ. Geol., vol. 10, No. 1, Jan., 1915, pp. 70–88.

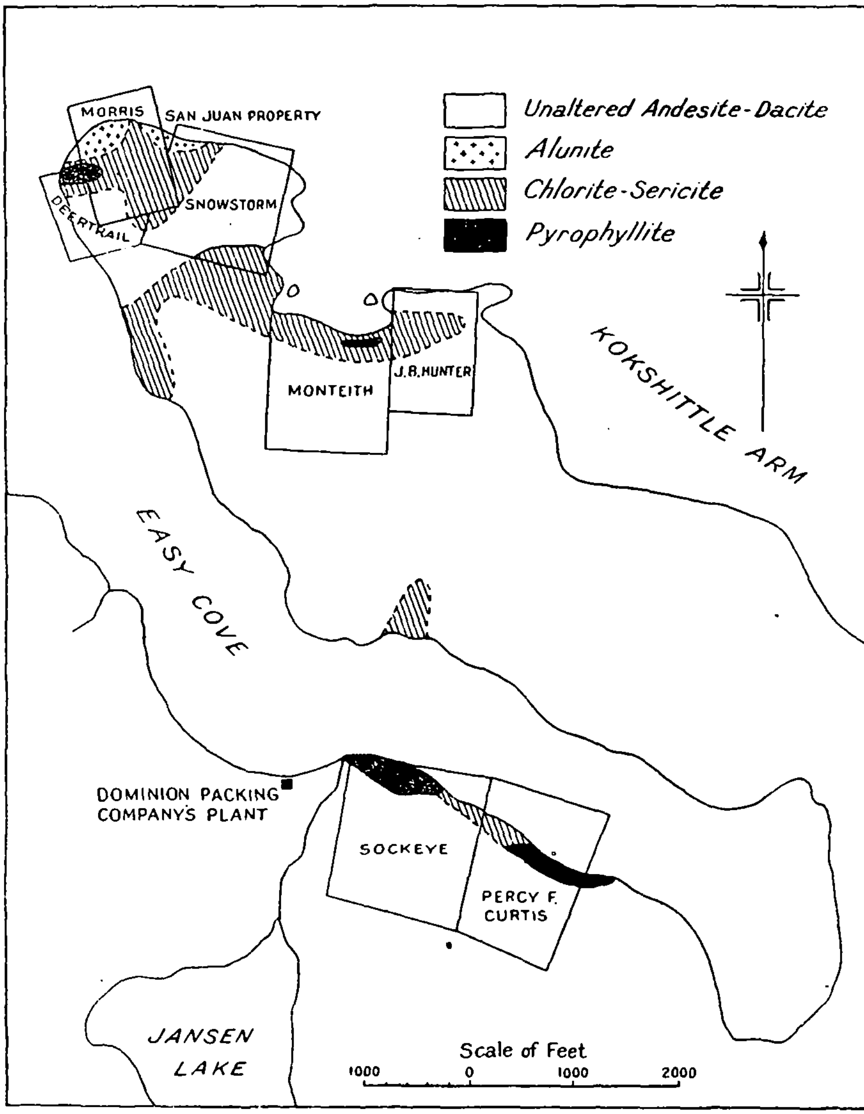

Figure 4. Sketch map showing pyrophyllite and alunite deposits on Kyuquot Sound, Vancouver Island, B.C.

circulating meteoric waters, resulting in kaolinization of the feldspar and oxidation of the contained pyrite to limonite, so that above ground-water level the rocks are commonly iron-stained and free from pyrite, while below this level they are of a blue-grey colour and contain disseminated pyrite. Low gold and silver values have been found in some of the more highly pyritic zones.

The alunite of the deposits is the sodic variety, natro-alunite, and occurs in masses of quartz-alunite rock, with alunite forming from 20 to 45 per cent of the whole. Some interest has been taken in it as a possible source of alum, but the large amount of associated impurities makes it of problematical value for such purpose.

The pyrophyllite is mainly of compact, massive type, and occurs in bodies of pyrophyllite-quartz rock, containing a little sericite and with quartz forming 20 to 50 per cent of the rock.

Quartz-sericite rock is the most abundant type. Quartz-pyrophyllite rock is less common, and appears to be developed chiefly on the Deertrail and Monteith claims, which lie, respectively, on the south and north sides of the small peninsula between Easy Cove and Kokshittle Arm. It is also exposed over a small area on the Sockeye and Curtis claims, on the south shore of Easy Cove (*see* Figure 4). On the first-mentioned claims there are exposures of 3 acres and 1 acre, respectively, of the rock. It is described as dense, with a pronounced greasy or soapy feel, and is readily crushed to a fine, smooth powder. It consists essentially of quartz and pyrophyllite, with small amounts of accessory sericite, pyrite (weathering to limonite), and kaolin. The quartz is very fine-grained and is regarded possibly as, in part, of opaline character. The pyrophyllite is in the form of very fine, microscopic flakes, and is of agalmatolite character.

Clapp says little about the width or extent of the pyrophyllite-quartz bodies or the development workings, but estimates the amount of material indicated in the quarry on the Deertrail claim as 400,000 tons, and in that on the Monteith claim as 100,000 tons, in both cases to sea-level. He notes, however, that on both claims irregular streaks or thin beds of quartz-sericite rock occur in the pyrophyllite zones and would reduce the above-quoted tonnages.

With respect to the grade of rock, nothing very definite is said, beyond estimating the quartz content between 20 and 50 per cent. Two analyses of samples are given and one of the quartz-sericite rock:

—	1	2	3
Silica	81·94	71·88	87·80
Alumina	15·29	23·56	9·08
Ferric oxide	0·11	0·14	0·40
Soda	0·40	0·36	0·02
Potash	0·50	0·43	1·70
Water above 105° C	2·40	3·24	1·04
Total	100·64	99·61	100·04

1. Pink to white quartz-pyrophyllite rock, from Monteith claim. Estimated pyrophyllite content, 42 per cent; quartz, 50 per cent.
2. White to grey quartz-pyrophyllite rock, from Deertrail claim. Estimated pyrophyllite content, 71 per cent; quartz, 20 per cent.
3. Cherty quartz-sericite rock, from Monteith claim.

Ceramic tests were made a number of years ago in the laboratories of the Bureau of Mines on material from the Monteith claim, the report[1] stating: "It burns steel hard at cone 1 and shows good refractoriness: in fact, there are few more refractory clays thus far known in the western provinces".

According to information furnished by the Canadian Pacific Railway Company[2], a small tunnel, 6 by 6 by 15 feet, was opened on the Monteith claim, from which most of the pyrophyllite used by the British Columbia Pottery Company was taken. On the Sockeye claim, pyrophyllite is exposed for 250 feet along the strike, with widths up to 150 feet, while on the adjoining Curtis claim, there is an exposure of 150 by 100 by 30 feet. The intervening section is covered by overburden, but, if continuous between these exposures, the band would have a length of 1,800 feet, with several hundred thousand tons of pyrophyllite ore indicated. The quartz content is about 45 per cent, and at a depth of 6 feet the rock is fresh and free from iron stain. In 1929, at the request of the above company, tests were made on the pyrophyllite by the Ceramic Department of the University of Saskatchewan. It was found to burn white, with a few dark specks, and to have a fusion point of cone 27. It was considered to have merit for whiteware bodies and also, possibly, for general industrial use, though for refractories the fusion point was low.

In 1938, samples of crude and powdered pyrophyllite from this locality (precise source not stated), and described as "impure surface material", were sent to the Bureau of Mines by Messrs. Hawkins and Horie, of Vancouver, who have been interested in trying to work up a trade in it for paper mill use. A composite of this material was analysed in the laboratories of the Bureau and showed as follows:

Silica	75·84
Alumina	16·70
Ferrous oxide	0·06
Ferric oxide	0·22
Lime	0·28
Magnesia	0·44
Soda	Nil
Potash	4·33
Carbon dioxide	Trace
Water above 105°C.	2·53
Total	100·40

QUEBEC

There have been a few scattered records of occurrences of pyrophyllite in the Province of Quebec, but the references are obscure and little information regarding them is available.

Lake Memphremagog District

Township of Potton

In 1929, L. P. Collin, of the Bureau of Mines, reported having examined an occurrence of "white clay material" believed to be pyrophyllite, on the west shore of Lake Memphremagog. No details of the exact locality are

[1] Ries, H. and Keele, J.: "Clay and Shale Deposits of the Western Provinces", Geol. Surv., Canada, Mem. No. 24, 1912, pp. 148-150.

[2] Supplied through the courtesy of G. M. Hutt, Assistant Development Commissioner, Canadian Pacific Railway Company, Winnipeg.

given, but it is referred to as about 8 miles from Mansonville and near the Quebec-Vermont boundary: this would place it in the Township of Potton, Brome County. The property was reported to be owned by Mrs. J. MacDonald, of Rock Island, Que. Several small surface exposures were examined, but the supposed pyrophyllite was found to be present in very small amount and to be so mixed with earthy impurities that nothing definite could be said about it.

Township of Stanstead

The most definite statement regarding pyrophyllite in the Province is contained in an early report[1] of the Geological Survey. It is there stated that pyrophyllite (agalmatolite) occurs on lot 15 of range I of Stanstead Township, on the east shore of Lake Memphremagog, in a belt 150 feet wide, enclosed in chloritic slates. The material is described as in part granular and almost pure, and in part schistose with considerable quartz. The massive type has a light yellow colour and is translucent and unctuous, resembling steatite. No further references to this occurrence are on record and no details regarding its possible economic importance are available.

In the same report, reference is made to occurrences of similar material near St. Nicholas (presumably the village of that name on the south shore of the St. Lawrence River, about 12 miles west of Levis), and near the Famine River, a tributary of the Chaudière, in the parish of St. Francis, Beauce County, southeast of the above. At the former locality the pyrophyllite is described as variously granular, massive, or schistose in texture, with a shining, waxy lustre, and of a greenish colour, resembling steatite, and forming thin layers up to 1 inch in thickness in shales and sandstones close to a body of intrusive trap rock. The St. Francis material is described as of similar character and forming a thin bed in clay slate. Apparently, no further data regarding these occurrences have ever been recorded. The report gives the following analyses of material from the Stanstead, St. Nicholas, and St. Francis localities:

—	1	2	3	4
Silica	48·42	48·50	50·50	50·30
Ferric oxide	4·50	5·67	Trace	Trace
Alumina	27·60	27·50	33·40	32·60
Lime	2·80	1·30	Trace	.....
Magnesia	1·80	2·24	1·00	1·20
Potash	5·02	5·30	8·10	.....
Soda	2·78	1·91	0·63	.....
Water	6·88	7·40	5·36	6·50
Total	99·80	99·82	98·99	90·60

1. Pyrophyllite (agalmatolite) from St. Nicholas.
2. do do do do
3. Agalmatolite from St. Francis.
4. Agalmatolite from Stanstead Township, range I, lot 15.

[1] Geology of Canada, 1863, p. 485.

In 1937, a sample of a clay-like material, said to come from near St. Ludger, in Marlow Township, Beauce County, was submitted to the Bureau of Mines and was found to consist in part of pyrophyllite. The sample was stated to have been obtained from a small exposure in the side of a creek, but no further details are available. The geology of the St. Francis-St. Ludger (Beauceville) region has been described by MacKay[1], who reports the occurrence of acid tuffs and rhyolite flows, and it is with these rocks that the pyrophyllite is presumed to be associated.

USES OF PYROPHYLLITE

As already noted above, ground pyrophyllite can substitute for ground talc in many of the industrial uses served by the latter mineral, but, being extremely limited in its occurrence, is only seldom so employed. Thus it may serve satisfactorily for practically all of the purposes listed for talc (*see* pages 4 to 8), e.g. as a filler or loader material in paper and paint, for textile bleaching, in rubber and roofing manufacture, in cosmetics, etc. It is stated that the mineral has been shown to have value in the manufacture of battery boxes. The compact, massive (agalmatolite) form may also serve for lava use, as well as for crayons.

By far the most important field of usefulness for the mineral lies in the ceramic industry, where its chemical composition (alumina content), and particularly its pyrochemical properties, make it of special value. While pyrophyllite has been employed to a limited extent in ceramics for many years, recent research has broadened its field of usefulness in this industry very materially, and it now has become definitely established as a ceramic raw material of considerable value. In semi-vitreous dinnerware bodies, an addition of pyrophyllite has been shown[2] to develop good drying and firing properties, high mechanical strength, and greatly improved resistance to delayed crazing. In wall-tile bodies, one of the largest ceramic outlets for both talc and pyrophyllite, the substitution of pyrophyllite for feldspar lessens crazing, due to thermal shock or moisture expansion, or both, fire-cracking, shrinkage, and warpage, while it increases the maturing or firing range of the body. At the same time, its use results in decreased die wear[3].

In high-grade refractories of the fireclay class[4], formed either by the dry-press or stiff-mud process, the use of pyrophyllite in amounts ranging from 75 to 90 per cent of the body results in increased resistance to spalling and to hot-load deformation, while it has also been shown to impart desirable properties to cold-setting refractory cements.

The thermal expansion of pyrophyllite has been studied by Greaves-Walker and Owens[5] who have shown that particle size exerts a marked difference in the firing behaviour of pyrophyllite bodies. Pyrophyllite

[1] MacKay, B. R.: "Beauceville Map-Area, Quebec", Geol. Surv., Canada, Mem. No. 127, 1921, pp. 24-31.

[2] Lintz, E. H.: "The Use of Talc and Pyrophyllite in Semivitreous Dinnerware Bodies", Journ. Amer. Ceram. Soc., vol. 21, No. 6, 1938, pp. 229-37.

[3] Sproat, I. E.: "Use of Pyrophyllite in Wall-Tile Bodies", Journ. Amer. Ceram. Soc., vol. 19, No. 5, 1936, pp. 135-42.

[4] Greaves-Walker, A. F. et al: "The Development of Pyrophyllite Refractories and Refractory Cements", Bull. No. 12, Eng. Exper. Station, State College, North Carolina, 1937.

[5] Greaves-Walker, A. F. and Owens, C. W.: "The Expansion of Pyrophyllite", Bull. Amer. Ceram. Soc., vol. 15, Sept., 1936, pp. 303-5.

undergoes a sudden expansion between dull red heat and 1,600° F., after which, material finer than 60 mesh exhibits shrinkage. The expansion is a function of the dehydration of the mineral, but its amount is dependent on particle size, for which reason finely ground or compact, cryptocrystalline material should be used in preference to the fibrous, needle type.

The pyrochemical properties of pyrophyllite have recently been investigated by Parmelee and Barrett[1], and the use of the mineral in electrical insulators has been described by Stevens[2]. For the latter use, pyrophyllite proved superior to porcelain for high-frequency application but inferior to steatite. However, where the qualities of steatite are not demanded, pyrophyllite offers the advantage of lower first cost, and the bodies have good properties in respect to modulus of rupture, dielectric strength and constant, specific gravity, and porosity. They are recommended where high puncture values or zero porosity are not required.

SUPPLEMENTARY NOTES

Pyrophyllite and talc being essentially similar in their occurrence and physical character, mining and milling of the material follow the same general procedure as outlined for the latter mineral (*see* Chapter V).

The effect and control of dust hazards in connection with pyrophyllite mining and milling have been discussed in a recent paper by Trice[3].

The term "pinite", originally used as a *mineral* name, in which sense it covered a rather broad range of alteration products derived from various aluminosilicate minerals, has recently come to be employed as a *rock* name, to indicate an acidic, volcanic rock, of rhyolite, andesite, or trachyte character, including often a tuff form of such rocks, that has been highly altered by hydrothermal agencies, with the conversion of the original aluminosilicate minerals to the hydrated silicates pyrophyllite and sericite. This alteration process is sometimes termed "pinitization", especially where the dominant secondary mineral is sericite, rather than pyrophyllite (*see* the paper by Buddington on the Newfoundland deposits, footnote 2, page 129). A recent paper by Kerr[4] describes the occurrence and character of a pinitized tuff at American Canyon, Nevada; this rock consists of a mixture of sericite and pyrophyllite, and mining of the material has recently been undertaken by the Stockton Firebrick Company for delivery to its plant at Pittsburg, California, where it is being employed for the manufacture of rotary cement kiln linings. Ceramic properties of this material have been discussed in a paper by Page, Raine, and Sullivan[5]; it is stated to fire to a snow-white colour and to be highly refractory, having a fusion point of cone 32.

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[1] Parmelee, C. W. and Barrett, L. R.: "Some Pyrochemical Properties of Pyrophyllite"; Journ. Amer. Ceram. Soc., vol. 21, No. 11, Nov., 1938, pp. 388-93.

[2] Stevens, F. J.: "Notes on the Use of Pyrophyllite as an Electrical Insulator", Journ. Amer. Ceram. Soc., vol. 21. No. 9, Sept., 1938, pp. 330-1.

[3] Trice, M. F.: "Pyrophyllite Dust—Its Effect and Control", Amer. Inst. Min. Met. Eng., Techn. Publ. No. 1179, 1940.

[4] Kerr, Paul F.: "A Pinitized Tuff of Ceramic Importance", Journ. Amer. Ceram. Soc., vol. 23, No. 3, March, 1940, pp. 65-71.

[5] Page, G. A., Raine, F. F., and Sullivan, V. R.: "Development and Preliminary Studies of Pinite", Journ. Amer. Ceram. Soc., vol. 23, No. 3, March, 1940, pp. 71-77.

Indicating the growing consumption of pyrophyllite for ceramic uses, it is stated[1] that 90 per cent of the American makers of wall-tile are now employing pyrophyllite-talc mixtures in order to overcome crazing, and that whereas such bodies were formerly matured around cone 11, the maturing temperature is now much lower, around cone 4 to 5; formulæ call for around 40 per cent pyrophyllite and 12 per cent talc. For dinnerware bodies, similar mixtures are now being used, with 19 per cent pyrophyllite and 6 per cent talc.

Ground pyrophyllite in 1939 was quoted at $8.50 per ton for best grade, with slightly off-colour material selling at $5.85 per ton, f.o.b. North Carolina mills.

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[1] U.S. Bur. of Mines, Mineral Trade Notes, Vol. 8, No. 1, January, 1939, pp. 32-3.

APPENDIX

SELECTED BIBLIOGRAPHY OF TALC, SOAPSTONE, AND PYROPHYLLITE

Below are listed a few of the more important and more recent general reference works to talc, soapstone, and pyrophyllite. The literature on talc and soapstone is voluminous and very scattered; but, as noted, certain of the works mentioned here contain extensive bibliographies, and these should be consulted by those interested in specific data. Many of the major articles so listed have been consulted in the preparation of this report, and numerous references are made to these in the text and footnotes.

1. Stutzer, O.: Lagerstätten der Nicht-Erze, vol. 5, 1933, pp. 320-70. (Contains an extensive bibliography of 142 references.)
2. Dammer und Tietze: Die Nützbaren Mineralien, vol. 2, 1928, pp. 395-411. (Contains numerous text references.)
3. Imperial Mineral Resources Bureau, the Mineral Industry of the British Empire and Foreign Countries, Talc, 1921. (With Bibliography.)
4. The Mineral Industry (McGraw-Hill, New York), Annual Volumes, 1906-38.
5. World Resources of Talc and Soapstone, United States Bureau of Mines, Reports of Investigations, No. 5, October, 1919.
6. Ladoo, R. B.: Talc and Soapstone, Mining, Milling, Products and Uses: United States Bureau of Mines, Bull. 213, 1923.
7. Spence, H. S.: Talc and Soapstone in Canada, Mines Branch, Department of Mines, Report No. 583, 1922. (With Bibliography.)
8. Die Chemische Industrie, vol. 55, No. 25, June 18, 1932, pp. 519-20. (Review of the world trade in Talc: translated from the Italian "Bollettino di Informazioni Commerciali," Rome.)
9. United States Bureau of Mines, Minerals Yearbook, Annual Volumes, Chapters on Talc and Ground Soapstone.
10. Gillson, J. L.: Talc, Soapstone and Pyrophyllite, Chapter in Industrial Minerals and Rocks Volume, Amer. Inst. Min. Met. Eng., 1937, pp. 873-92. (With Bibliography of 96 references.)
11. Gillson, J. L.: Origin of the Vermont Talc Deposits, Econ. Geol., vol. 22, No. 3, May, 1927, pp. 246-87. (Contains notes on a number of other talc occurrences.)
12. MacConkey, C. A.: Grading and Uses of Talc, Nat. Research Council, Canada, Oct., 1934, 46 pages, with 71 literature references to uses, etc., of talc. (Unpublished report.)
13. United States Tariff Commission, Tariff Information Surveys, Paragraph 69, Talc and Soapstone, 1921, pp. 11-22.
14. Dominion Bureau of Statistics, The Talc and Soapstone Industry in Canada. (Annual Reviews.)
15. Wilson, M. E.: Talc Deposits of Canada, Geol. Surv., Canada, Economic Geology Series, No. 2, 1926. (Contains numerous text references, mainly geological.)

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