CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN McLEISH, DIRECTOR

MICA

BY

H. S. Spence

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1929

No. 701

Price, 30 cents

Photo by M. E. Wilson, Geol. Surv., Canada.)

View of Lièvre River valley, Que., looking southeast towards the village of Notre-Dame de la Salette. Photograph taken from ridge upon which some of the largest phosphate mines in the province were opened. The view illustrates the general physiographical features of the Quebec mica-apatite region—low, wooded hills and ridges of gneiss, crystalline limestone and pyroxenite, separated by clay flats.

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PREFACE

A report on mica, entitled "Mica, Its Occurrence, Exploitation, and Uses," was published by the Mines Branch in 1905. This report was followed by a more comprehensive monograph, bearing the same title, issued in 1912 as Mines Branch Report No. 118. Both these publications are long since out of print.

A description of the muscovite deposits in the Tête Jaune and Big Bend districts, in British Columbia, appeared in Mines Branch Summary Report for 1913, pp. 42-49.

The above comprise the principal reports published by the Mines Branch on the subject of mica.

In the accompanying report, the writer has condensed the more important data contained in the earlier publications of the Mines Branch; gives a review of the present status of the mica industry in Canada, and presents the available information relating to mica and the mica industry throughout the world.

In view of the present depressed condition of mica mining in Canada, much of the data relating to individual properties, now idle, given in earlier publications has been omitted from the present report. These publications can, however, be consulted in the principal Public, Departmental, University, and Institutional libraries, both in Canada and in foreign countries.

The writer's acknowledgments and thanks are tendered to those individuals and firms who have kindly supplied information, illustrations, or other material used in this report; or who, by permitting access to their mines or plants, have aided in its preparation. To Mr. C. W. Jefferson, Manager of the Mica Insulator Company's works, at Schenectady, N.Y., the writer is particularly indebted for kind co-operation in scanning the proof of the section dealing with the electrical uses of mica in Chapter IX.

CHAPTER I

INTRODUCTORY SUMMARY

OCCURRENCE AND DISTRIBUTION OF MICA

Mica is one of the commonest minerals, being an essential constituent of many types of crystalline rocks, such as granite, gneiss, mica schist, etc. In such rocks the mica occurs in the form of small flakes, which have no commercial value except, possibly, where the rock can be crushed and the mica recovered as a low-priced material for the ground mica trade. This procedure has been followed in the United States, but is not known to have been practised elsewhere.

The mica of commerce is derived exclusively from granite pegmatites and basic, magnesian rocks known as pyroxenites. The former yield the potash variety muscovite, or white mica,[1] while the latter furnish phlogopite, or amber mica. Practically the whole of the Canadian production consists of phlogopite. This variety is far less common than muscovite, which constitutes the bulk of the world's supply of mica, and, outside of

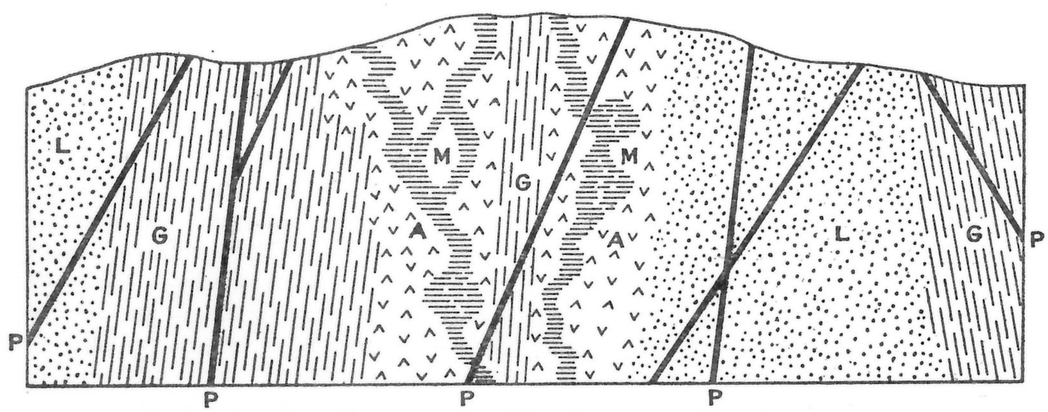


Figure 1. Schematic section through mica-bearing series, showing typical association of principal rock types. L, crystalline limestone; G, gneiss; A, pyroxenite with mica leads M; P, pegmatite dykes.

Canada, few occurrences are known. The most important of these are in Madagascar where development of the deposits is proceeding on an increasing scale. Madagascar phlogopite is now competing strongly with the Canadian product. Phlogopite is also known to occur in Chosen (Korea), Ceylon, Mexico, and Central Africa, but these countries have not as yet accounted for any important production. Muscovite, on the other hand, is

[1] NOTE.—Strictly speaking, the term "white mica" is not a true synonym for muscovite, which, in thickish sheets, has often a green, brown, or reddish colour. In the trade, however, it is often applied indiscriminately to all muscovite, or potash mica, to distinguish it from the predominantly amber-coloured phlogopite, or magnesian mica.

widely distributed and deposits are known in many countries, although the bulk of the world's supply is derived from relatively few sources. India is by far the largest producer of muscovite mica, and in 1927 supplied more than 60 per cent of the total world production of sheet mica.

COMPOSITION AND CHARACTERISTICS OF THE MICAS[1]

Chemically, the micas are silicates of alumina and other bases, notably potash, soda, magnesia, iron, and lithia. They are chiefly characterized by very perfect basal cleavage, which enables the crystals to be split into exceedingly thin sheets. These sheets are highly transparent when free from iron stains and other impurities. They are soft yet strong, very flexible and elastic, and possess remarkable insulating properties. On account of its high di-electric strength which, in combination with its other exceptional properties, makes it unique among materials, mica has become an indispensable substance in the electrical industries, practically all major electrical equipment requiring its use.

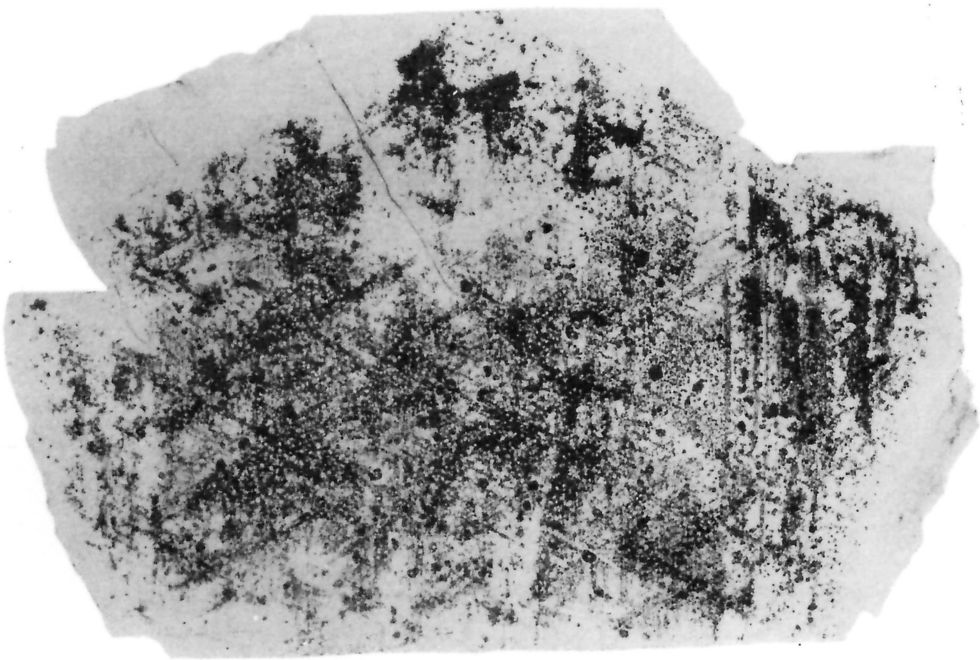
The principal micas of commerce are the following:

Muscovite. Both muscovite and phlogopite are colourless, or nearly so, when split into very thin sheets. Blocks or thick plates of muscovite, however, often exhibit a greenish colour, while certain of the Indian deposits yield mica of a characteristic ruby shade. More rarely, muscovite is found having a smoky brown colour. Characteristic of muscovite, however, is a red or black spotting or blotching, due to the presence between the layers of thin films of iron or manganese oxides. These films are often made up of small individual specks arranged in geometrical patterns conforming to the crystal axes of the sheets, but they are as often quite irregular in size, shape, and arrangement. Such films constitute an imperfection in mica that is to be used for stoves and certain types of electrical work, e.g. condensers, but for general electrical insulating purposes, stained and spotted muscovite is quite satisfactory. In fact, spotted mica is often referred to in the trade as "electrical mica" to differentiate it from the clear, stove or condenser quality. Black spots in muscovite do not materially impair its di-electric strength and render it liable to puncture, but they are objectionable where low surface conductivity is required, and in such cases clear or slightly red-stained mica is used. Most muscovite mines yield a proportion of spotted mica.

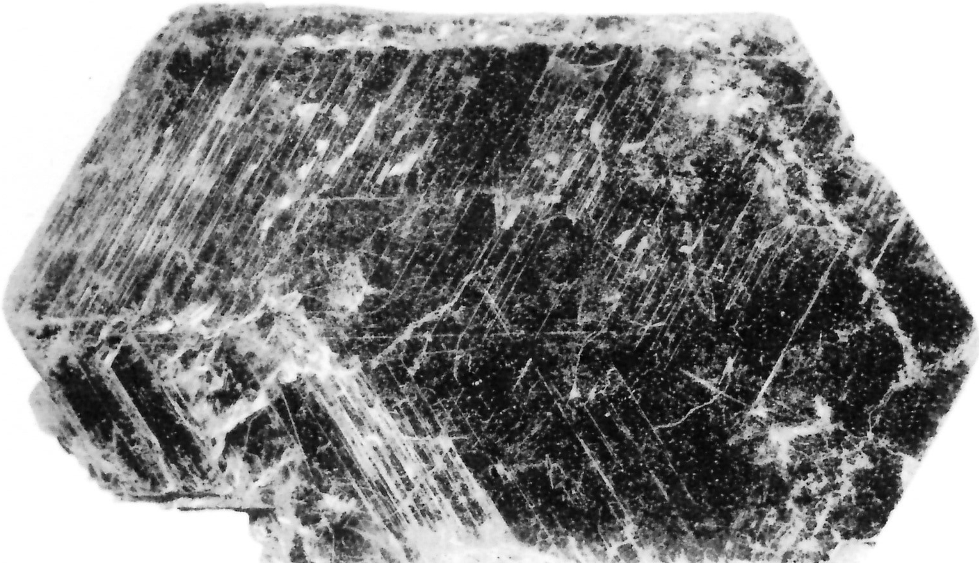
Phlogopite. Phlogopite nearly always has a brown or greenish brown colour, and, according to the shade, is variously classified as dark amber, light amber, silver amber, wine amber, etc. A high iron content, replacing magnesia, may render phlogopite almost black in colour, and such mica is almost opaque, even in thin sheets. Black phlogopite is harder than the brown type, is usually a poor splitter, and has lower di-electric strength, for which reasons it has little value for electrical purposes.

Biotite. Biotite is a black iron mica found in granite pegmatites, sometimes in association with muscovite. Sometimes, crystals are found consisting partly of muscovite and partly of biotite. Like dark phlogopite,

[1] See chart in pocket at end of report.



A. Plate of muscovite, showing the spotting often so typical of this variety of mica. The spots are caused by infinitesimally thin films of iron oxide between the mica layers. Such films are frequently arranged in a geometrical pattern corresponding to the axes of the crystal; traces of such arrangement are visible in the specimen illustrated. From range I, lot 31, Villeneuve township, Que. (One-sixteenth natural size.)



B. Section of mica crystal, illustrating the imperfection known as "herring bone" structure.

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it possesses no value for electrical purposes, and can be utilized only as grinding scrap. A variety of biotite containing a large percentage of ferric iron is known as lepidomelane; like biotite, its only value is for scrap.

Lepidolite. Lepidolite, or lithia mica, is a variety usually found in granite pegmatites characterized by an abundance of other lithia minerals, such as spodumene, lithia tourmaline, amblygonite, etc. It seldom occurs in large, clear sheets, but generally as compact aggregates of small flakes or spangles. Clear sheet lepidolite is, however, reported to occur in Western Australia, and to have been utilized for gramophone diaphragms. The chief uses of lepidolite are as a source of the element lithium and in the manufacture of glass.

Jefferisite. Jefferisite is an uncommon variety of mica to which some attention has been drawn in recent years. Belonging to the vermiculite group of altered, hydrated micas, it possesses the peculiar property of swelling up enormously when heated, to form a light, spongy mass. Under the trade name of "zonolite," it has been produced in the United States and marketed as a heat-insulating, sound-deadening, and paint material.

Roscoelite. Roscoelite is a rare variety of mica, remarkable for containing as high as 29 per cent of vanadium oxide. It occurs in the form of minute flakes in the sandstones of the Rifle, Newmire, and Placerville districts, Colorado, where it has been utilized as an ore of vanadium. The metallic vanadium content of the run-of-mine ore is stated to average 1·5 to 5·0 per cent.

IMPERFECTIONS OF MICA

Both the transparency and the splitting quality, and particularly the latter, of sheet mica, may be seriously impaired by the inclusion within the crystals of mineral impurities taken up during growth, or by imperfect crystal development. As already noted, muscovite is particularly subject to spotting or staining by films of oxide, which, however, although they may lower the quality of the mica, seldom injure its splitting properties. A very large proportion of the muscovite mined, however, is rendered useless, by crystal imperfections developed during growth, for any other purpose except grinding. Such imperfections commonly give rise to what are termed "tangle sheet" and "wedge" mica, the former being unsplittable and the latter yielding sheets of unequal thickness. Phlogopite crystals, due to rock movement subsequent to their formation, are often crushed, buckled or broken, or may have developed lines of weakness that result in what is known as "herring bone," "ribbon," or "ruled" mica. The waste due to such imperfections may, in some instances, represent a very large proportion of the mine output. In addition, the inclusion of quartz, tourmaline, and garnet crystals in muscovite often spoils a large amount of otherwise sound mica; and much phlogopite is similarly spoilt by the presence of included calcite, iron pyrites, pyroxene, or apatite. For these reasons, the amount of sound, merchantable mica secured in mining is often a very small proportion of the total quantity mined and many deposits have been abandoned on that account.

MINING OF MICA

Owing to the irregular mode of occurrence of mica systematic mining operations are rarely possible. It is characteristic of mica, both muscovite and phlogopite, to occur in irregular and impersistent, pockety bodies or shoots, the mining of which often entails the moving of a large amount of dead ground. The deposits are usually mined or quarried by open-cast methods, the excavation being abandoned when the visible supply of mica is exhausted. Consequently, mica-bearing districts are generally dotted with numerous shallow pits, which may be re-worked from time to time for short periods, and on a small scale, with portable equipment. In the case of Canadian phlogopite mines even the largest and deepest workings do not extend below 300 feet.

Up to comparatively recently, mining at the smaller Canadian mica mines was often conducted by hand-drilling or with the aid of steam drills run by a light, portable boiler. These methods have now been largely supplanted by the use of air-drills, run from a portable gasoline-driven compressor. These machines are much lighter than the old style steam equipment and can readily be taken in to remote locations through even the roughest country.

In mining mica, considerable care has to be exercised both in the placing of the drill holes and in the charge of explosive used, the aim being to loosen the ground with the least possible injury to the crystals.

PREPARATION FOR MARKET—CANADIAN PRACTICE

In mining, mica crystals, or "books" as they are sometimes termed, usually break up into plates an inch or more in thickness. These are removed from the pit and taken to a cobbing and trimming shed at the mine. Here, adhering rock is broken off, the plates are roughly split and most of the waste, broken or imperfect mica is removed. The resulting sheets, termed "rough-cobbed" mica, are then usually shipped to centrally-located mica "shops," where they undergo a further splitting and trimming and are graded according to size and quality. This roughly "thumb-trimmed" mica may be marketed as such to manufacturers of electrical equipment, who cut or punch from it the sizes or shapes they require, or this work may be performed by the producers, or by dealers operating shops equipped with the necessary facilities.

A considerable proportion of mica of the smaller sizes (1 x 1 to 1 x 3 inches) is converted into "splittings" for the mica plate (micanite) trade. "Splittings" are thin leaves of mica, approximately one-thousandth of an inch in thickness, which are afterwards bonded together with shellac or some other binder to form large plates that can be cut or moulded into shapes of any desired size or form.

Practically all of the work necessary to prepare mica for the market is performed by hand with the aid of a small splitting knife. Roughing of the edges of the sheets in order to facilitate splitting is effected by rubbing on sandpaper or by means of a mechanically driven burr wheel. Guillotine knives are used to cut sheet mica to specified dimensions, and mechanical punches fitted with the necessary dies, to make disks, washers, and segments. Most of the larger Canadian producers maintain their own establishments for this work, and there are, in addition, similar " shops " run by dealers who buy the rough output of the smaller mines and trim, split, and grade it for market. The making of " splittings " is done almost exclusively by girls, and is often piece-work performed in the workers' homes. Many of the larger mica shops are located in rural communities in the province of Quebec, which provide an adequate supply of the type of labour required, and the making of splittings is often farmed out through surrounding villages.

As already remarked, the mining and preparation of sheet mica nearly always entails the production of a great deal of waste material, and in past years this found its way to the mine dumps. In the early days of mining, also, when there was a market for only large sheet mica, all the small-sized mica went to the rock dumps. With the development of manufactured mica plate, a demand arose for even the smallest sheets, and consequently the rock dumps at all the principal mines have been worked over in recent years to recover material formerly discarded as worthless. At the same time, the growing production of ground mica, for roofing and other purposes, has developed a market for all kinds of refuse mica, so that, to-day, very little mine scrap or shop scrap (waste from the trimming and splitting shops) finds its way to the waste pile.

USES OF MICA

Sheet Mica

Almost the entire recorded world's production of sheet mica, to-day, is utilized in the electrical industries, most types of electrical equipment employing mica insulation in some shape or form. Among its more important uses for such purposes are:—

(1) For separating the copper bars of commutators and for commutator rings, cones, and cores.
(2) For electrical heating units, such as cookers, irons, and toasters.
(3) For disks, washers, bushings, etc., in all types of electrical power and lighting equipment.
(4) For tubes for induction coils, commutator sleeves, rheostat rods, and general high potential insulating purposes.
(5) For separating the plates or leaves of electrical condensers.

Certain of the above uses require the employment of built-up mica plate, and for others, natural sheet mica is suitable or more desirable. For condenser mica, thin films of the highest quality muscovite are requisite.

In addition to being built up into mica plate or board, mica is also layered with different kinds of paper, or with cloth, to form flexible wrapping or winding insulation known variously as mica paper, mica cloth, mica tape, etc. Mica is similarly layered with paper or with asbestos to make mica tubing.

A certain amount of clear sheet muscovite finds employment in stove doors, furnace windows, lamp canopies, chimneys, shields and shades, goggle eye pieces, gas masks, and for similar purposes where transparency coupled with resistance to heat or shock is required.

Ground Mica

Ground mica, made from mine waste or shop scrap, finds various uses, and production has been considerably increased in recent years. A number of grades of different qualities and mesh sizes are made, depending on the purpose for which they are intended, and both wet and dry grinding are employed.

The roofing industry probably absorbs the greater part of the ground mica produced. For this purpose mica does not need to be ground extremely fine and grinding is dry. The product is used to coat the surface of rolled roofing and asphalt shingles in order to prevent sticking. Mica has much greater covering power than talc, which was formerly the material chiefly favoured for this purpose. Most of the phlogopite scrap exported in recent years from Canada to the United States has been ground for the roofing trade.

Coarsely ground mica, chiefly muscovite, is used for Christmas tree "snow."

A small and decreasing amount of mica is used in compounding axle grease and certain special lubricants, where it serves to lower friction.

The finest grade of ground mica is taken by the wall-paper trade, where it is used to impart lustre to the paper. Only white mica is suitable for this purpose, and the scrap is ground wet and water-floated so as to ensure a clean and uniformly fine product. Ground mica is also used, for its decorative effect, to surface stucco and plaster, and in concrete.

The rubber trade uses a considerable amount of ground mica in the manufacture of tires, the mica serving as a lubricating or dusting medium during stages of manufacture. Placed between the inner tube and casing, ground mica lowers friction and prevents sticking.

CHAPTER II

STATUS OF THE CANADIAN MICA INDUSTRY

Mica mining in Canada, in point of the number of producers, has materially declined in recent years, and in 1928 not more than half a dozen mines were being actively worked. Operations, at present, are mostly confined to a few large mines, and even these are working with reduced staffs and mining is often intermittent.

Operators and dealers report a steady decline in the demand for amber mica during the past two or three years, the falling-off being particularly pronounced in the case of the larger sizes of trimmed sheet, 3 by 5 inches and over. In view of the increasing consumption of mica by the electrical industries, to which the rapid growth of the automobile, radio, and aeroplane have materially contributed, it may be difficult to understand to what the lessened demand for Canadian amber mica is to be attributed. In the first place, it seems clear that the growing production of amber mica in Madagascar is seriously affecting the Canadian trade, since Madagascar mica, both trimmed sheet and splittings, is being offered at prices considerably below those asked by Canadian producers. A survey of the mica industry in the United States, made by the writer in 1928, showed that at that time Madagascar amber mica splittings were selling, laid down and duty paid, at from 15 to 20 cents per pound less than the prices asked by Canadian dealers for comparable grades. London dealers, also, reported to the writer in 1925 that Madagascar amber mica was being offered there at prices much below those charged for Canadian mica, and that the quality and grading of the former was much superior. The superior grading is due to the fact that the Indian system of sickle-trimming is practised in Madagascar, while Canadian mica is mostly sold thumb-trimmed. The latter yields a considerable proportion of waste, whereas sickle-trimmed sheet yields little or none.

With respect to mica splittings, the lower cost of production in countries supplied with native labour enables this class of mica to be sold at a considerably lower figure than is possible for the Canadian product. That splitting costs in this country are a material factor in the lessening demand for Canadian mica is evidenced by the fact that one prominent American firm manufacturing mica insulation, which has maintained splitting shops in the province of Quebec for a number of years past, closed down operations permanently during the early part of 1928. The reported perfection of a mechanical device for splitting mica, which will supersede the old hand-splitting method, may also have a bearing on the present situation.

A further factor that is a contributory cause of the present dullness in the market for Canadian mica is that there appears to be less insistence now than formerly on the use of amber mica in electrical insulation. Amber mica was long preferred and specified for use in commutators, owing to its greater softness over muscovite mica, resulting in more even wear of the copper and mica segments. Even for this purpose, however,

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less regard is now paid to the use of amber mica, since undercutting of the mica segments permits of the use of the harder muscovite.

Yet a further factor bearing on the situation is that, despite the greatly increased use of such electrical appliances as toasters, irons, and heaters of various types in recent years, manufacturers of such articles are, to a large extent, now using built-up mica plate in their construction, in place of the large-sized, natural sheet mica formerly considered requisite. A new type of mica plate has been developed that is found to answer requirements for the above purposes satisfactorily, and being, per unit area, much cheaper than natural sheet mica effects a considerable saving in the cost of manufacture. Heater shapes may also now be built up by edge-lapping two or more pieces of natural sheet mica, previously cut to form, and securing them together by eyelets. As a result Canadian producers are finding it increasingly difficult to market their stocks of large-sized sheet mica, and are faced with the prospect of having to sell at prices greatly below those of former years or of cutting up the larger grades for conversion into splittings. Either course must entail loss, since operators have relied on the larger, high-priced grades for their principal profit.

Due to competitive sources of supply, a condition appears to have come about in the mica industry similar to that which has often arisen in other industries, where it has proved possible to replace a comparatively scarce and accordingly high-priced material, hitherto considered as essential, by a lower-priced substitute. Unless Canadian amber mica can be produced and sold at prices that will enable it to meet the competition of similar mica from Madagascar and other sources, and of muscovite, it appears doubtful whether any material improvement in the condition of the Canadian mica industry can be expected.

STATISTICAL

Production

In the following table is shown the total production of mica of all classes (sheet, ground, and scrap) in Canada from the inception of the industry to 1928.

TABLE I

Annual Production of Mica in Canada, 1886-1928

(In short tons)

Year	$	Year	Tons	$	Year	Tons	$
1886	29,008	1900	....	166,000	1914	595	109,061
1887	29,816	1901	....	160,000	1915	417	991,905
1888	30,207	1902	....	135,904	1916	1,208	255,239
1889	28,718	1903	....	177,857	1917	1,166	358,851
1890	68,074	1904	....	160,777	1918	747	271,550
1891	71,510	1905	....	178,235	1919	2,754	273,788
1892	104,745	1906	....	303,913	1920	2,203	376,022
1893	75,719	1907	....	312,599	1921	702	70,063
1894	45,581	1908	....	139,871	1922	3,349	152,263
1895	65,000	1909	369	147,782	1923	3,525	326,974
1896	60,000	1910	758	190,385	1924	4,091	357,272
1897	76,000	1911	590	128,677	1925	4,020	261,463
1898	118,375	1912	580	143,976	1926	2,545	229,204
1899	163,000	1913	1,104	194,304	1927	2,738	174,377
					1928	3,580	82,179

A greatly increased tonnage, without a proportionate increase in the value, will be noted for the year 1919. This increase, which has fallen off materially in only one year since (1921), is due to the large shipments of scrap mica that have been made during the period. Previous to 1919, only small amounts of scrap, mostly shop waste, had been marketed. With the growth of the ground mica industry, the demand for scrap increased very materially and has led to the working over in recent years of the waste dumps at many of the old, idle mica mines. These dumps have yielded large amounts of grinding scrap, as well as of the smaller sizes of thumb-trimmed mica. Accumulations of waste at old trimming shops have also been reclaimed and the production from this source has helped to swell the total.

Table II shows the production of mica in Canada by provinces, 1909 to 1928.

TABLE II

Production of Mica in Canada by Provinces, 1909-1928

Year	Quebec		Ontario		Year	Quebec		Ontario	
	Tons	$	Tons	$		Tons	$	Tons	$
1909.....	128	93,298	241	54,484	1919.....	2,429	218,437	325	55,351
1910.....	316	87,295	442	103,090	1920.....	737	281,460	1,466	94,562
1911.....	217	69,465	373	59,212	1921.....	484	41,172	218	28,891
1912.....	196	81,044	384	62,932	1922.....	1,360	97,748	1,989	54,515
1913.....	626	125,488	478	68,816	1923.....	1,545	216,684	1,980	110,290
1914.....	246	62,794	349	46,267	1924.....	1,677	185,020	2,414	172,252
1915.....	217	50,390	200	41,515	1925.....	2,415	178,800	1,605	82,663
1916.....	844	192,343	364	62,896	1926.....	1,664	170,118	881	59,086
1917.....	774	286,730	392	72,121	1927.....	2,085	107,842	1,281	74,579
1918.....	481	229,119	266	42,431	1928.....	1,277	56,180	2,303	25,999

The figures in the preceding tables relate almost wholly to phlogopite, or amber mica; the production of muscovite, or white mica, in Canada having seldom exceeded a few hundred pounds in any one year.

Returns of production showing classes of mica shipped have only been furnished since 1921. Previous to that year, the figures included cobbed and trimmed mica, splittings and scrap.

The following table shows the production of mica, by classes, 1921 to 1928:

TABLE III

Production of Mica in Canada, by Classes, 1921-1928

Class	1921		1922		1923		1924	
	Pounds	$	Pounds	$	Pounds	$	Pounds	$
Rough-cobbed	329,010	31,920	186,470	22,305	280,767	26,926	535,295	33,337
Thumb-trimmed	48,517	17,481	95,702	25,837	419,130	87,769	662,709	142,405
Splittings	20,350	15,365	112,778	72,303	210,056	176,785	164,734	137,248
Total sheet mica	397,877	64,766	394,950	120,445	909,953	291,480	1,362,738	312,990
Scrap	986,230	5,282	6,302,157	31,818	6,139,076	35,494	6,819,636	44,282
Ground mica	20,000	15	...	...	...	...	...	...
Total	1,404,107	70,063	6,697,107	152,263	7,049,029	326,974	8,182,374	357,272

Class	1925		1926		1927		1928	
	Pounds	$	Pounds	$	Pounds	$	Pounds	$
Rough-cobbed	413,500	23,471	109,880	11,724	255,925	16,943	...	...
Thumb-trimmed	357,943	73,443	322,639	64,958	443,090	72,513	91,064	16,698
Splittings	188,265	129,454	180,603	120,503	81,919	54,048	25,367	14,974
Total sheet mica	959,708	226,368	613,122	197,185	780,934	143,504	116,431	31,672
Scrap	7,080,331	35,095	4,476,405	32,019	4,696,058	30,873	7,043,795	50,507
Ground mica	...	...	...	...	...	...	...	...
Total	8,040,039	261,463	5,089,527	229,204	5,476,992	174,377	7,160,226	82,179

Exports

Exports of Canadian mica from 1906 to 1928 are shown in the following table:—

TABLE IV

Exports of Canadian Mica, 1906-1928

(In short tons)

Year	Tons	$	Year	Tons	$
1906	912	581,919	1917	636	451,345
1907	558	422,172	1918	433	410,000
1908	290	198,839	1919	2,740	641,962
1909	359	256,834	1920	3,303	824,107
1910	469	330,903	1921	1,164	224,683
1911	347	242,548	1922	3,833	464,512
1912	448	334,054	1923	5,442	757,276
1913	409	240,775	1924	4,892	543,966
1914	335	178,940	1925	5,249	411,310
1915	440	236,124	1926	4,158	499,242
1916	654	379,720	1927	4,860	326,846
			1928	4,462	175,761

Table V shows the classified exports of Canadian mica from 1920 to 1928. The figures possibly include a small amount of Indian or other foreign mica, imported into Canada by dealers for working up, and re-exported. Since the Customs classification did not separately list mica imports previous to 1925, and since the present import classification reads "mica and manufactures of," it is difficult to estimate the quantity of such foreign mica that may be included in the export figures.

TABLE V

Exports of Mica from Canada, by Classes, 1920-1928

(In short tons)

Class	1920		1921		1922		1923		1924	
	Tons	$	Tons	$	Tons	$	Tons	$	Tons	$
Rough-cobbed and thumb-trimmed	42	55,724	12	12,942	74	45,151	85	40,286	88	52,527
Splittings	522	725,946	185	195,479	286	366,974	502	624,110	285	424,503
Scrap	2,739	33,963	967	12,061	3,473	41,949	4,855	70,866	4,519	63,610
Mica plate and manufactured	......	8,474	......	4,201	......	10,438	......	22,014	......	3,326
Total	......	824,107	......	224,683	......	464,512	......	757,276	......	543,966

Class	1925		1926		1927		1928	
	Tons	$	Tons	$	Tons	$	Tons	$
Rough-cobbed and thumb-trimmed	28	21,366	44	20,516	165	54,937	32	15,951
Splittings	230	324,967	315	432,345	159	213,651	84	80,902
Scrap	4,991	63,931	3,799	45,297	4,536	57,499	4,346	78,262
Mica plate and manufactured	......	1,046	......	1,084	......	759	......	646
Total	......	411,310	......	499,242	......	326,846	......	175,761

Of the total sheet mica production in Canada in 1928 nearly 22 per cent was splittings, and of the exports, 73 per cent. The figures of value are even more striking, for in the same year the value of the splittings produced was 47 per cent of that of the total sheet mica production, while the value of the splittings exported was 84 per cent of that of the total sheet mica exports.

Table VI shows the destination of Canadian mica exports, by classes and countries, from 1920 to 1928. It is to be noted that the figures in this table and in Table VII relate to the fiscal year, while those in the other accompanying tables have reference to the calendar year.

TABLE VI

Exports of Mica from Canada, 1920-1928, by Classes, Showing Country of Destination

(Fiscal years ending March 31st)

Class	Destination	1920		1921		1922		1923		1924		1925		1926		1927		1928	
		Cwt.	$	Cwt.	$	Cwt.	$	Cwt.	$	Cwt.	$	Cwt.	$	Cwt.	$	Cwt.	$	Cwt.	$
Rough-cobbed and thumb-trimmed	United Kingdom	806	46,981	183	15,969	64	4,853	135	4,066	58	3,271	105	10,266	102	8,262	......	16	36	3,060
	British India	129	153,355	20	400	......	......	......	......	......	......	......	......	......	......	......	......	10	210
	Newfoundland	1	65	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	France	......	......	32	2,115	38	2,125	......	......	44	2,156	14	769	46	2,355	1	72	3	125
	Germany	......	......	......	......	......	......	......	......	......	......	20	182	......	......	17	228	38	525
	Japan	......	......	......	......	2	110	......	......	......	......	......	......	......	......	......	......	......	......
	United States	1,678	40,729	211	12,156	247	7,295	1,325	45,449	2,291	48,290	877	22,141	336	9,060	1,312	27,326	3,041	47,393
	Total	2,614	241,130	446	30,640	351	14,383	1,460	49,515	2,393	53,717	1,016	33,358	484	19,677	1,330	27,642	3,128	51,313
Splittings	United Kingdom	73	6,430	332	28,600	273	16,973	250	15,289	256	18,134	304	23,912	105	7,635	231	14,830	150	11,025
	British India	......	......	2	130	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Chile	21	1,075	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	France	......	......	......	......	......	......	12	1,200	64	5,690	39	3,915	......	......	6	468	......	......
	Italy	......	......	......	......	......	......	......	......	13	500	......	......	......	......	......	......	......	......
	United States	9,953	502,479	7,875	565,396	2,778	177,931	6,574	451,497	9,305	571,434	4,609	337,033	5,650	395,522	5,152	346,973	2,117	140,259
	Total	10,047	509,984	8,209	594,126	3,051	194,904	6,836	467,986	9,638	595,758	4,952	364,860	5,755	403,157	5,389	362,271	2,267	151,284
Scrap and waste	Germany	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	11	60
	United Kingdom	......	......	......	......	......	......	45	71	88	179	44	90	22	45	112	215	135	240
	United States	55,072	21,548	48,263	27,625	27,161	15,876	83,462	51,476	97,287	74,406	79,919	55,663	94,342	58,594	83,837	50,029	81,522	54,841
	Total	55,072	221,548	48,263	27,625	27,161	15,876	83,507	51,547	97,375	74,585	79,963	55,753	94,364	58,639	83,949	50,244	81,668	55,141
Mica plate and manufactures of mica	United Kingdom	......	......	......	481	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Newfoundland	......	......	......	......	......	......	......	254	......	......	......	......	......	......	......	......	......	......
	New Zealand	......	......	......	......	......	......	......	......	......	150	......	......	......	......	......	......	......	......
	Brazil	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	225	......	......
	Mexico	......	......	......	......	......	......	......	......	......	......	......	......	......	100	......	536	......	100
	France	......	......	......	1,500	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Norway	......	......	......	......	......	924	......	2,426	......	3,274	......	......	......	......	......	......	......	......
	United States	......	1,707	......	5,846	......	4,342	......	17,696	......	10,360	......	271	......	829	......	496	......	781
	Other countries	......	......	......	......	......	......	......	......	......	7	......	50	......	......	......	......	......	......
	Total	......	1,707	......	7,827	......	5,266	......	20,376	......	13,791	......	321	......	929	......	1,257	......	881

As will be seen from the preceding table, the bulk of the mica exported from Canada finds a market in the United States. Practically all of the scrap mica exported is consigned to American grinding mills. A considerable proportion of the exports of electrical mica represents the production from the large mine of the General Electric Company, at Sydenham, Ont.; this mica is trimmed and split in Canada for consignment to the company's works at Schenectady, N.Y.

Great Britain is Canada's next best customer, with France as the only other country receiving regular shipments. Part of the British imports, doubtless, is re-exported to the Continent through London brokerage houses.

Imports

Table VII shows the unclassified imports of mica into Canada from 1925 to 1928, with the country of origin. The imports from British India and Madagascar may be taken as representing trimmed sheet and splittings; those from other countries probably include manufactures of mica.

TABLE VII

Value of Imports of Mica and Manufactures of Mica into Canada, 1925-1928, with Country of Origin

(Fiscal years ending March 31st)

—	1925	1926	1927	1928
	$	$	$	$
United Kingdom	5,202	9,232	9,335	18,293
British India	59,261	29,342	27,595	13,878
France	41	....	....	....
Madagascar	403	3,968	....	....
Germany	145	4,610	139	240
Switzerland	225	220	....	162
United States	89,431	75,333	92,624	67,466
Total	154,708	122,705	129,693	100,039

Statistics relating to power, labour, wages, etc., in the mica industry may be found in Annual Report on the Mineral Production of Canada, 1927, pp. 264-9, 362, published by the Dominion Bureau of Statistics.

CHAPTER III

WORLD'S SUPPLY AND PRODUCTION OF MICA

For many years past, the greater part of the world's supply of mica has been received from three main sources—India, the United States, and Canada.

Up to some ten years ago, mica production figures for all other countries except the United States might be regarded as relating mainly to sheet mica in some form, principally for use in the electrical industries. Some also went to the stove and other trades, but, in any event, production figures referred to a more or less similar grade of material. With the growth of the ground mica industry, however, tables of production showing only total quantities, without indicating the proportion of scrap and ground mica, might give a false impression of the relative importance of the different producing countries as producers of electrical mica. For example, the quantity of mica produced in Canada in 1921 was reported as 702 tons valued at $70,063. In 1922 the quantity increased nearly five times, to 3,349 tons, through the inclusion in this total of 3,156 tons of scrap mica, most of which was consigned to American grinding mills. The value of the 1922 production, however, was only $152,263, or little more than double that of the previous year.

With the proper allowance made for such considerations, India is seen to have been, for many years, the world's premier producer of sheet (electrical) mica. Even in the case of the Indian statistics there is a wide variation between production figures and export figures, due, it is claimed, to the large amount of mica stolen from the mines. This mica is disposed of to receivers, and finds its way into export channels, but does not figure in the returns of production. It has been estimated that the quantity of mica reported in the Indian official returns of production represents only about 50 per cent of the actual output.[1] This would seem to be borne out by the official figures, for, in 1925, exports of mica from India were reported as nearly 5,000 tons valued at approximately £800,000, while production totalled only 2,300 tons valued at £165,000. For the above reasons, statistics of production of Indian mica are usually given in terms of exports, since it is felt that these give a truer index of the actual output.

The United States follows India in point of production of sheet mica, with Canada and Madagascar competing for third place. India and the United States produce muscovite exclusively, while Canada's output is practically all amber mica, or phlogopite.

Of the other countries producing mica, the Union of South Africa and Russia reported the largest output in 1927—1,660 long tons and 1,496 long tons, respectively. Japan reported 1,065 long tons in 1925, but more recent

[1] See "Mica and Its International Relationships—Discussion", by G. V. Hobson, Bull. Inst. Min. Met., 271, April 1927, pp. 20, 24.

statistics are lacking. In the case of all three of these countries, no exact figures are available that indicate the proportion of sheet mica contained in the totals, but it is known that the recorded output relates to run-of-mine production and not to trimmed sheet.

In recent years, Madagascar has come rapidly to the fore as a producer of high-grade sheet mica, both amber and white, and increasing amounts of trimmed sheet and splittings have been coming on the market. It is, indeed, considered that the competition of Madagascar phlogopite mica is responsible in large measure for the present marked decline in the demand for Canadian amber mica. Although the mica of some of the Madagascar phlogopite deposits is stated to be unsuitable for certain electrical purposes owing to its property of swelling when heated, increasing quantities of superior sheet mica are being produced. This mica is sickle-trimmed and can be laid down in London and New York at prices materially below those asked for Canadian mica of similar or even lower grade. Due to cheap labour, also, Madagascar splittings are able to undersell the Canadian product.

The Union of South Africa has also increased its production of mica very considerably during the last few years, and Southern Rhodesia and Tanganyika are also reporting a growing output. Most of the mica from these sources is believed to be muscovite.

During the last ten years, due, in part, to the acute mica shortage experienced during the war and to the growing recognition of the importance of mica as an essential material for the electrical industries, increasing interest has been taken in the commercial possibilities of mica deposits throughout the world. As a consequence promising occurrences have been reported, and in some cases are being developed, in a number of countries, particularly in various parts of Africa. The rapid opening up of the African continent by railroad transportation seems likely to result in an increasing production of mica from African sources.

Table VIII shows the world's production of sheet (electrical) mica from 1921 to 1927. As already pointed out, the inclusion of scrap and ground mica in production totals obscures the issue and does not give a true index of the industry. Accordingly, where known, the amount of ground or scrap mica has been omitted and the figures given relate to sheet mica (rough-cobbed, trimmed, and splittings) only. In the case of the United States and Canada, the official returns report sheet mica separately, so there is no difficulty. For the Union of South Africa, Hobson[1] has estimated that not more than 20 per cent of the reported production represents sheet mica, and, accordingly, the figures have been computed on this basis. Little information is available respecting the mica industry in Japan, whose reported production rose from 15 tons in 1922 to 1,065 tons in 1925. A communication from the Director of the Japanese Bureau of Mines, dated October 8, 1928, states, however, that the Japanese production is " powdery and of low grade, while that of Chosen is platy and of high grade." It has been assumed, accordingly, that only a small proportion—estimated for the purpose of this report at 10 per cent—of the Jap-

[1] Hobson, G. V.: "Mica and Its International Relationships". Bull. Inst. Min. Met., 270, March 1927, pp. 6-12.

anese output represents sheet mica suitable for electrical purposes, and the figures in the table have been computed on this basis.

Little is known about the Russian mica industry, and it is only in the latest report of the Imperial Institute, issued in 1928, that production figures have been given for that country. Advice received from the Director of the Geological Committee of the United States of Soviet Russia, however, indicates that only about 10 per cent of the total recorded output consists of sheet mica, and, accordingly, this proportion has been inserted in the table.

TABLE VIII

World's Production of Sheet Mica, 1921-1927*

(In long tons)

—	1921	1922	1923	1924	1925	1926	1927
British Empire—							
Northern Rhodesia	....	....	....	....	1	4	8
Southern Rhodesia	76	66	81	134	130	163	183
Tanganyika (a)	3	11	32	55	68	52	42
Union of South Africa (c)	....	....	3	178	211	226	332
Canada	178	176	406	608	428	274	349
Ceylon (a)	5	1	1	....	....	....	....
India (a)	1,547	2,992	4,165	3,505	4,985	4,497	3,874
Australia	....	4	....	2	4	7	9
Total	1,809	3,250	4,688	4,482	5,827	5,223	4,797
Other Countries—							
Norway (a)	2	1	....	....	23	41	6
Sweden	....	8	5	4	93	52	10
Russia (d)	(b)	8	(b)	(b)	19	48	150
Spain	2	....	3	....	....	....	....
Madagascar	152	91	162	281	282	325	338
United States	331	481	921	651	801	970	675
Argentina (a)	145	63	100	118	117	83	75
Brazil (a)	45	66	55	78	64	51	39
Guatemala	....	....	....	....	16	12	(b)
Japan (d)	....	2	42	58	106	(b)	(b)
Chosen (Korea)	....	....	11	23	20	16	(b)
Total	677	720	1,299	1,213	1,541	1,598	1,293
Grand total	2,486	3,970	5,987	5,695	7,368	6,821	6,090

* Figures based on Statistical Summaries of the Imperial Mineral Resources Bureau (Imperial Institute).
(a) Exports.
(b) Information not available.
(c) 20 per cent of total production estimated as sheet mica (see text).
(d) 10 per cent of total production estimated as sheet mica (see text).

From the above table, it appears that in the year 1927, about 79 per cent of the world's total output of sheet mica was produced within the British Empire. Of the world's total, in the same year, Canada produced 5·7 per cent, and of the Empire total, 7·3 per cent.

The United States and Canada are the only countries definitely reporting important amounts of scrap mica. It has been estimated,[1] however,

[1] Hobson, G. V.: loc. cit.

that about 80 per cent of the total reported mica production of the Union of South Africa consists of exported scrap, and accordingly the figures given in the next table have been computed and entered on that assumption. Most of the Canadian phlogopite scrap is exported to the United States, where it is dry-ground, principally for roofing purposes and the rubber trade. Being dark in colour, it is not acceptable to the wall-paper trade, which employs only a superfine grade of wet-ground muscovite.

Enormous accumulations of muscovite scrap exist in India, but little or no attempt has been made to utilize or find a market for the material.

TABLE IX

World's Production of Waste or Scrap Mica, 1921-1928

(In short tons)

—	1921	1922	1923	1924	1925	1926	1927	1928
United States............	2,577	6,641(a)	8,054(a)	4,709	9,695	7,043	6,280	5,800 (c)
Canada..................	493	3,151	3,070	3,410	3,540	2,144	2,348	3,522 (c)
Union of South Africa (b).	......	....	13	797	944	1,012	1,487	....
Total............	3,070	10,792	11,137	8,916	14,179	10,199	10,115	....

(a) Includes mica recovered from mica schist.
(b) Quantities computed on basis of 80 per cent of total recorded production.
(c) Preliminary figures.

The average value of Canadian scrap mica during the period 1921-1927 ranged from \$9.91 per ton in 1925 to \$13.15 per ton in 1927, the mean for the whole seven-year period being \$11.54. American scrap mica during the period 1921-1927 sold at an average price of from \$16.10 per ton in 1923 to \$22.06 in 1921, the mean for the entire seven-year period being \$18.45.

MICA IN FOREIGN COUNTRIES

Data regarding the occurrence and mining of mica in countries other than the three major producers, India, United States, and Canada, are somewhat meagre. The following notes are taken principally from the publications listed in the footnote.[1] Where other sources of information have been used, references to the publications are given in the text.

NORTH AMERICA

UNITED STATES

The United States is the world's second largest producer of sheet (electrical) mica, ranking next to India.

All the electrical mica produced in the United States is muscovite, no important deposits of phlogopite being known.

[1] Mineral Industry, Annual Volumes.
Mica, War Period (1913-1919), Bulletin Imperial Mineral Resources Bureau, 1922.
Mica, by W. M. Myers, Information Circular No. 6044, U.S. Bureau of Mines, 1927.
Mica and Its International Relationships, by G. V. Hobson, Bull., Inst. Min. Met., March 1927.

A large scrap mica industry exists, domestic mine and shop scrap being shipped to grinding mills, which produce a variety of grades of mica powder for various purposes. These mills also utilize considerable foreign scrap, obtained principally from Canada and South Africa. In addition, mica schist and similar rock is mined and milled for its flake mica content.

Lepidolite, or lithia mica, is mined for its lithia content and for use in the glass industry. This mica is found in the form of compact masses of small flakes, there being no recorded occurrences of sheet lepidolite similar to that from Western Australia.

An altered, hydrous phlogopite known as jefferisite is mined in Montana, and marketed under the trade name of "zonolite" for heat-insulating, sound-deadening, and paint purposes.

Deposits of mica occur in many states of the Union, but active production[1] in 1927 was confined to the following eleven states: New Hampshire, North Carolina, New Mexico, South Dakota, Virginia, Georgia, Colorado, Alabama, Maine, Nevada, and Connecticut. The 1927 sheet mica production showed a decrease in quantity of 30 per cent and in value of 47 per cent, as compared with that of 1926.

The largest quantity of sheet mica (*see* Table XI) is produced by New Hampshire, which, in 1927, sold 48 per cent of the total. North Carolina, in the same year, accounted for 44 per cent of the total sheet mica sales, so that these two states supplied 92 per cent of the country's total output of sheet mica.

The following table shows the quantity and value of sheet and scrap mica sold by United States producers from 1918 to 1928:

TABLE X

Production of Mica in the United States, 1918-1928

—	Sheet mica		Scrap mica		Total	
	Short tons	$	Short tons	$	Short tons	$
1918	822	731,810	2,292	33,130	3,114	764,940
1919	773	483,567	3,258	58,084	4,031	541,651
1920	842	546,972	5,723	167,017	6,565	713,989
1921	371	118,513	2,577	56,849	2,948	175,362
1922	539	194,301	6,641	114,045	7,180	308,346
1923	1,032	311,180	8,054	129,695	9,086	440,875
1924	730	212,035	4,709	87,242	5,439	299,277
1925	897	321,962	9,695	173,537	10,592	495,499
1926	1,086	400,184	7,043	136,643	8,129	536,827
1927	756	212,482	6,280	110,139	7,036	322,621
1928 (a)	810	259,200	5,800	104,400	6,610	363,600

(a) Preliminary figures.

Table XI shows the quantity and value of sheet and scrap mica produced in the two principal producing states, New Hampshire and North Carolina, from 1923 to 1927:

[1] Mineral Resources of the United States, "Mica in 1927," Bureau of Mines, 1929.

TABLE XI

Production of Mica in the Two Principal Producing States, 1923-1927

Year	Sheet mica: Short tons	Sheet mica: $	Scrap mica: Short tons	Scrap mica: $	Total: Short tons	Total: $
	New Hampshire					
1923	418	107,674	1,078	25,871	1,496	133,545
1924	372	88,737	492	9,498	864	98,235
1925	560	198,858	1,953	47,525	2,513	246,383
1926	686	235,890	1,738	38,213	2,424	274,103
1927	360	78,849	1,284	22,909	1,644	101,758
	North Carolina					
1923	565	188,317	5,005(a)	65,764	5,570(a)	254,081
1924	299	108,656	3,212	59,620	3,511	168,276
1925	296	105,376	5,095	74,818	5,391	180,194
1926	350	150,362	2,880	54,048	3,230	204,410
1927	333	114,514	2,995	50,505	3,328	165,019

(a) Includes flake mica recovered from mica schist.

The following notes on mica-mining operations in 1927 indicate the extent of the industry in the chief producing states.[1]

Colorado

Scrap mica only was produced in Colorado, the output being derived from mines near Jamestown, in Boulder county, and Golden, in Jefferson county.

Connecticut

A small amount of mine-run mica was sold from a property near Portland, in Middlesex county.

Georgia

A small output was reported from one mine, situated near Hollysprings, in Cherokee county. Chlorite schist has been mined and ground at Canton, Cherokee county, for some years past.

Maine

Mining of a clear, amber-coloured muscovite was conducted at a mine near Hebron, in Oxford county.

New Hampshire

The average value of sheet mica produced in New Hampshire in 1927 was 11 cents per pound, and the average value of scrap mica, $18 per short ton.

[1] For further information relating to the occurrence, etc., of mica in the United States, *see* Sterrett, D. B.: "Mica Deposits of the United States", Bull. No. 740, U.S. Geol. Surv. (1923).

Most of the production is derived from mines situated near Alexandria, Dorchester, Grafton, and Orange, in Grafton county; Alstead and Gilsum, in Cheshire county; and Springfield, in Sullivan county. The mica-bearing belt extends in a northeasterly direction from Surrey, in Cheshire county, to Easton, in Grafton county. Most of the mica obtained from the various mines in the state is handled in and around the towns of Keene, Rumney Depot, Alexandria, and Bristol.

The earliest mica mining in the United States was conducted in New Hampshire, the Ruggles mine, in Grafton county, having been opened in 1803; it is still in operation.

New Mexico

New Mexico produced a small quantity of sheet mica and an unstated tonnage of scrap mica in 1927. The deposits are situated near Ojo Caliente, in Taos county, and Las Tablas, Petaca, and La Madera, in Rio Arriba county.

North Carolina

The production of North Carolina sheet mica in 1927 decreased 5 per cent in quantity and 24 per cent in value over that of 1926. Sales of scrap mica increased 4 per cent over those of 1926, and represented 48 per cent of the total scrap sold by American producers. The average value of the sheet mica sold was 17 cents per pound, and of the scrap, $17 per ton.

Most of the production comes from mines situated near Spruce Pine, Estatoe, Franklin, and Penland, in Mitchell county; Newdale and Celo, in Yancey county; Crabtree and Waynesville, in Haywood county; and from deposits in Avery, Macon, and Catawba counties. The principal centres for handling the mica produced in the state are Spruce Pine, Franklin, and Asheville.

Previous to 1924, when New Hampshire took the lead, North Carolina was the principal producing state for sheet mica; it is still the largest producer of scrap mica. A considerable portion of the output is obtained as a by-product from feldspar mining operations in the Spruce Pine district, and there has been a recovery of a considerable tonnage of small flake mica from kaolin washing plants.

Most of the mica recovered from kaolin waste is simply screened to the desired mesh size and sold to the roofing trade.

There is considerable production of ground mica in the state. Most of the grinding is done in wet mills which run on mine and shop scrap, residual mica obtained by washing operations on weathered pegmatitic stringers rich in flake mica, and mica schist.

South Dakota

The mica production of South Dakota consists mostly of scrap, sales of which increased in 1927. The 1926 scrap output was 835 tons. Only a few hundred pounds of sheet mica were produced in 1925 and 1926, the output coming from near Custer; no production was reported in 1927.

Most of the scrap sold represents by-product material obtained during mining operations for feldspar and lithium minerals.

Virginia

There was a small output of sheet and scrap mica in 1927 from a mine near Martinsville, in Henry county, and also in Amelia county.

Other States

Other states possessing deposits of muscovite mica are Arizona, Idaho, Montana, Wisconsin, Wyoming, and Texas, but there is little, if any, present production from these sources.

Lepidolite. The United States contains important deposits of lepidolite, or lithia mica; most of the production comes from New Mexico, California, and South Dakota. Mining for lepidolite in New Mexico is conducted at Camp Harding, near Dixon and Rinconada; in California, at Pala, San Diego county; and in South Dakota, near Keystone. The discovery of an extensive body of lepidolite near Leavenworth, Washington, has been reported.[1] The whole of the production is utilized in the chemical and glass industries.

Vermiculite. An altered mica, termed variously vermiculite or jefferisite, is found near Libby, Montana.[2] It occurs in small- to medium-sized plates and is useless for any of the ordinary purposes to which mica is put. It, however, possesses the unusual property of expanding to many times its original volume when heated, and it can be converted, by suitable heat treatment, in either an oxidizing or reducing atmosphere, to an exceedingly light, golden- or silver-coloured powder. A plant to treat this mica was erected near Libby a few years ago, the finished product being marketed under the name of "zonolite." It is claimed that it serves as an excellent heat insulator, possesses great sound-deadening properties, and can be used to advantage for various ornamental purposes, as well as in lubricants and oil refining. Other deposits of this variety of mica are reported from near Westcliffe and Hecla, in Colorado, and from Casper, Wyoming.

GUATEMALA

Muscovite mica is reported to occur at a number of localities in Guatemala, but only a limited amount of mining has been undertaken. Most of the mica obtained has come from the Departments of El Quiche and Baja Verapaz, the mines lying 40 miles distant from Guatemala City. White, green, and dark amber-coloured muscovite is mined. In 1928, the United States imported nearly 13 tons of mica from Guatemala, most of which was trimmed sheet. This quantity constituted practically the entire production.[3]

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[1] Eng. Min. Jour., vol. 122, No. 12, Sept. 18, 1926, p. 468.
[2] *See* p. 115; *also* U. S. Geol. Surv., Bull. 805-B (1929).
[3] U.S. Commerce Reports, April 15, 1929, p. 160.

MEXICO

A small intermittent production of muscovite mica is recorded from Mexico. Phlogopite also exists and has been worked on a limited scale.

NEWFOUNDLAND

Muscovite is known to occur at various places in Newfoundland and on the adjacent territory of Labrador. No systematic mining is known to have been conducted in recent years, and the only production is believed to consist of small amounts secured intermittently by trading ships.

SOUTH AMERICA

ARGENTINA

Argentina produces a small tonnage of muscovite mica. Numerous deposits are known, the most important lying in the provinces of San Luis, Cordoba, San Juan, Salta, and Catamarca. The principal mines are situated near La Tomo, in San Luis, and Calamuchita in Cordoba. Despite the number of known deposits, mica mining has not become an established industry and operations are of an intermittent and primitive character.

Previous to the war, the average annual production of sheet mica was about 10 tons, much of which found a domestic market. Production for export was greatly stimulated in 1917, when the output rose to 70 tons. The largest recorded production was in 1920, when 269 tons were exported. In 1926, the United States imported 50 tons of mica from Argentina.

BRAZIL

Small amounts of muscovite mica have been mined in Brazil for a number of years. The mineral is widely distributed, but remoteness of the deposits and lack of communication have prevented development of the deposits on any important scale. The most important workings are situated in the Cayama and Popogais mountains, in the vicinity of Santa Luzia de Carangola, and in the Espera Feliz district, in the State of Minas Geraes, where mica has been mined intermittently for the last thirty years; near Santa Maria de Felix; in the São José do Tocantins and Meia Ponte districts in the State of Goyaz; at a number of localities in São Paulo; and on the Braço Grande river, near Juguitiba.

Much of the Brazilian mica is ruby muscovite. The pegmatite dykes have suffered intensive weathering and are kaolinized to a considerable depth, so that the mica can be easily and cheaply won, but much of this surface mica is of inferior quality.

Exports of mica from Brazil have averaged about 50 tons per annum since 1920.

AFRICA

ABYSSINIA (ETHIOPIA)

Muscovite deposits are known to exist in Abyssinia, and in 1924 a concession to exploit the occurrences was granted. The concessions are located in the Haossa, Guinner, Wollaga, and Harrar districts, covering an area of 540 square kilometres. There is no record of any important production from this source.[1]

[1] *See also* Eng. Min. Jour., vol. 125, No. 7, Feb. 18, 1928, p. 285.

BRITISH SOMALILAND

Numerous muscovite occurrences are reported in the foothills, and on the northern and northwestern slopes of the Mirsa plateau, 30 miles south of Berbera, and at the base of the Golis range as far west as Mandera. No mining of these deposits is known to have been undertaken.

KENYA COLONY

Development of mica deposits in East Africa Protectorate (Kenya Colony) was commenced under Governmental control during the war. Mining was conducted at Sultan Hamud and at Chuka, on the slopes of mount Kenya. Only a few tons were produced and 2 tons of trimmed sheet were exported to England. Operations ceased when the war ended, and no further mining has been recorded.

MADAGASCAR

Madagascar[1] has come rapidly to the fore in recent years as a producer of both muscovite and phlogopite mica. Previous to 1919, the mica resources of the country had attracted little attention, and the annual output was only from 1 to 4 tons. The production rose to 18 tons in 1919, and has continued steadily to increase until, in 1927, it totalled 338 tons, all of which is believed to be sheet mica.

The output of phlogopite has shown by far the greatest increase, whilst that of muscovite has remained fairly stationary. Madagascar now probably is fourth among the world's producers of sheet mica, and ranks second, after Canada, in the production of phlogopite. The proportion of phlogopite to muscovite, of the total mica produced, is indicated by the following table of exports:

TABLE XII

Mica Exported from Madagascar, 1919-1927

(In metric tons)

Year	Phlogopite	Muscovite	Total
	Tons	Tons	Tons
1919	1	(a)	....
1920	34	(a)	....
1921	93	(a)	....
1922	43	36	79
1923	70	62	132
1924	163	48	211
1925	230	37	267
1926	273	23	296
1927	506	38	544

(a) Information not available.

[1] Bulletin des Mines de Madagascar, March 1923, pp. 48-9; Feb. 1924, p. 30; July 1925, pp. 107-11: Bulletin Economique Mensuel, Jan.-March 1926, pp. 82-3.
Mining Journal (London), Oct. 16th, 1920, p. 790.
Commerce Reports, U.S. Department of Commerce, Sept. 10th, 1928, p. 679.

The above figures illustrate the very considerable increase in the mica production of Madagascar in the nine-year period of 1919-27. The figures are believed to relate principally to sheet mica. The large increase in the production of phlogopite during the last few years has not been without effect upon the Canadian mica industry, the present depression in which is held to be largely due to the competition of Madagascar phlogopite.

The greater part of the mica exported is consigned to France, the remainder going chiefly to the United States and England. Practically all shipments of high-grade muscovite go to France, the exports to other countries being classed as "phlogopite and other mica."

In 1926, mica ranked second in value of all mineral exports. The following table shows the amount of mica of the various grades exported in 1926, and indicates the system of sizing:

TABLE XIII

Mica Exported from Madagascar in 1926, by Classes

(In metric tons)

Size	Muscovite	Phlogopite	Total
	Tons	Tons	Tons
No. 1, over 155 sq. cm.	1	6	7
No. 2, 40 to 155 sq. cm.	3·5	19·5	23
No. 3, 6 to 40 sq. cm. and splittings	18	216	234
No. 4, scrap, etc.	0·5	31	31·5
Total, tons	23	272·5	295·5
Value, francs	699,600	3,208,800	3,908,400

About 75 per cent of the mica deposits of the island are said to be controlled by a single syndicate, the Société des Minérais de la Grande Ile, which took over the more important phlogopite properties in 1926.

The phlogopite deposits of Madagascar lie in the extreme south of the island, in the provinces of Fort Dauphin and Betroka, and principally in the first-named. The most important mines are those of Ambatoabo, Sahakara, and Elakelaka. The deposits evidently possess much similarity with those of Canada, and are associated with pyroxenites, crystalline limestones and gneiss of Precambrian age. As in Canada, apatite, sphene, and scapolite are common accessory minerals, and the veins are pockety and often contain large cavities formed by the leaching out of soluble mineral matter. The principal mineral of the enclosing pyroxenites is a light-coloured, aluminous diopside, classed as leucaugite.

Only superficial weathering of the rock has taken place in this section of the island, and the laterite cover is seldom more than a few feet thick. Consequently, mining operations have to be conducted in hard rock, in direct contrast to those on the muscovite deposits in the more northerly

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districts. The chief obstacles to a more intensive development of the mica deposits of this region are the climate, and the lack of transportation and labour.

Numerous occurrences of muscovite mica are known in the high plateau region forming the central portion of the island. Mining for muscovite has been conducted chiefly in the Lake Alaotra district, province of Moramanga, and in the provinces of Ambositra and Fianarantsoa. The rocks of this region have been very deeply weathered, and the mica is recovered from the loose, unconsolidated laterite by pick and shovel methods.

Lepidolite is found at several localities. At Maharitra, it occurs in plates up to 8 inches across, the colour being a pale violet; small, spangle lepidolite also occurs at this locality. Colourless lepidolite, in sheets up to 4 inches across, occurs in the Antaboaka district, while large plates of a rose shade are found near Ampangaba. The lithia content of the Madagascar[1] lepidolite ranges from 4·7 to 5·4.

NYASALAND

Small amounts of surface mica have been produced from time to time in the district around the southwest part of lake Nyasa, in northern Augoniland, and in the Upper Shire, Dedza, and North and South Nyasa districts. There are no records of output.

RHODESIA

A small production of mica was reported from the Susaka district, Northern Rhodesia, previous to 1920, but there was no recorded output from that year until 1925, when a few hundred pounds were produced. There was an increase to 4 tons in 1926, and a further increase to 8 tons in 1927. In Southern Rhodesia, however, there is a rapidly growing mica industry, and from 5 tons in 1919, the production has risen to 183 tons in 1927. An output of 152 tons is reported for the first nine months of 1928.[2]

The principal mines in Southern Rhodesia are situated in the Lomagundi district, between the Mwami and Mwichi rivers, on the western flank of the Angwa River basin, and the known mica-bearing area covers about 40 square miles. The deposits are pegmatites carrying muscovite mica.[3]

Muscovite also occurs in the Tuli district, near the Limpopo river, and in the Urungwa district in Mashonaland.

Deposits of lepidolite, or lithia mica, are reported to occur south of Umtali, and in the Victoria, Belingwe, and Salisbury districts. A production of 19 tons of lithium mica was reported in 1927.

[1] For a description of the mica occurrences in Madagascar, *see* A. Lacroix, Minéralogie de Madagascar, 1922, vol. I, pp. 473–480; vol. II, pp. 143–7.
[2] Mining Journal, Jan. 26, 1929, p. 64.
[3] Southern Rhodesia, Geol. Surv., Short Report No. 10, 1920.

TANGANYIKA TERRITORY

Important deposits of muscovite mica occur in Tanganyika (formerly German East Africa). Development of the deposits was commenced under German rule and considerable amounts of mica were mined and exported to Germany. The mines were worked under the control of the British Government from 1917 to 1920, and a total of 146 tons of mica, estimated to be valued at about $200,000, was exported. Since 1924, under private operation, Tanganyika mines have produced an average of 50 tons of mica per annum. The quality of the mica is high, and, the deposits being fairly accessible, it is expected that the territory will become an increasingly important source of the world's supply.

The principal deposits are found in the Uluguru mountains, in the region bordering the river Mbakana, a tributary of the Mgeta, and in the district north of Morogoro. Certain of the deposits yield dark green muscovite, and others a brown shade, both of first quality.

UNION OF SOUTH AFRICA

Mica mining in this territory is a comparatively recent development, and previous to 1923 only a small annual output was recorded. Between 1910 and 1912, there was considerable mining activity in the two mica fields near Mica Siding and Malelane, in the Transvaal, but the results were not encouraging and by 1916 all the properties had closed down. A revival of interest in the deposits led to a resumption of mining in 1917, but it was not until 1924 that any important tonnage was recorded. In that year, a production of 892 tons was reported and this has grown to 1,660 tons in 1927. It is stated, however, that these quantities included a large amount of scrap mica, which was shipped to the United States for grinding purposes, and it has been estimated that only about 20 per cent of the reported production consists of sheet mica (*see* page 16).

Transvaal

All of the production consists of muscovite mica, and most of the output comes from the Leydsdorp field, along the northern bank of the Olifants river, in the Pietersburg district. Most of the mines are located within a radius of 50 miles of Mica Siding, on the Selati railway, from which point shipment is made to the port of Laurenço Marques. The mica-bearing belt[1] extends for a distance of about 50 miles and has a width of from 2 to 4 miles.

A shipment of 500 tons[2] of scrap mica was made to the United States in 1924 for grinding purposes, and this amount is included in the total production figure for that year. The largely increased production figures for subsequent years, also, evidently relate chiefly to scrap mica.

The mica exports include a small quantity of manufactured mica, in the shape of disks, rings and washers, and there is a small micanite industry in Johannesburg.

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[1] Union of South Africa, Geol. Surv. Memoir No. 13, 1920; Mining Magazine, May 1916, p. 269.
[2] Bull. Imp. Inst., vol. 24, 1926, p. 557. South African Jour. Ind., Dec. 1924, pp. 798–801.

Cape Province

A small amount of muscovite mica has been produced from deposits near Jackals' Water, in Little Namaqualand, and the Prieska and Gordonia districts are reported to possess promising occurrences.

Natal

Mica has been worked in a small way in the Umfuli valley, and near Fort Yolland, on the Mvuzana river, but there is no record of any important production.

ASIA

CEYLON

Ceylon is one of the few countries that are known to possess deposits of phlogopite mica. The mica is reported to occur in veins in crystalline limestone, and the deposits would thus appear to possess a genetic similarity to the Canadian phlogopite occurrences.

A small amount of mining was done prior to 1918, but the first systematic attempt to develop the deposits was made in that year. The Ceylon Government took an active part in the operations, which resulted in a small production of mica of excellent quality in the years 1918-1921. The cost of production, however, was found prohibitive, chiefly due to the irregular nature and small size of the deposits, and mining has now virtually ceased. The greatest recorded production was in 1920, when 15 tons were exported.

CHINA

Little is known respecting the mica resources of China, though the country is credited with possessing economic deposits of muscovite. Sporadic attempts to develop certain of these occurrences are reported, but it is not believed that systematic mining has ever been undertaken on an important scale and there is no recorded output. Among the localities where mica has been worked is Sungpanting, in Szechwan province.

Small amounts of mica are mined by the Chinese for ornamental purposes and windows; the mineral is also believed to possess the property of curing disease and is employed in the form of powder as a medicine. Mica is known in China, Japan, and Chosen by the name "ummo," signifying "mother of cloud," and Oriental imagination has led to fantastic conceptions being held concerning its origin.

CHOSEN (KOREA)

Data relating to mica mining in Chosen (Korea) are meagre and there would appear to be some confusion over statistics of production. Hobson[1] gives the output in the years 1923 and 1924 as 424 and 582 tons respectively, while the Imperial Institute reports[2] credit these amounts to Japan. According to the same reports, the annual Chosen mica production for the

[1] Bull. Inst. Min. Met., March 1927, p. 7.
[2] Imperial Institute, Statistical Summaries, 1926 and 1927.

four-year period 1923-26 averaged 17·5 tons, with a low of 11 tons in 1923 and a high of 23 tons in 1924. The total presumably included both muscovite and phlogopite. Small amounts of high quality phlogopite are reported to have been reaching the market from Chosen during the last few years. The following notes on mica in Chosen are taken from a report[1] of the Chosen Government.

Systematic mining for mica in Chosen was first undertaken in 1909 by the Japanese. The attempts did not prove successful and in a short time nearly all the mines were closed down. A few tons of mica are reported to have been exported to England and Japan between 1909 and 1911.

Both muscovite and phlogopite mica occur, and both varieties have been mined. The phlogopite occurs in pockety bodies, upon which small surface pits have been opened and abandoned as soon as the pocket was exhausted. Most of the mica produced appears to have been phlogopite, but the amount of clear, saleable sheets secured is stated to have been small; a large proportion of the mica mined consisting of crushed or otherwise imperfect material. Lack of transportation has added to the difficulties of operation, many of the deposits being situated in remote localities. As in Canada, the phlogopite mica is found associated with pyroxenite and altered limestones of Precambrian age. These rocks are developed chiefly along the Machonnyong mountains, which extend northward from the treaty port of Joshin, in the northeast portion of Chosen. Muscovite, on the other hand, is found at many places in the gneiss and granite areas which make up the greater part of the country. Most of the mica produced is stated to come from the Kankyonando district.

COCHIN INDIA

A fine quality of phlogopite mica occurs in Cochin India and there has been a small production.

INDIA

India produces about 70 per cent[2] of the world's supply of sheet mica, practically all of which is exported in the form of cut sheet and splittings. Little, if any, mica plate is manufactured within the country and no use is made of the large accumulations of scrap mica. India will probably continue to hold her position as the world's largest producer of electrical mica, owing to her important known resources of mica of excellent quality and the unfailing supply of cheap labour. The dominant position of India as the world's principal mica-producing country is further illustrated by the fact that for the period 1921-1926 the Indian production averaged about five times that of the United States, her nearest competitor.

Indian sheet mica is usually referred to as "block" mica, and this is classified as either exportable block or splitting block. The former comprises the best quality mica that can be exported for use as such. The most desirable mica for splittings is the soft ruby muscovite found in Bihar.

[1] "Mica in Chosen," Bulletin on the Mineral Survey of Chosen (Korea), vol. I, pt. 2, published by the Government General of Chosen, 1916.

[2] For the seven-year period 1921–27, the proportion of Indian mica to the total production of sheet mica (as computed from the figures in Table VIII) averaged 65·3 per cent, ranging from 78·2 per cent in 1923 to 52·1 per cent in 1927. The large increase in the Russian production is chiefly responsible for the drop in the latter year; but, as mentioned on page 17, it seems doubtful whether more than a portion of the total credited to Russia actually was sheet mica.

Owing to the ample supply of cheap labour available, mica is shipped to India in considerable quantities from outside sources to be there split and re-exported. For this reason the export figures, which are generally regarded as a truer index of the production than the official returns of output, owing to the large amount of mica believed to be stolen from the mines and thus not reported (*see* page 15), may really be above the actual figures. The exports of mica from India from 1913 to 1927 are given in the following table.

TABLE XIV

Exports of Mica from India, 1913-1927

(In long tons)

1913	3,124	1918	2,998	1923	4,165
1914	2,025	1919	2,955	1924	3,505
1915	1,520	1920	3,826	1925	4,985
1916	2,735	1921	1,547	1926	4,497
1917	3,128	1922	2,992	1927	3,874

Of the total exports in 1926, about 45 per cent was consigned to the United States, and 32 per cent to Great Britain, the remainder being divided between France, Germany, and other countries.

It has been stated[1] that the mica industry in India gives employment to a total of over 15,000 hands, including men, women, and children, engaged in the various operations in and about the mines, trimming shops, and splitting establishments.

India's most important mica deposits are situated in the province of Bihar and in the Madras Presidency.

Bihar

The mica belt runs obliquely across the districts of Gaya, Hazaribagh, and Monghyr, forming a strip some 12 miles wide by over 60 miles long. The most important producing area is centred around Koderma and Domchanch, whence the greater part of the output is consigned direct to the port of Calcutta by the Grand Chord line of the East Indian railway. Bihar is estimated to yield about 65 per cent of the total Indian production of mica.

The Bihar mica is a rich ruby-coloured muscovite, known in the trade as "Bengal ruby mica," the term being retained from the days when this district was in the province of Bengal, and not, as now, in the more newly-constituted province of Bihar.

The mining methods followed in the Bihar field differ from those practised in the Nellore area, Madras, the difference being largely due to the distinct physiographical conditions in the two districts. In the Koderma field, the surface is cut up into many small valleys, and the pegmatite outcrops are well exposed. These outcrops were originally worked by native miners, who extracted the mica by following it from crystal to

[1] Mineral Industry, 1921, p. 466.

crystal, in haphazard fashion, and allowing themselves only the minimum of room to work. The resultant workings thus developed into a series of tortuous, narrow burrows, without any plan or system. Later, these passages were enlarged in the search for more mica, but it is only in recent years that anything approaching a systematic method of mining has been developed. Geological knowledge, resulting in the recognition of the lenticular nature of the pegmatite bodies, has solved many former problems and led to improved methods of working. Nevertheless, the pockety and sporadic occurrence of the mica crystals complicates mining operations and renders the blocking out of definitely mica-bearing ground impracticable.

The pegmatites are hard, and the rock, which requires blasting, stands well without much timbering. The usual procedure is to drill shallow holes, only one foot or so deep, and to blow down a small amount of rock in the hope that a mica crystal will be exposed. Such mica is then removed by the use of chisel and crowbars. Drilling is usually done by hand, but jackhammer air-drills have recently been introduced at some of the mines.

Lighting of the workings is very primitive and is usually effected by earthenware lamps of the open dish type, with the wick lodged in a lip on the side.

Ventilation is always natural, most of the mines having several entrances.

Unwatering of the pits is usually effected by draining the water into a sump and bailing it out by hand, the vessels being passed from hand to hand by a chain of women coolies. In shallow workings, a bucket attached by a rope to a pivoted wooden pole is often employed. Hand pumps are sometimes used, and at a few of the larger mines, steam- or portable, electrically driven pumps have been installed.

Waste rock and small mica are carried out of the workings in small baskets, whilst large mica is tied up in bundles in the pits and taken out on the heads of coolies. Winches and buckets are used at a few of the mines. The whole operation of mica mining in the Bihar field is thus seen to be generally of a most primitive nature, only the larger operators employing anything in the way of mechanical equipment.

In the preparation of the crude mica for market, Bihar practice differs in various particulars from that followed in Madras. The mica is first rough-sorted at the mine and is then weighed and put into store. It is issued, as required, to the cutters, who first split the "books" into sheets that can be cut by the sickle that is used as a trimming tool in this field. All loose pieces are removed and the rough edges and flawed mica are cut off, the resultant sheet being roughly oval or circular in shape, with bevel edges. This method of trimming has the advantages that: (1) the sheets contain less waste; (2) there are no square corners to become frayed or bruised; (3) splitting is facilitated; (4) the mica is not classed as manufactured mica under the American customs tariff.

The trimmed sheets are then graded by size according to the Bengal standard, which uses the number of square inches in the sheet as an index (*see* page 55). The sized sheets pass to the graders, who are the most skilled hands in the industry. These raise the quality by splitting off imperfect films, rejecting otherwise faulty mica, and grade the sheets into (1) clear, (2) slightly stained, (3) fair stained, (4) stained, and (5) heavily stained. In the grading operation, a loss of about 10 per cent usually results, one-half of this representing waste and one-half thin films which can be converted into splittings or otherwise utilized.

Madras

The mica deposits of Madras Presidency lie in the Nellore district, and the mica-bearing area is often referred to as the Nellore field. The occurrences are distributed over a wide expanse of country, but production is centred in four main districts around the towns of Gudur, Podalakur, Atmakur, and Kavali. Most of the output is shipped through the port of Madras, by way of the North East line of the Madras and South Mahratta railway. Madras produces about 31 per cent of the total Indian output of mica.

Most of the mica consists of green muscovite, though brown muscovite is yielded by one area.

Surface conditions in the Nellore field are quite different from those in Bihar. The whole mica-bearing area is mantled with alluvial drift, and rock outcrops are rare. The earliest mining for mica was conducted upon such outcrops as exposed pegmatite. Later, operations were commenced upon pegmatites uncovered in the course of excavating earth for the dams of irrigation tanks, and prospecting along the strike of known pegmatite bodies has also led to the discovery of mica deposits. A common feature in this area is the occurrence in the drift cover of surface mica, weathered out of pegmatite which has decomposed in place, and pits put down to recover this mica have frequently exposed pegmatite.

Mica mining in this field is almost invariably open-cast and some very large excavations have resulted. This method has the disadvantage of leading to flooding of the pits during the rainy season, since the drainage of the entire surrounding alluvial area seeps into them. It also entails the removal of an enormous amount of waste, particularly where only narrow pegmatite bodies have been struck. In addition, this waste sometimes has to be moved several times to permit of enlargement of the workings.

The pits are usually carried open-cast to a depth about equal to their width, after which further mining has to be conducted by means of inclined galleries driven from the bottom of the workings.

Trimming practice consists in first roughly splitting the mica into sheets that can be cut, but the cutting is done by shears instead of by the sickle used in Bihar. Shears of the ordinary European garden type are used, one blade being held in a fixed position in a block of wood at an angle of 45 degrees and with the cutting edge below. The operator squats down, holding the block steady with his feet, and trims the sheets by working the free blade. Mica cut in this way is roughly rectangular in form and has straight, unbeveled edges, as contrasted with that prepared in Bihar. It is known in the trade as "Madras-trimmed mica." The sheets are sized according to surface area, but the numbers start with the smallest sizes (*see* page 55). The Madras Government collects a royalty on mica at a fixed rate per pound, based on size and grade of the sheets, and mica cannot be shipped from the mines until this royalty has been paid.

Other Indian Mica Occurrences

Numerous occurrences of muscovite mica are known in Rajputana, and deposits are being worked in the Ajmera-Merwara district. The output from this source represents about 2 per cent of the total Indian production, and most of it is exported through the port of Bombay.

A small production of muscovite is also made from southeast Wainad, in the Nilgiris hills, the output being estimated at about 20 tons per annum.

In the Mysore and Hasson districts, in the state of Mysore, promising deposits of muscovite are reported to exist, and a small production is made.

Phlogopite mica is reported to occur in Travancore, and attempts have been made to work the deposits. There is as yet, however, no important output.

JAPAN

As noted under Chosen, reports of the Imperial Institute credit Japan with a production of 424 and 582 tons of mica in the years 1923 and 1924 respectively, while Hobson assigns these amounts to Chosen. The Imperial Institute further records an output of 1,065 tons for Japan in 1925. A communication received from the Director of the Bureau of Mines, Tokyo, indicates that the above figures have been correctly credited by the Imperial Institute to Japan.

There is little authoritative information available respecting the occurrence and mining of mica in Japan, but most of the output would appear to be of scrap grade rather than sheet (*see* page 16). The entire production is presumed to be muscovite.

The chief producing districts are: Nagasakiken, Saitamaken, Yamaguchiken, and Gunmaken.

Japan exports no mica, and the whole of the production of scrap is utilized in the powder form for such purposes as decorating the walls and ceilings of houses, screens, doors, tile and porcelain, fans, etc.; it is also used in fire-proof paints and lubricants.

Information supplied by the Director of the Bureau of Mines, Tokyo, indicates that most of the Japanese mica-grinding plants are small mills, employing stamps or some other simple form of grinding appliance, which are driven by water-wheels of about 10 h.p. The ground mica is water-floated in wooden pans and then bolted through 120-mesh screens.

TIBET

Small amounts of green muscovite mica have been obtained from time to time from Tibet, and mining is said to have been conducted near Tinki, in the Giagong district. No particulars regarding the deposits are available.

AUSTRALIA

Intermittent mining for mica has been conducted in various parts of Australia, for a number of years, but the recorded production is very small. The largest output was in the year 1917, when 38 tons were mined in South Australia. During the 1918-1927 period, the recorded production did not exceed nine tons in any one year.

Northern Territory

Muscovite mica occurs in the Macdonnell and Hart's ranges, in the Northern Territory, and attempts at mining have been made. A few tons of mica of excellent quality were taken out in 1924 and operations were reported to be continuing in 1925.[1]

South Australia

As noted above, South Australia produced 38 tons of mica in 1917, this being taken out in the Hundred of Para Wirra. There is no record of any further production.

Queensland

Muscovite occurs at a number of localities in northern Queensland, notably on the Einasleigh river, southeast of Georgetown, and at Brooklands, near Junction creek, both within the Etheridge goldfield.

A mica belt of undetermined extent is known to occur along Rifle creek, a tributary of the Upper Leichhardt river, 68 miles west of Cloncurry. None of the occurrences have been actively exploited, and only a small amount of surface mica has been taken out.

Western Australia

A small, intermittent production of muscovite mica is recorded from occurrences in Western Australia since 1914. The largest output previous to 1926 appears to have been 4 tons, in 1914,[2] but it is reported[3] that in 1926 increased mining activity resulted in the shipment of 43 tons to England.

The deposits lie in the Lockyer range, on the Upper Gascoyne river, and other occurrences are known at Mullalyup and Northampton. In 1926, mica is reported to have been shipped from a deposit near Yinnietharra station, 240 miles from Carnarvon.

Lepidolite, or lithia mica, occurs in large clear sheets in the Londonderry district, near Coolgardie, and has been worked on a small scale. This mica is stated to have formerly been in demand for gramophone diaphragms, on account of its high resonant quality.

NEW ZEALAND

A few tons of muscovite mica were mined in 1911-12 near Charleston, south of Westport. Occurrences are also known at Dusky sound, in southwestern Otago; at Mitre Peak, Milford sound; and at several localities in northwestern Otago. There is no record of any further production.[4]

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[1] Bull. Imp. Inst., 1926, p. 333.
[2] Reports of Department of Mines, Western Australia.
[3] Mineral Industry, 1926, p. 467.
[4] Minerals and Mineral Substances of New Zealand, Geol. Surv., New Zealand, Bull. No. 32, 1927, p. 71.

EUROPE

AUSTRIA

In 1924, mining for mica was reported to be proceeding in the mountains near Köflach, west of Graz, in Styria, and also in Carinthia. No details respecting the operations are available.

GERMANY

Germany produces no sheet mica, but is reported to have produced 493 tons of lithia mica in 1925, and 654 tons in 1926.

NORWAY

Prior to the war, little development of the Norwegian mica deposits had taken place, although muscovite-bearing pegmatites were known in various localities. German war demands for mica led to the working of an old mine in the Kragerö district, on the southeast coast, and in 1914, 32 tons were produced. Mining has continued intermittently since, with the largest output, 95 tons, in 1919. Exports of mica totalled 41 tons in 1926, but the amount declined to 6 tons in 1927.

PORTUGAL

No sheet mica is produced in Portugal, but there is a record of production of 184 tons of lithia mica in 1926.

RUMANIA

Important deposits of mica, presumably muscovite, were reported to have been found in the Mehedinti district in 1919. A production of 71 tons was returned in 1919, and 133 tons in 1920. There have been no further records of any output, and details respecting the occurrences are lacking.

Muscovite is also reported[1] to occur in the Lodru mountains, in the district of Vâlcea, where a small production was reported in 1918.

RUSSIA

Mica appears to have been mined in Russia two and a half centuries ago, for it is reported[2] that, as early as 1681, Russian mica exports to Holland, England, and North America totalled nearly 100 tons. Subsequently, however, the mica industry declined, and all traces of production were lost. It was not until 1912 that some of the old mines were rediscovered, and there has since been a small but increasing output. Investigations have shown that muscovite mica occurs at a number of localities, and rich deposits are recently reported from the Bodaibinsk region in Siberia. Other occurrences are found along the Mama river, in Irkutsk province; on the Bystraya and Slyudyanka rivers, at the south end of lake Baikal; on the Tasyeeva river, an affluent of the Angara; and along the river Kan, in Krasnoyarsk Uyezd, Yeniseisk province, all in

[1] See Annales des Mines de Roumanie, Jan. 1922. (Quoted in Bull. Can. Inst. Min. Met., Sept. 1922, p. 1002.)
[2] Soviet Union Year Book, 1928, p. 113.

Siberia. Lack of communication is said to have hindered earlier development of these properties. In European Russia, the principal deposits occur in Archangel and Volyn provinces; on the Kola peninsula; and along the coast of the Black sea. Recent production is reported to have been derived principally from the Kan River and Archangel deposits; the former district is credited with an output of 75 tons in 1917.

Statistics of Russian mica production in recent years have only lately become available. The latest report of the Imperial Institute, issued in 1928, shows an output of 190 tons in 1925, which more than doubled in 1926, and rose to almost 1,500 tons in 1927. According to advice received[1] from the Director of the Geological Committee of the U.S.S.R., however, only about 10 per cent of the production figures represent sheet mica, the totals relating to run-of-mine material. Accordingly, the figures given in the table on page 17 have been computed on this basis. Apparently, the bulk of the mica produced is consumed within the country, since inquiry has failed to discover that any important amount of Russian mica is reaching the open market.

SWEDEN

Muscovite occurs in Sweden, but the deposits received little attention until the war years, when a small industry developed. Mining has been conducted in Bohuslän, north of Göteborg, and since 1915, a small output of mica has been maintained. Figures of production are lacking, but the annual exports ranged from 5 to 10 tons between 1915 and 1924. In 1925, there appears to have been an increase in activity, the production being returned at 93 tons.

OTHER COUNTRIES

Other countries, reported to contain mica resources, some of which have produced small amounts of mica at various times, include Chile, Bolivia, Peru, Costa Rica, Switzerland, and Papua.

[1] Letter dated March 14th, 1929.

CHAPTER IV

MICA IN CANADA:

DISTRIBUTION, MODE OF OCCURRENCE, METHOD OF MINING, AND PREPARATION FOR MARKET

DISTRIBUTION

Phlogopite or Amber Mica

The occurrence of phlogopite, or amber mica, is chiefly confined to a belt of rocks, having a northeasterly trend and extending along a median line drawn from Kingston, Ontario, on the St. Lawrence river, to Ottawa, and thence northward into Quebec, between the Gatineau and Lièvre rivers. The length of this belt is probably about 150 miles (though its northern limit has not been determined) and its width is from 60 to 70 miles.

For some 15 miles northward from the St. Lawrence front, the crystalline, mica-bearing rocks are concealed beneath Palæozoic sediments (limestones, sandstones, and shales). Another band of these sediments, about 50 miles wide, projects westward across the mica belt between Ottawa, on the north, and the Rideau lakes, on the south, thus interrupting its continuity and dividing it into a northern (Quebec) district and a southern (Ontario) district. The Ottawa river, which forms the Provincial boundary, flows eastward along the northern edge of this band of sediments. (See maps at end of report.)

The rocks of the mica belt comprise an exceedingly complex association of sillimanite- and garnet-gneisses, crystalline limestones, pyroxenites, and granite pegmatites. It is with the pyroxenites alone that the commercial bodies of phlogopite mica are found associated. Small, isolated bands and masses of this rock occur scattered throughout the region, enclosed sometimes in a country rock of gneiss and sometimes in crystalline limestone. They are seldom persistent for any distance, though in certain districts (e.g. Templeton and Hull townships, Quebec, and North Burgess and Loughborough townships, Ontario) a number of such masses occur in fairly close proximity. Thus, while the total width of the mica-bearing belt, as stated above, is about 65 miles, the greater part of the mica produced has come from a much smaller area. This area comprises mainly the territory embraced within the above-named townships, and represents a belt only about 15 miles wide, within the larger belt. Few important mica deposits have been found outside this area, although dozens of small mines have been worked in the past in the adjacent and outlying townships.

While the occurrence of phlogopite is confined principally to the region described, a small deposit of amber mica occurs, and was worked some years ago, near Petit Pré, a few miles east of Quebec. This mica and its enclosing rock (pyroxenite) appear similar in all respects to that of the mica region proper, which lies over 200 miles to the west.

Muscovite or White Mica

In contrast to phlogopite, the occurrence of which is confined to a single belt of pyroxenic rocks in the Ottawa district, muscovite, or white mica, is found at numerous, widely separated points.

Deposits are known, and in some instances have been worked in a small way, at remote localities along the shores and rivers of Labrador and northern Quebec, Hudson bay, and Baffin island. Numerous occurrences are known at points along the north shore of the St. Lawrence river, in Saguenay and Berthier counties, and also farther to the west, in Argenteuil, Papineau, and Labelle counties. Probably the greater proportion of the total small output of muscovite mica in Quebec province has come from deposits along the Lièvre river, in Papineau county, where the pegmatites have been worked simultaneously for mica and feldspar. Muscovite has also been mined in a small way in Timiskaming county, near Mattawa.

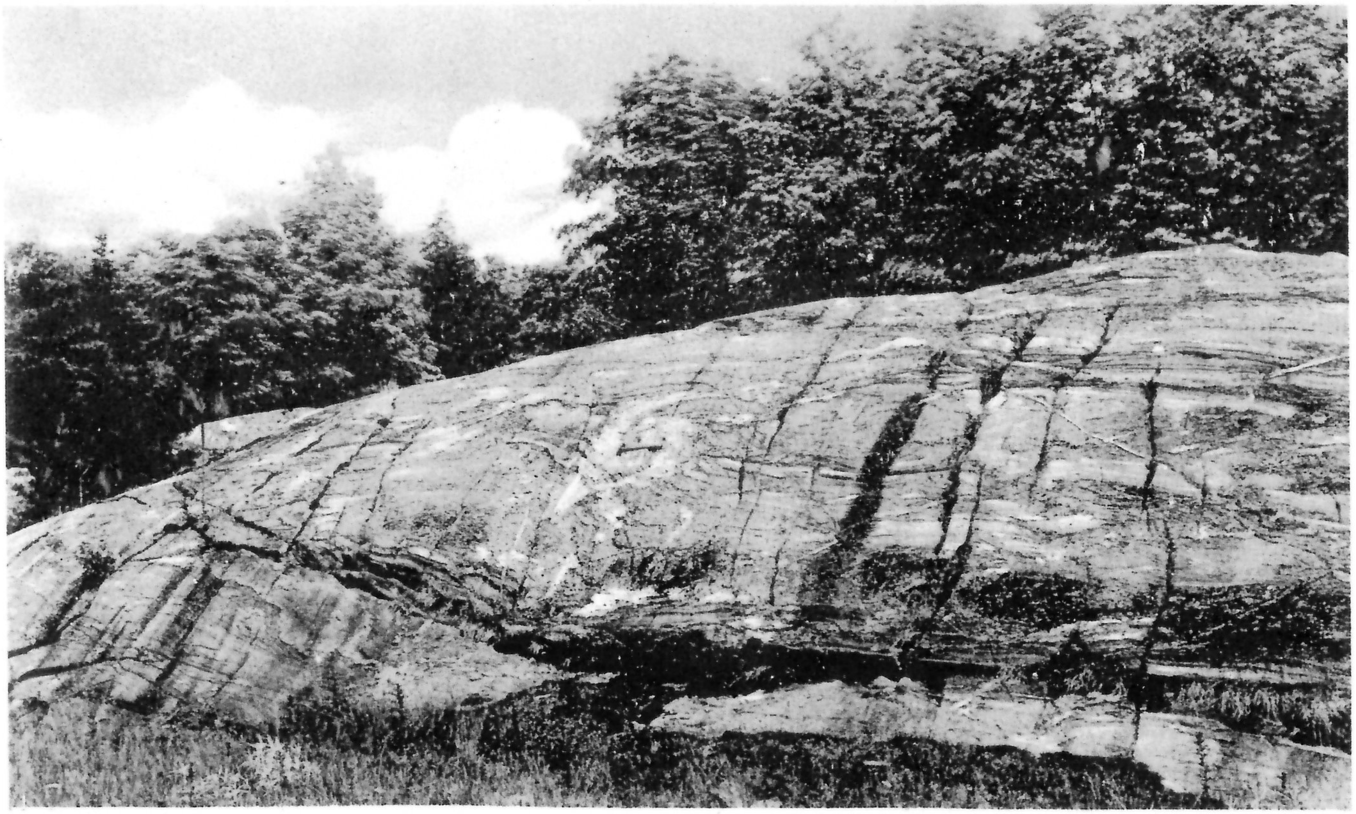
In Ontario, muscovite occurrences have been worked intermittently at a number of scattered localities in the territory lying between the Ottawa river and the Ottawa—Parry Sound line of the Canadian National railway, from Pembroke in the east, to Georgian bay in the west. A small amount of muscovite has also been mined in Hastings and adjacent counties in central Ontario. In western Ontario, muscovite is reported to have been worked in the Lake of the Woods region, and it has also been recorded from northern Manitoba and Saskatchewan, though there is no record of any production in the latter provinces.

Muscovite occurs at several localities in British Columbia, most of the known deposits being situated in the Selkirk mountains, between the main lines of the Canadian Pacific and Canadian National railways. Attempts at mining have been conducted near the Big Bend of the Columbia river, and near Tête Jaune, on the Canadian National railway. The quality of the mica from this district is exceptionally good,[1] but attempts to develop the properties have not proved successful, operations having been hindered in some cases by the remote locations of the deposits. More recently, in 1927, an attempt has been made to exploit muscovite occurrences on the Finlay river, near Fort Grahame, which lies over 200 miles north of Prince George, the nearest rail point; a few hundred pounds of trimmed sheet mica are reported to have been shipped in 1927.

Despite the comparatively wide distribution of muscovite mica in Canada and the large number of recorded occurrences, the total production of this variety has been quite small, as compared with the output of phlogopite. Mining operations for muscovite have seldom been attended with much success, and have usually not proceeded much beyond the prospect or initial development stage. This has been due to the often small amount of mica actually present in the pegmatites, and also to the average low quality of the mica encountered, many of the dykes yielding an unduly large proportion of spotted, stained, wedge, or otherwise imperfect sheets.

[1] Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1918, p. 51.

PLATE III



(*Photo by M. E. Wilson, Geol. Surv., Canada.*)
Typical glaciated outcrop of garnet gneiss, Templeton township, Que., showing pegmatite stringers. Such "hogsbacks" of gneiss—the dominant rock of the region—are characteristic of the mica-apatite districts of both Quebec and Ontario.

PLATE IV

PLATE IV

(*Photo by M. E. Wilson, Geol. Surv., Canada.*)

Characteristic weathered exposure of Grenville crystalline limestone, containing inclusions of harder, hornblendic rock, Buckingham township, Que. Thick bands of this limestone are of widespread occurrence throughout the gneiss of the mica-apatite districts of both Quebec and Ontario.

Lepidolite or Lithia Mica

Lepidolite, or lithia mica, in deposits of possible economic value, was discovered in 1924 in the Pointe du Bois district, northeast of Winnipeg, in Manitoba. Further prospecting has led to the locating in the same general region, of a number of pegmatites carrying lepidolite and other lithium-bearing minerals. Many of the properties lie some distance from transportation, and, up to the present, mining operations have been confined to the original discovery. From this property, a small quantity of lepidolite has been shipped for use in the glass industry.

The lepidolite of the Manitoba deposits has no value as sheet mica, occurring in the form of compact aggregates of small flakes.

A pegmatite dyke carrying fair-sized crystals of lepidolite occurs in Wakefield township, Hull county, Quebec. The crystals, however, yield only wedge sheets, having poor splitting quality, and are of no value for sheet mica.

Biotite or Black Mica

Black, iron mica, or biotite, is found in the pink or reddish pegmatite dykes, which are common in the Precambrian, crystalline rocks of eastern Ontario. Many of these dykes have been worked for their feldspar content, and in some instances, the biotite mica has been disposed of as grinding scrap. In recent years, a small amount of mining for biotite has been conducted upon mica-rich dykes of this type, notably in Hastings and adjacent counties, Ontario, most of the output being shipped for grinding purposes. Biotite, on account of its high iron content, and consequent low di-electric strength, hardness and poor splitting quality, has little value as sheet mica, and practically its only use is as scrap mica.

Biotite occurrences are also reported from scattered localities in northern and western Ontario and southwestern Quebec. In the pegmatites of Berthier, Charlevoix, and Saguenay counties, Quebec, along the north shore of the St. Lawrence, biotite and muscovite mica often occur in parallel intergrowth in the same crystals.

MODE OF OCCURRENCE

Phlogopite or Amber Mica

The general tendency of Canadian phlogopite deposits is to form irregular shoots or pockety bodies, approximating to impersistent veins. These shoots occur in a rock consisting predominantly of greenish pyroxene. The character of the mica bodies has suggested that they have been formed in and along cavities and fissures developed in the enclosing pyroxenite rock through a combination of pneumatolytic and dynamic agencies, which were active more or less contemporaneously with the supposed metamorphic origin of such rock from magnesian limestones.

While the metamorphic theory of formation possibly has been the most favoured one, it should be stated that the origin of the pyroxenites and their associated mica and apatite bodies has been the subject of considerable dispute since the days when the deposits were first studied, and the question cannot yet be said to be definitely settled. A number of geologists, including Osann, Bell, Coste, Selwyn, and Ells, believed that the pyroxenites were basic igneous intrusives, which were themselves the source of the apatite- and mica-forming solutions, though Osann believed the mica and apatite might be, in part, secondary.[1]

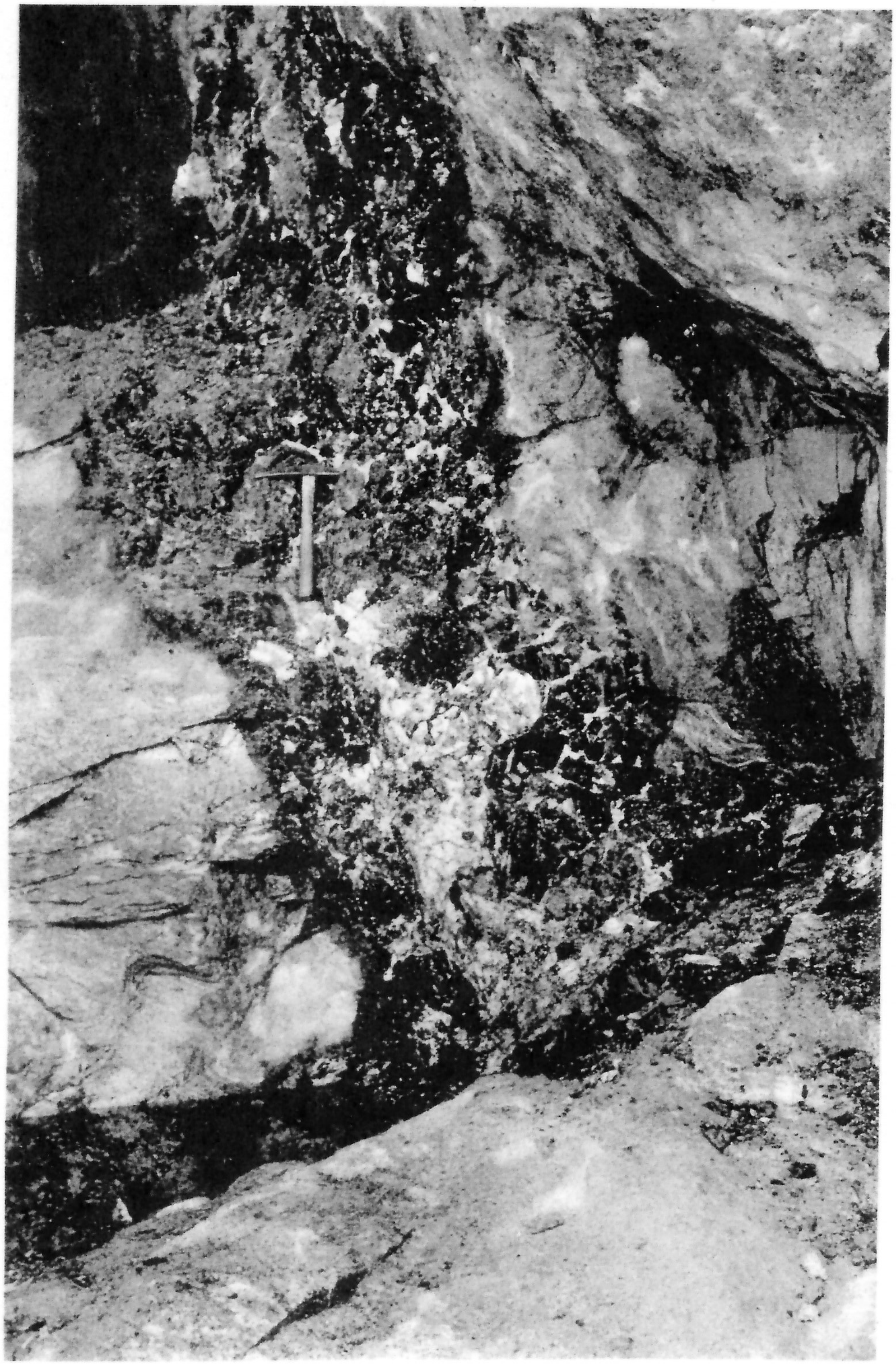
One of the principal objections to the igneous hypothesis has doubtless been the usual presence within the pyroxenite bodies of large amounts of calcite, which mineral was held to be residual from original crystalline limestone rather than of primary igneous origin. It is now known, however, that calcite can be a primary constituent of igneous rocks, and several occurrences of feldspar pegmatites containing important amounts of calcite have been recorded in Canada in recent years. Careful examination doubtless would reveal more. A notable example of such a pegmatite is that on lot 18, concession VII, of the township of Monteagle, near Hybla, Ontario, where, at a depth of 80 feet, the feldspar has been found to give way to calcite across a great part of the width of the dyke. Walker and Parsons,[2] from a study of the calcite from this pegmatite and of that from a calcite-apatite deposit in Renfrew county, Ontario, have concluded that the mineral in both cases is primary and that the last-mentioned deposit appears to be definitely of igneous origin.

Various characteristics of the pyroxenites and mica-apatite bodies lend considerable support to the view that they are of igneous origin, and are basic intrusives, akin to pegmatites. Chief of these is the fact that the pyroxenite exhibits sharp, frozen contacts with the enclosing gneiss or limestone. The writer has observed no instance of a gradual transition of mica-bearing pyroxenite to country rock, as might be expected if the pyroxenite were a product of metamorphism. The fact that the usual constituent minerals of the pyroxenites—augite, hornblende, scapolite, apatite, sphene, pyrite, and pyrrhotite—are all typical of high temperature rocks, and that the four first-named, with their associated phlogopite, frequently occur in the form of "giant" crystals so typical of pegmatites, lends support to the view that the parent rock is of igneous origin and represents a basic counterpart to normal granite pegmatite. The often drusy character of the pyroxenites, also, is common to many igneous rocks, and is especially characteristic of pegmatites.

That the granite pegmatite dykes and stringers often found intruding the pyroxenites have been the agencies directly responsible for the formation of the mica and apatite does not appear to be borne out by the field relationships, since these minerals do not pronouncedly follow such intrusions. Where such dykes are present, also, there is often evidence of more or less intensive action on the adjacent rock, the pyroxene usually being attacked and changed to secondary tremolite or actinolite. Such intrusions have also generally resulted in considerable crushing of the mica and phosphate, and the former is sometimes partially altered.

[1] A bibliography of the earlier literature dealing with the geology of the mica-apatite deposits of Ontario and Quebec, with a review of the different authors' hypotheses as to their origin, will be found in Mines Branch Report No. 118, pp. 260–72, 391–6.

[2] "The Characteristics of Primary Calcite", Contributions to Canadian Mineralogy, University of Toronto Studies, No. 20, pp. 14–17, 1925.



(*Photo by M. E. Wilson, Geol. Surv., Canada.*)

Phlogopite vein in pyroxenite, Moose Lake mine, range IV, lot 1, Villeneuve township, Que., showing mica crystals disseminated throughout a matrix of calcite, pyroxene, etc.

From observations made on a great number of mica-bearing pyroxenites during the past twenty years, the writer is inclined to regard these rocks as basic intrusives (true dykes) rather than as metamorphic products, and the mica and apatite associated with them as formed by pneumatolytic solutions originating in the pyroxenites themselves rather than in granite pegmatites injected into them.

The mica bodies, while having a general vertical trend, pinch, swell and fork in an exceedingly irregular manner, often making it difficult to follow their course, rendering mining difficult and making the blocking out of mica-bearing ground impracticable. Mica crystals seldom occur in the pyroxenites away from the main shoots or veins, any isolated crystals or pockets usually being connected with the main bodies by narrow and often inconspicuous stringers.

Phlogopite deposits, therefore, differ in certain marked respects from those of muscovite, the crystals of which often occur as isolated individuals distributed throughout the mass of pegmatite dykes or in more or less persistent zones along one or both contacts of pegmatites with their enclosing rocks.

Pyroxenite is a common rock throughout the productive mica areas, forming bands and isolated masses in the gneiss-crystalline limestone complex of the region, but by no means do all pyroxenite exposures prove to be mica-bearing.

While the phlogopite deposits, in general, possess the characteristics noted above, there are certain rather marked respects in which they may differ. Such differences cannot be said to be peculiar to the deposits of particular districts, since all the types, and gradations from type (1) to type (2), may be found in one and the same area. They are, possibly, to be referred to variations in the size, character, and chemical constitution of the pyroxenite bodies and also, perhaps, in the nature of the enclosing country rock.

Broadly speaking, the phlogopite deposits may be classed under the following three types:—

(1) Vein deposits;
(2) Pocket deposits;
(3) Contact deposits.

Actually there is often no strict line of demarcation between the first two, which may grade into each other. As a rule, however, individual deposits exhibit more or less pronouncedly the characteristics of one particular type.

(1) *Vein Deposits.* The principal characteristics of this type of deposit are: Fairly pronounced persistence and regularity in width, dip and strike; the occurrence of a system of more or less parallel, single leads with defined walls; the vein matter consists of mica crystals disposed through a filling of pink calcite and granular apatite; the veins are usually narrow; the enclosing pyroxenite is generally fine- to medium-grained.

Gradations from this type to the next are, however, not infrequent, and it is sometimes difficult, failing good exposures, to say into which class a deposit properly should fall. Examples of such indefinite types are to be met with in some of the larger mines, where mica leads have proved to be persistent for considerable distances, both vertically and horizontally, although following a somewhat erratic course. Such leads have no well-defined walls, pitch and dip irregularly, and often pinch out to an inconspicuous stringer. In some cases, however, they have been found to widen out into bodies of very large dimensions.

Deposits of this type often prove the most remunerative to work, since they usually consist wholly of mica, with but little calcite or apatite gangue, the mica occurring as a closely intergrown mass of crystals, sometimes in individuals of very large size. Owing to the fact that the rock of such deposits usually is hard and compact, and to the absence of soft vein-filling, the mica carried is less prone to have suffered crushing through earth movements, and the crystals yield a far larger proportion of merchantable sheets than do those of the other types of deposits.

(2) *Pocket Deposits.* As the name indicates, this type of deposit is characterized by pronounced irregularity in the shape, size, course, and persistence of the mica bodies. While the individual pockets may be connected by narrow stringers, these are often too small and too irregular in their course to be followed profitably in the hope that they will lead into other pockets. Consequently, mining of this class of deposit is attended with much uncertainty, and the usual practice has been to work out surface showings to their economic limit and then abandon them in a search for other bodies. Probably, by far the greater number of mica mines have been opened on pocket deposits, and this accounts for the large number of small, abandoned pits scattered throughout the field.

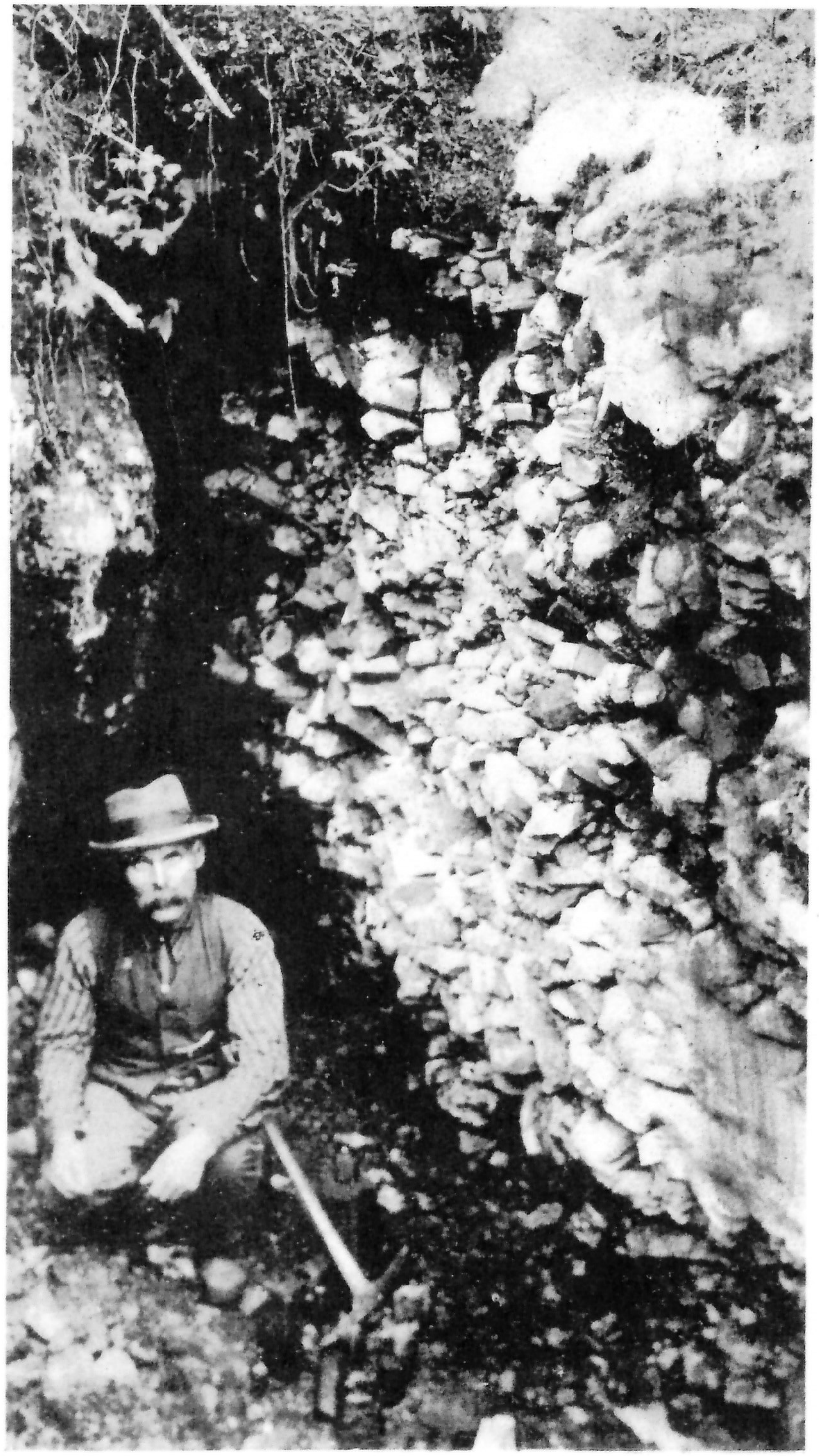
The pyroxenite rock enclosing deposits of this type is usually more coarsely crystalline and open-textured than that of the vein deposits, and the pockets are often lined with large and well-developed pyroxene crystals. The filling of the pockets generally consists of pink calcite, often accompanied by considerable amounts of apatite; the latter either granular and powdery, or massively crystalline, and, also, often in the form of large, individual crystals. Throughout this filling, mica crystals occur distributed in irregular fashion, and it is deposits of this class that often yield the largest crystals.

Leaching of the calcite filling of surface pockets by ground waters has sometimes resulted in the formation of open cavities and sink-holes, containing quantities of loose mica and apatite crystals.

In certain sections of the productive mica belt, e.g. in the township of Portland, in Papineau county, Quebec, deposits of the pocket class carry apatite as the chief filling, mica and calcite being present in very small amount. The apatite here is mostly of the hard, crystalline type. This district was formerly the seat of an active phosphate mining industry,[1] and few, if any, of the mica workings either in Quebec or Ontario exceed in size or have been carried to as great depths as many of the old phosphate mines along the Lièvre river. At one of these mines, phosphate was worked to a depth of over 600 feet, with no evidence of exhaustion of the ore-body.

[1] See "Phosphate in Canada", Mines Branch, Dept. of Mines, Canada, Rept. No. 396.

Mass of vein-filling from a mica lead, concession VI, lot 13, North Burgess township, Ont. Illustrates the typical mode of occurrence of phlogopite crystals disseminated throughout a matrix of pink calcite in deposits of the pocket type.



Large crystals of pyroxene lining the walls of a mica-apatite pocket, range XV, lot 13, Hull township, Que. This pocket probably was originally filled with calcite, which has been removed in solution by surface waters.

Since the phlogopite and phosphate deposits undoubtedly owe their origin to similar geologic processes, there is no reason to believe that the mica bodies necessarily are confined to relatively shallow depths, as is sometimes claimed, and do not extend far below the present limit of working (about 300 feet).

(3) *Contact Deposits.* Occurrences of this class are much less common than those of either of the foregoing types, and their importance as a source of sheet mica is small. In no case have such deposits been the object of important mining operations, and probably not more than half a dozen have been worked to a depth exceeding a few feet.

The deposits included here exhibit very marked dissimilarity to those of the foregoing types. In the first place, the mica is quite distinct, being usually of a pale, cloudy, honey colour, although some deposits yield sheets of a cinnamon-brown shade. The mica is usually harder, more brittle and does not possess so good splitting qualities as normal phlogopite. In addition, there is generally a larger proportion of imperfect sheets, due to crushing or buckling, and to imperfect crystallization.

Geologically, and mineralogically also, the deposits differ from those of ordinary phlogopite. The mica is usually found associated with a peculiar, pale greyish brown pyroxene, and considerable amounts of fibrous tremolite are often present. Dark brown magnesian tourmaline, also, is frequently a conspicuous mineral. The deposits contain no apatite. The pyroxene bodies are always enclosed in, or border on, crystalline limestone.

Deposits of this type show more decided evidence of metamorphic origin than those of types (1) and (2). They apparently have been formed by the intrusion into crystalline limestone of igneous dykes of a different character to the pegmatites often found associated with normal phlogopite bodies. Owing to the limited amount of mining done for this class of mica, and the small extent of the workings and shallow depths reached, there has been little opportunity to study the deposits. At one mine, however, a dyke of fine-grained, igneous rock, determined as rhyolite, was cut in a drift, and probably it is from intrusives of this or similar character that the mica-forming solutions of this type of deposit have been derived.

MINERALS OF THE PHLOGOPITE DEPOSITS

The principal component minerals of the phlogopite deposits are pyroxene, phlogopite, calcite, and apatite.

Pyroxene

Pyroxenite being the mother-rock of the deposits, pyroxene is, of course, always the predominating mineral. It is a diopside, varying considerably in its outward characteristics, but usually, in proximity to the mica, decidedly coarsely crystalline. In the pocket type of deposits the cavities are often lined with large, well-formed pyroxene crystals, which sometimes attain a length of 12 inches, with a diameter of 4 to 5 inches. The colour ranges from a pale greenish grey to dark blackish green. The crystals often enclose small plates of phlogopite. A typical analysis shows:—

Silica	50·87
Alumina	4·57
Ferric oxide	0·97
Ferrous oxide	1·96
Manganese oxide	0·15
Lime	24·44
Magnesia	15·37
Potash	0·50
Soda	0·22
Loss on ignition	1·44
	100·49

Phlogopite

The general character of the phlogopite has already been indicated. Where much calcite or apatite is present, and the mica occurs scattered throughout bodies of such mineral, the crystals are usually well-formed and possess sharp outlines. The mica of such crystals usually yields little edge-waste, but it is often impaired by gliding planes, in which case the sheets break readily into strips termed "ribbon mica." Where cross gliding planes have been developed, the result may be pieces of triangular outline, having bevelled edges. In contrast to the foregoing, the mica books found in pyroxene usually have most irregular form, often with no vestige of crystal outline.

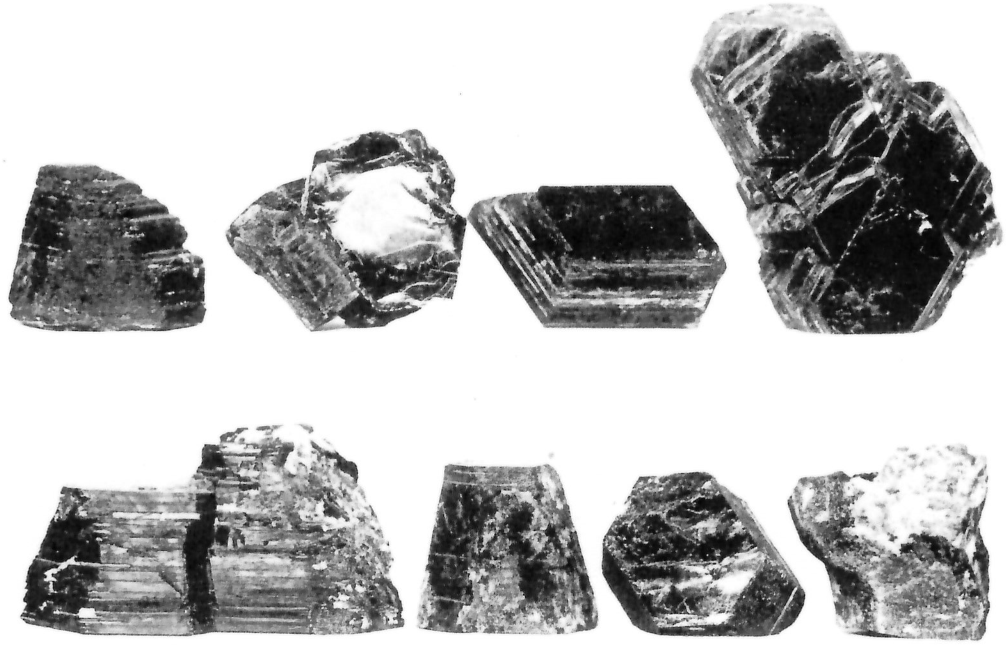
Crushing of the mica books, due to rock movements, is common and is the cause of much waste. Relatively little sound, perfectly flat, large mica is encountered, most of the larger sheets being slightly waved. The mica of different deposits varies much in this and other respects, and no general observation can be taken as applying to all the occurrences, without exception.

Inclusions between the laminæ are common in the mica of certain deposits. In the crystals enclosed in calcite or apatite, such inclusions usually take the form of thin, tapering films of these minerals. In crystals that have suffered pronounced crushing or buckling, thin, flattened lozenges of quartz, or of calcite, are sometimes present between the layers.

From records kept over a period of several years at the Blackburn mine, in the township of Templeton, Quebec, it was found that of the total amount of mica taken out, approximately 35 per cent represented merchantable thumb-trimmed sheet, the remainder being waste.[1] The percentages of the different market sizes yielded by this merchantable sheet and by the total run-of-mine output were as follows. This mine is one of the largest and oldest established producers, and the figures may be taken as a fair average for a Canadian phlogopite deposit:—

Size	Percentage of merchantable sheet	Percentage of total run-of-mine mica
1 x 1 inch	44	15·40
1 x 2 "	26	9·10
1 x 3 "	15	5·25
2 x 3 "	9	3·15
2 x 4 "	4	1·40
Larger sizes	2	0·70

[1] "Mica as Mined and Treated at the Blackburn Mine," by H. L. Forbes. Paper presented at Annual Meeting, Canadian Institute of Mining and Metallurgy, 1921.



A. Examples of Canadian phlogopite crystals, illustrating the wide variety of forms exhibited.

B. Large stock-pile of apatite at a mica-apatite mine, range I, lot 6, Portland township, Que.

Relatively little of the mica is perfectly clear and transparent, even in thin sheets, most of it exhibiting a certain degree of cloudiness. This characteristic is a variable, however, and often depends on the angle at which the sheet is held to the line of vision.

In colour, the phlogopite of different deposits varies from almost black, through all shades of brown, to pale amber-yellow, depending probably on the iron content. Such colour variations have led to the designations, in the trade, of the different shades as "dark amber," "light amber," "wine amber," "silver amber," etc. A type of cloudy phlogopite exhibiting a slight degree of opalescence is termed "milky amber." While a particular lead usually yields mica of a more or less uniform colour, adjacent leads in the same pyroxenite body may carry mica of quite distinct shades. As a rule, the depth of colour of the mica varies with that of the enclosing pyroxenite, the best silver-amber quality being always associated with pyroxenite of a pale greenish grey tone.

In thin plates, the phlogopite shows varying degrees of pleochroism; that is, when looked through, the sheets exhibit distinctly different depths of colour according to the position in which they are held.

Asterism, the optical phenomenon whereby a thin plate of mica when held against a strong light exhibits a regular system of light rays radiating from a common centre, is often very pronounced in Canadian phlogopite.

Calcite

The calcite of the mica deposits exhibits a strikingly uniform character throughout the entire mica field. It generally possesses a pleasing salmon colour and is usually medium to coarsely crystalline. Occasionally, it is found with a deeper, reddish shade and is then sometimes fine-grained. More rarely, it is pale cream or buff, and in such cases the deposit usually carries a large amount of pyrite or pyrrhotite.

Apatite

In few phlogopite deposits is apatite found to be completely absent, and in many cases it is present in such amount that it can be saved as a by-product of mica mining. It occurs in three typical forms, all of which are sometimes met with in one and the same deposit. The most common form is the massively crystalline variety, occurring as the filling of pockets or veins, which sometimes yields hundreds of tons of the mineral. A second common variety is the saccharoidal type ("sugar phosphate") found in equally large masses. This material is made up of small, loosely-coherent, rounded grains, and is usually of a white to pale green colour. The third mode of occurrence is as individual crystals. These are usually found enclosed in the calcite filling of veins and pockets, and range in size from small forms as big as a pea to large individuals weighing many pounds. While they sometimes exhibit fairly sharp crystal outlines, the angles are often rounded and the faces pitted by resorption. The rounded nodules of massive apatite often found lying in the sugar variety are probably crystals that have undergone intensive resorption that has destroyed all traces of crystal form. The crystals often contain small pea-like inclusions of calcite and flakes of phlogopite.

The most common colour of the apatite is green, of various shades, but blue, red, and yellow are not unusual.

A typical analysis of Canadian apatite shows:—

Phosphoric acid	39·24
Lime	55·70
Ferric oxide } Alumina }	0·72
Magnesia	0·20
Soda } Potash }	0·80
Chlorine	0·65
Fluorine	3·10
Water	0·28
Insoluble	0·06
	100·75
Equivalent to tricalcic phosphate	85·74

Other Minerals

Other minerals that have been reported from the mica-apatite deposits are the following:—

Actinolite
Albite
Allanite
Anhydrite
Anthraxolite
Barite
Chabazite
Chalcopyrite
Chlorite
Datolite
Epidote
Faujasite
Fluorite
Galena
Garnet *(Almandite, Hessonite, Uwarowite)*
Goethite *(Przibramite)*
Graphite
Hematite
Hornblende
Magnetite
Microcline
Molybdenite
Natrolite
Olivine
Orthoclase
Prehnite
Pyrite
Pyrrhotite
Quartz
Rensselaerite
Rutile
Scapolite
Serpentine
Specularite
Sphalerite
Spinel
Steatite
Titanite
Tourmaline *(Schörl, Dravite)*
Tremolite
Vesuvianite
Wilsonite
Zircon

With the exception of pyrite, pyrrhotite, scapolite, and hornblende, all of which are frequently met with, none of these are common enough to be considered typical accessory minerals, and some of them are rare.

Muscovite or White Mica

Muscovite mica is very widely distributed in Canada and is found in pegmatite dykes of various types, and probably all of Precambrian age.

Even in one and the same district various types of pegmatites occur, and not all are mica-bearing. Some of the dykes carry predominantly buff-coloured to pink, and even dark red, microcline (potash feldspar), often with minor amounts of white albite (soda feldspar) or greenish oligoclase (lime-soda feldspar). Others carry principally white microcline. Dykes carrying important amounts of albite are less common. Many of the pegmatites contain small amounts of radioactive minerals. Tourmaline and garnet crystals are common in certain dykes, and large crystals of hornblende often occur in the wall zones.

The pegmatites are chiefly valuable as a source of feldspar, large quantities of which are mined in western Quebec and eastern Ontario. Small amounts of muscovite are sometimes recovered during feldspar mining operations, most of it being disposed of as scrap. Much of this mica is wedge mica, or is so heavily spotted and stained as to be of inferior quality as sheet. While a small amount of mining for muscovite was conducted many years ago, operations seldom proved profitable and no important mines were opened. There has been virtually no production of sheet muscovite in recent years.

The proportion of muscovite in the pegmatites is usually very small. The mica is commonly confined to small leads or stringers in, or bordering, local segregations of quartz within the dykes, or occurs in shoots along the walls. The size of a dyke is not necessarily an index of the amount of mica likely to be present, as some of the largest dykes that have been worked for feldspar are entirely barren of mica. Where mica is present, however, the shoots or leads are usually larger in wide dykes than in narrow ones.

In all essential respects, Canadian muscovite deposits resemble those of other parts of the world and call for no particular description.

Biotite or Black Mica

While not an uncommon mineral, biotite mica is much less frequently met with than either muscovite or phlogopite. Very dark phlogopite, probably approaching biotite in composition, is yielded by certain mines in the northern part of the Quebec mica field, as well as elsewhere, but deposits of true biotite are comparatively rare.

Certain pegmatite dykes, particularly those carrying reddish feldspar, contain small amounts of biotite. Except that they contain biotite mica, these dykes differ in no important respect from other (muscovite-bearing or mica-barren) pegmatites occurring in the same region. Probably the greatest distribution of such biotite pegmatites is to be found in the Ottawa, Parry Sound, and Bancroft districts, in Ontario. Near Verona a band of very coarse-leaved biotite, containing plates sometimes as much as several inches across, has been worked in a small way for grinding scrap.

The mica pegmatites along the north shore of the St. Lawrence, in some of which both muscovite and biotite mica occur, often in parallel intergrowth in the same crystals, carry pale, flesh-coloured and white feldspar.

Lepidolite or Lithia Mica

Lepidolite is rarely met with in large crystals that will yield sheet mica. The only important occurrence of large lepidolite crystals is in a pegmatite dyke in Wakefield township, Quebec. This pegmatite is of a type quite distinct from the many other dykes in the district. It consists of pale-coloured microcline, with considerable amazonite, and besides lepidolite, carries a quantity of pink and green tourmaline. An attempt to recover tourmaline of gem quality was made about twenty years ago, but the crystals proved to be opaque and cloudy and of no value. The lepidolite occurs in wedge-shaped books, sometimes as much as 10 inches across, but the mica is hard and brittle and splits poorly. The sheets are opaque and of a drab grey colour and of no value as sheet mica.

The lepidolite discovered in 1924 in Manitoba is quite distinct from the foregoing, and is of the usual commercial type mined in California, South Dakota, New Mexico, and elsewhere for its lithia content and for glass manufacture. It also occurs in pegmatite dykes, but these carry a mineral association quite distinct from that of ordinary muscovite pegmatites. While lithia-bearing pegmatites have been located at several localities in southeastern Manitoba, only one of the discoveries has been worked to any extent. At this mine, the lepidolite occurs in large, compact masses and shoots of small lilac- or lavender-coloured flakes within a dyke mass consisting principally of pink albite feldspar and spodumene. Small amounts of amblygonite also occur, as well as beryl, topaz, garnet, lithiophilite, columbite, etc. Cassiterite is reported to have been found in other similar dykes in the district.

In their general character and association of minerals, the Manitoba lithia pegmatites possess considerable similarity with those of the Black hills, in South Dakota, which have been worked extensively for lithia minerals.

METHOD OF MINING

Many of the mines that later developed into important mica producers were opened up originally for phosphate, between 1870 and 1890, in the days when apatite was an important raw material for the superphosphate industry. There was little or no use at that time for the mica encountered, and most of it went to the waste dumps. When the market for apatite disappeared, owing to the discovery of the immense sedimentary phosphate deposits of the southern United States, most of the mines were closed down. With the development of the electrical industry, a demand sprang up shortly afterward for mica, and the old phosphate dumps were worked over for the formerly discarded phlogopite. Some of the mines that had yielded considerable mica were also re-opened about this time, the mica being now the more valuable mineral and the apatite a by-product, for which only a limited market could be found. At this time, it was chiefly the larger-sized sheets that were in demand and only the best and largest mica was recovered. Later, when a market for progressively smaller and smaller mica developed, the dumps were worked over again, in some cases several times over a period of years. Finally, during the past few years, the demand for scrap mica has led to the dumps being worked for practically the last vestiges of mica that they contained, the finer rock matter being screened and all mica over one-half inch salvaged.

Only a few of the larger, old established mines possess permanent mining equipment, buildings, sleep camps, etc. Most of these larger mines use steam power; one mine, in Quebec, uses electric power, generated at its own station on a nearby stream. Much of the labour employed is recruited, as required, from the surrounding farms and villages, the retention of a permanent mining force being impracticable owing to the usually intermittent nature of the operations.

Mining for mica in Canada, being mostly surface working, calls for little in the way of detailed description. In the case of phlogopite, small open pits are first sunk on surface showings, and the size and character of the mica body disclosed—whether an apparently persistent vein or merely a pocket—decide the nature of further operations. In any case, the aim is always to extract all the mica in sight, and the leads and pockets are mined out until they pinch to unprofitable dimensions. Prospecting by means of surface trenches is then conducted upon likely looking ground around the original showing, and new pits are opened on any leads found. Where deposits are of the pocket type, the workings thus often consist of a large number of individual, small, shallow pits. These pits seldom become connected up by drifts or crosscuts, since any intervening mica stringers are usually considered too poor to work and underground prospecting through barren ground is too expensive.

The erratic and impersistent character of phlogopite bodies has generally prevented anything in the nature of systematic mining, and comparatively few of the total large number of mines have proved up deposits extensive enough to permit of large-scale and sustained operation. Most of the larger mines have been opened on deposits of the vein type, either on a single, exceptionally large vein or on a parallel system of smaller ones. In the latter event, each vein has usually been worked individually by a single long pit or by a series of pits put down at intervals along the strike; these latter sometimes have been joined up later underground by drifts. In a few instances, where a vein has proved unusually wide, or where a series of veins or more than usually persistent pockets occur in close proximity, the workings have been subsequently glory-holed into a single large excavation. Side-hill occurrences of veins and pockets are sometimes also worked quarry fashion from a single large pit, but such openings have seldom been carried down below ground level at the base of the knoll or hill.

Only in a few exceptional instances have phlogopite bodies been worked from a shaft, sunk either on the original surface showing or put down subsequently to one side of workings which had disclosed important quantities of mica. In almost all cases where shafts have been employed, their sinking has been dictated by caving of the original workings, and they have been put down in firm ground to one side of old pits. The mica leads have then been picked up by means of crosscuts driven beneath the old workings, and the mica mined by drifts and stopes. Such shafts are usually vertical, and the greatest depth obtained is not much over 300 feet. The great majority of mica pits, however, do not extend below 50 to 75 feet.

That the comparative shallowness of most phlogopite workings cannot be taken to indicate that phlogopite deposits in general may not extend to much greater depth, has already been remarked. In mining for phlogopite, and for mica generally, the limit of mining is nearly always decided by immediate results, and mica leads are followed only as long as they continue to yield paying amounts of mineral. Prospecting with the drill has very seldom been practised, either from surface or from existing workings at depth. The pockety nature of the deposits makes it difficult to lay out a drilling program and might well render the results of drilling inconclusive and even misleading.

Being located in an intensively glaciated region, the phlogopite deposits are enclosed in hard, unweathered rock from the surface. The rock is tight and compact, without joint-planes or slip faces, and stands well, so that little timbering is required. Overburden is usually light, since most of the mines have been opened upon outcrops on the eroded tops or flanks of ridges and knolls. Many deposits have been exposed by natural wash on the slopes surrounding lakes, which are a conspicuous physiographic feature of the mica region.

No muscovite mines of any size have been opened, and most of the workings are of the hillside, open quarry type. In very few instances have there been any sustained operations for muscovite, and the deposits have generally been abandoned at a shallow depth.

Since the value of mica depends essentially on the perfect quality of the sheets, care is necessary to avoid damage to the crystals in mining. Shallow holes are usually drilled and light charges are employed, the aim being to loosen the rock without injuring the mica or blowing it down among the heavy waste, where it is liable to become crushed. The loosened crystals or books are picked down and collected after each round and the pit is then mucked.

During the initial stages of development, hand-drilling has usually been employed, to be replaced later by steam drills, if the deposit showed promise. The use of compressors and air-drills was the exception up to comparatively recently, but the development of the portable, gasoline-driven compressor unit, which can be easily moved in to remote locations through rough bush country, has now led to the general adoption of air-drilling on small mines and prospects.

Hoisting, in most instances, is done by a bucket raised by steam derrick or small hoist. At small mines, derricks operated by horse-power, either with a whim or by direct traction, are often employed. Inclined skipways are used at some of the larger mines and in the case of deposits dipping much from the vertical.

Only at the larger and deeper mines, where considerable rock has to be handled, and at those mines equipped with shafts, is the waste run to the dumps on trestle tramways; usually it is dumped from the derrick bucket directly alongside the pits.

At those mines containing much apatite, the phosphate is usually sorted out during mucking operations and stock-piled. Formerly, most of the phosphate encountered was consigned to the Electric Reduction Company's works, at Buckingham, Quebec, for use in the manufacture of phosphorus, or to a superphosphate plant at Masson, both located near the Quebec mica field. At present, there is little or no demand for apatite, and unless met with in considerable quantities, it, as a rule, goes to the waste dumps.

PREPARATION FOR MARKET

Cobbing, Trimming, and Splitting

Rough-cobbed Mica. After removal from the pit, the rough mica usually undergoes an initial cobbing at the mine. For this operation it is taken to the cobbing shed, where a few men or boys are sufficient to take care of quite an important output. Adhering rock is cobbed off with hammers, and the block mica is broken into plates from one-half inch downward in thickness. It is then known as rough-cobbed mica, and may be disposed of as such to dealers, who conduct its further preparation for market.

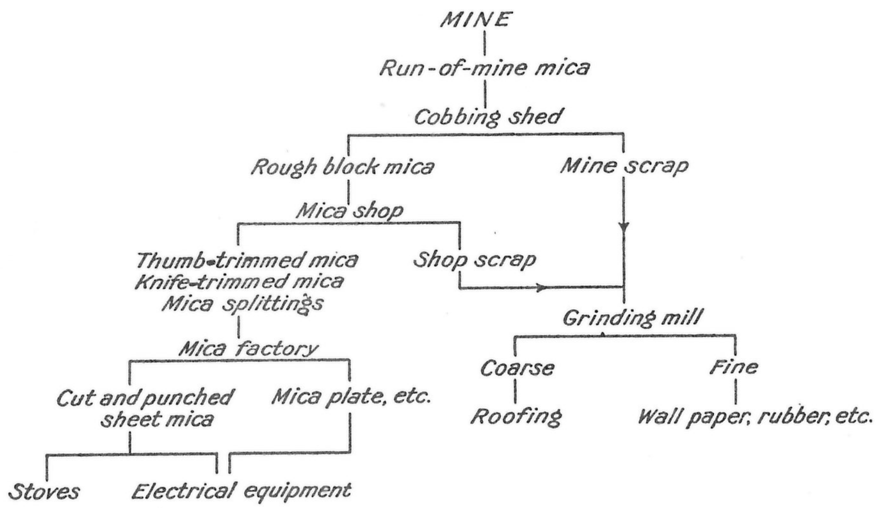


Figure 3. Outline of operations, showing course of mica from mine to finished product. Each stage—mine, shop, factory, mill—may be conducted by individual concerns, or there may be any degree of overlap, as when a mine operator is also a dealer and trims and splits his output, perhaps, also turning out cut and punched shapes.

Thumb-trimmed Mica. Some operators maintain trimming shops at or near their mines, where the cobbed mica is split by men or boys into thinner sheets, one-sixteenth inch and under in thickness, and the rough, hard edges broken off by hand. The resultant sheets are then known as thumb-trimmed mica; this is chiefly sold to the trade to be cut or punched into special shapes and sizes.

Such special shapes, as well as rectangular sheets of specified dimensions (pattern mica), are also cut to order by mica dealers, who, in addition, turn out a certain amount of punched mica washers, disks, segments, etc. Most of such cut and punched mica finds a domestic market, owing to the high tariff upon manufactured mica entering the United States. The cutting of sheet mica to special shapes and sizes is mostly done by shears or guillotine knives; and washers, disks, etc., are punched out on foot or mechanically operated presses, equipped with the requisite dies.

Much of the thumb-trimming, however, is done by girls, and the rough-cobbed mica is often shipped from the mine to a trimming shop located in a nearby village, where an adequate supply of labour can be obtained. In the case of dealers operating their own mines and also buying the output of other small operators, all the preparation subsequent to rough-cobbing is usually done at centrally located mica shops. Important centres for such mica shops are Ottawa, Perth, and Kingston, in Ontario; and Hull, Sorel, and Victoriaville,[1] in Quebec. A worker can turn out on an average of about 80 pounds of thumb-trimmed mica per shift.

Knife-trimmed Mica. Thumb-trimmed mica may be further cleaned by knife-trimming, by which the rough, broken, and frayed edges are cut off, leaving clear, perfect sheets containing no waste. Such mica, termed knife-trimmed, is mainly employed for the making of thin splittings (see below). Knife-trimming may be done by hand with the aid of a mica knife, a short, thick-handled implement with a four-inch blade, which is practically the only tool used in the hand preparation of mica. Sharpened to a point, this knife is also used to make thin splittings. In the larger mica shops, however, knife-trimming is usually effected by mechanical knives. These consist of a vertical disk about 20 inches in diameter, rotating within a casing provided with a narrow horizontal slit for the insertion of the piece of mica. The disk has two narrow, radial slits cut in it, and in these are bolted blunt-edged blades. The disk is set so that when it rotates, these blades just clear the edge of a small flat plate forming part of the frame of the machine. The piece of mica is laid on this plate and pushed forward through the slit in the casing against the face of the disk, the blades cutting off a narrow strip from the edge. Various modifications of this type of machine exist, but they all work on the same principle. A skilled worker can trim about 100 pounds of mica per shift with such a machine.

Mica Splittings. Mica splittings are mostly made from the smaller sizes, 1 by 1 inch to 1 by 3 inches, of knife-trimmed mica sheets. They are the thinnest sheets that can readily be split from mica sheets, and are required not to exceed one to two mils (one to two thousandths of an inch) in thickness. Their only use is for the manufacture of mica plate, in which they are built up with the aid of a shellac or similar binder to form a hard board. A large proportion of the smaller-sized mica mined is converted into splittings.

Mica splittings are made by hand, with the aid of the same type of knife as is used in trimming and splitting the thicker sheets. The blade, however, is dull-edged and kept sharply pointed. To facilitate the splitting off of the extremely thin mica leaves, the edges of the knife-trimmed sheets are rubbed along a piece of sandpaper or a rasp in order to burr them slightly.

As already mentioned, splitting is performed almost entirely by girls who work in centrally located mica shops. A great deal of the splitting is also farmed out and done in the operators' own homes. Most of the work is piece work and paid for by the pound of finished product. A good worker can turn out about 7 pounds of 1 by 1-inch splittings per nine-hour day and from 10 to 12 pounds of 1 by 2-inch.

[1] The important mica shops of the Mica Insulator Company, of New York, at Victoriaville, were closed down early in 1928, owing, it is stated, to the high labour costs involved in trimming and splitting mica in Canada.

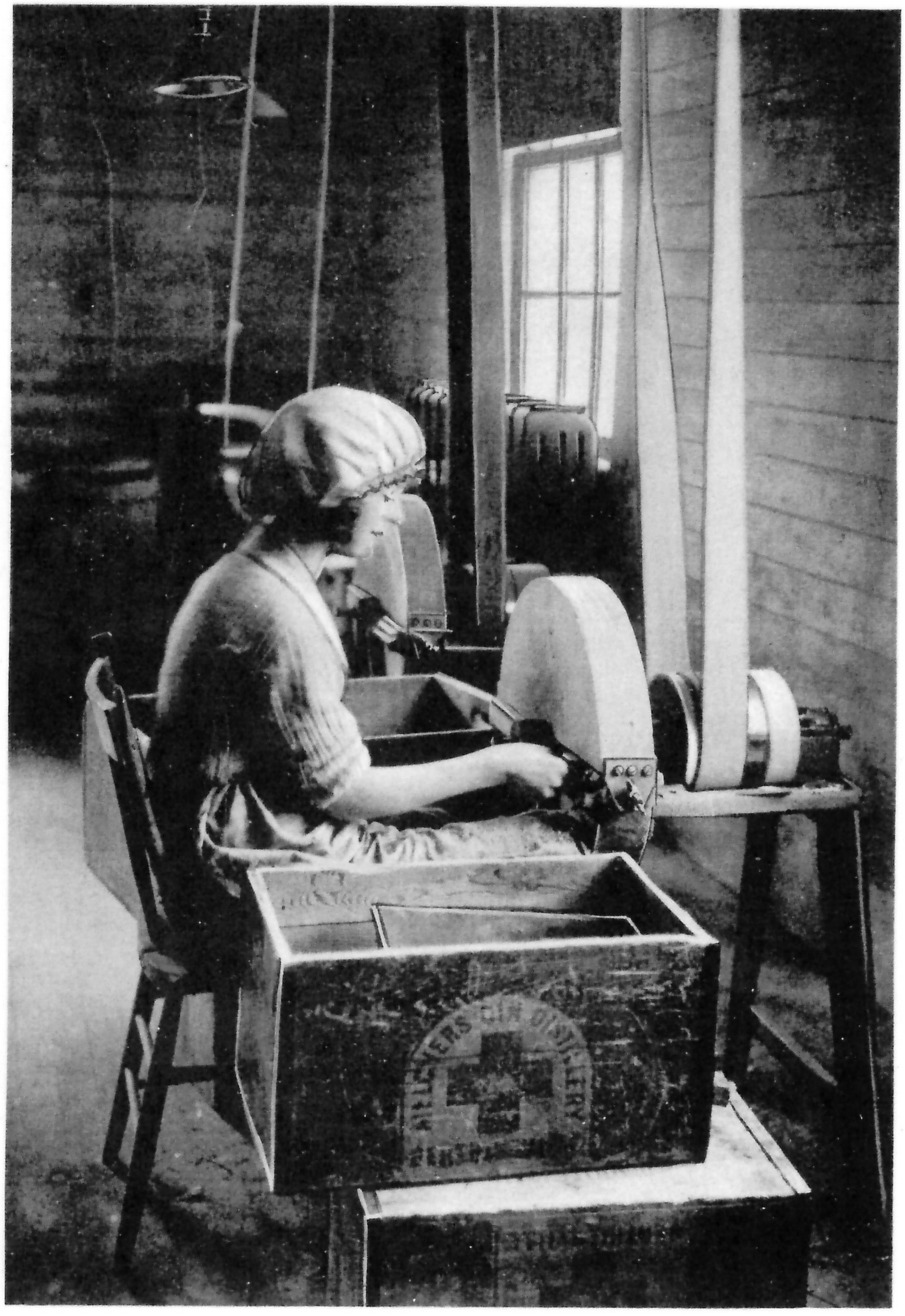
PLATE IX

PLATE IX

(*Photo by Messrs. Blackburn Bros., Ottawa, Ont.*)

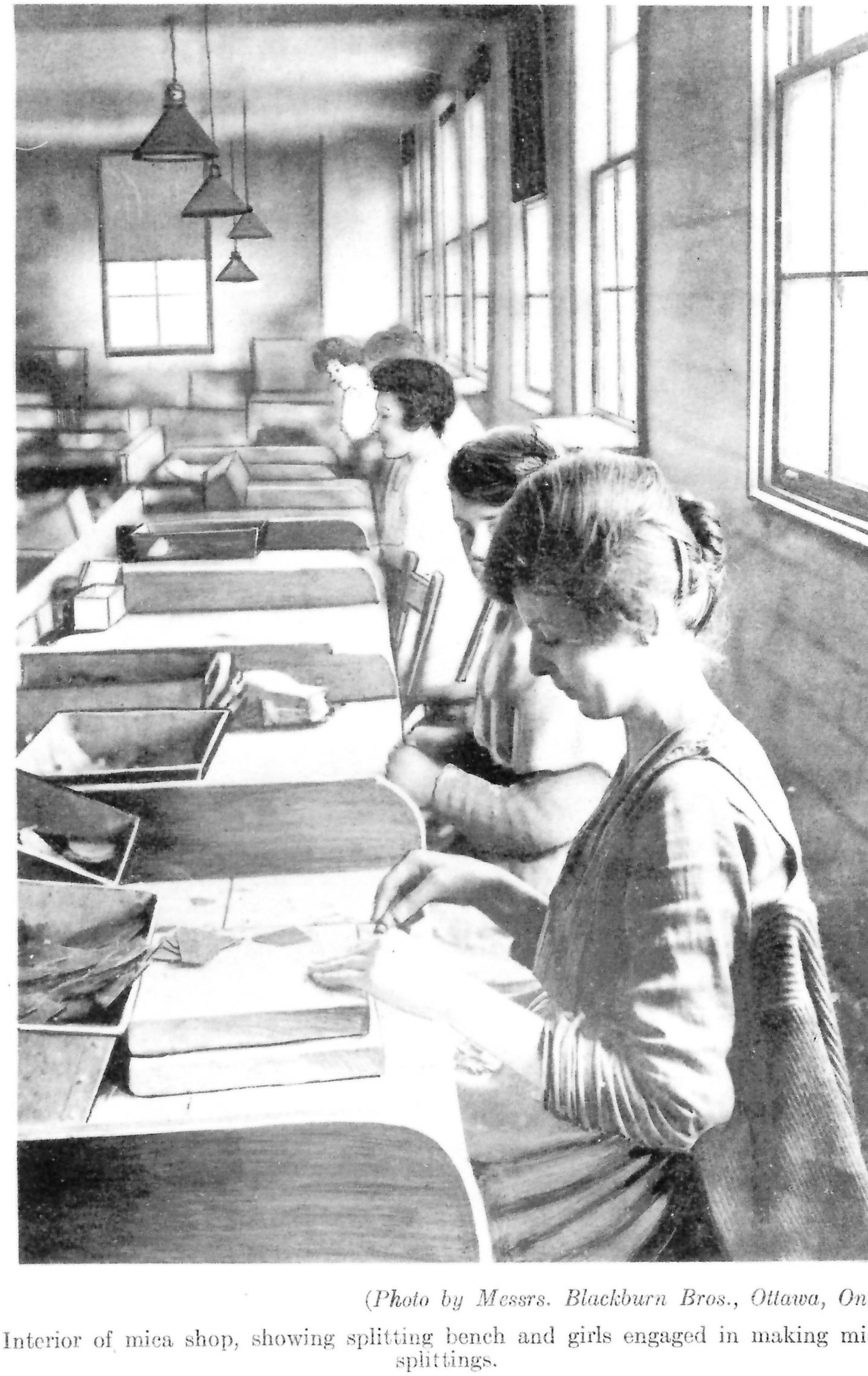
View of mica shop, showing girls engaged in trimming and grading mica.

PLATE X



(*Photo by Messrs. Blackburn Bros., Ottawa, Ont.*)

View of knife-trimming section of mica shop. Mica to be turned into splittings is first knife-trimmed by the power knife shown, which cuts off the rough waste and gives the sheet a clean edge.



(Photo by Messrs. Blackburn Bros., Ottawa, Ont.)

Interior of mica shop, showing splitting bench and girls engaged in making mica splittings.

While numerous attempts have been made to devise a machine that will make mica splittings as satisfactorily as they can be made by hand labour, no such mechanical equipment has, as yet, come into general use. A number of patents have been taken out for mechanical splitters, and it is understood that some of the devices have found a limited use, particularly in the larger American mica works. The modern tendency toward mass production in industry, and the ever-growing demand for standardized and cheaper materials, have led to the increasingly widespread employment in the electrical industry of built-up mica plate in place of natural sheet mica. This has brought about a demand for progressively smaller-sized mica and cheaper splittings. The latter demand has been met to some extent by the expedient of shipping mica to the Orient, chiefly India, to be there split by cheap labour and re-exported to the point of consumption. The introduction of improved mechanical methods of laying mica plate, however, has made it possible to use smaller and smaller splittings, and it would seem that the day cannot be long distant when the mechanical splitting of mica will have become perfected to the point where it will successfully supplant the comparatively expensive hand method. The need for this is felt particularly keenly in the United States, where high labour costs and the tariff of 30 per cent ad valorem on imported mica splittings make the laid down cost of this class of mica a matter of considerable moment to the manufacturer of mica plate.[1]

Grading and Sizing

The requirements of the mica trade call for close attention to the grading and sizing of the trimmed sheets, and it is in these branches that probably the greatest knowledge and care are demanded.

Grading

Mica, whether phlogopite or muscovite, varies widely in quality. In the case of the former, ease of splitting, degree of hardness and flexibility, and colour are the chief factors determining the market value. Transparency and freedom from spots and stains are important in muscovite. In all cases, of course, a prime consideration is that the sheets be free of included mineral matter, holes, cracks, creases, and similar defects; that they be, in short, sound mica. Some phlogopite swells up on the application of moderate heat, and is consequently unsuitable for use in electric heating equipment or in insulation liable to be subjected to heat.

The chief physical character that gives mica its value in the electrical field is its high di-electric strength, and micas may vary quite widely in the degree of such strength. Except for special purposes, however, where particularly high strength is demanded, most phlogopite and clear muscovite may be considered as strong enough for the electrical trade.

General quality in phlogopite is usually related to colour, the best mica being the light- and medium-coloured amber grades. Dark amber mica is generally a poor splitter, and sometimes very light phlogopite has the same fault. Colour, therefore, is an important guide in the grading of phlogopite, and since different pits on the same property often yield mica

[1] For descriptions of various patented methods of splitting mica, *see* Appendix I.

of varying shades, it may be necessary to keep the products separate. Dealers, too, often buy up small lots of mica from different, scattered operators, and care must be exercised not to mix the shipments, since parcels of uniform colour are more readily marketed than mixed consignments. An experienced worker can grade about 250 pounds of mica per shift.

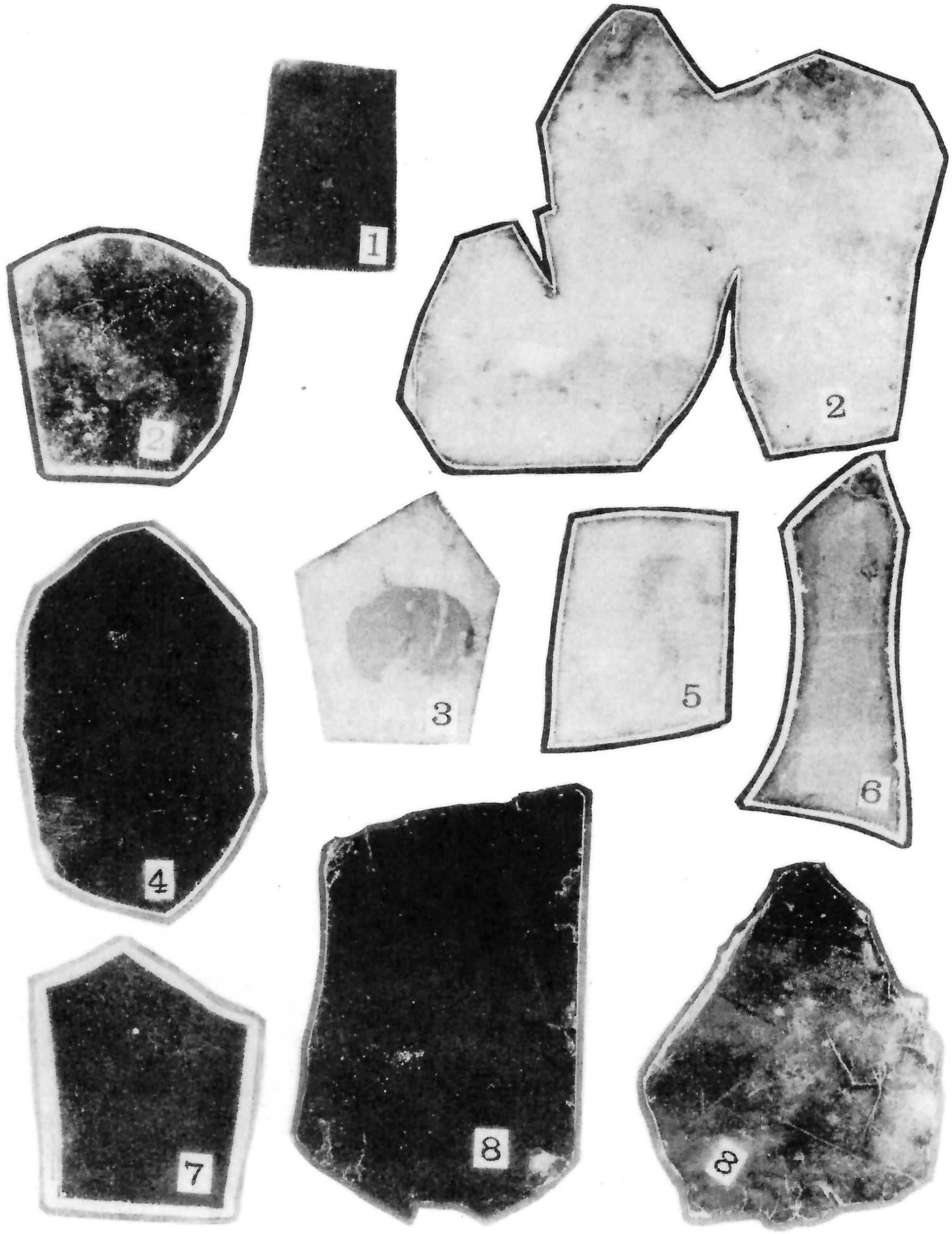
The grades (colours) of phlogopite mica recognized in the trade are: light amber, silver amber, medium amber, and dark amber. The very dark phlogopite is often termed black mica, and there is a type of light phlogopite styled milky amber. While colour in Canadian phlogopite is taken as a general index of quality, and grading by colour is practised in order to ensure more or less uniformity in shipments, no arbitrary standards along such lines have been set up as marketing terms, as in the case of Indian muscovite, and the mica is mostly sold by sample. The consumer, in all cases, conducts the necessary tests for di-electric strength, heat resistance, etc.

As already described, amber mica is sold in various stages of preparation, termed (1) rough-cobbed; (2) thumb-trimmed; (3) knife-trimmed; and (4) splittings; the unit value rising with each stage, by reason of the increased amount of labour involved.

Little rough-cobbed mica gets on to the open market, the bulk of it being worked up by producers and dealers to the stage of trimmed sheet. Trade in knife-trimmed mica is also small, since this class of mica is designed primarily as raw material for thin splittings, which are made from it by the dealers themselves. The greater part of the mica sold is marketed in the form of thumb-trimmed sheet and splittings.

Of the Canadian system of thumb-trimming mica, it may be said that it has little to recommend it. The sheets have irregular form, their edges are ragged and broken, and the purchaser is faced with an undue amount of waste on which he has had to pay freight. In a market where Canadian mica has to meet the competition of clear, knife- or sickle-trimmed sheets, such as are produced in India and other parts of the world, the offering of thumb-trimmed mica has tended to bring Canadian mica as a whole into disrepute, especially since the price asked is often considerably higher than that of the foreign product. While thumb-trimming entails less labour on the part of the producer than knife-trimming, and also probably nets him a greater return, since he is selling a proportion of waste at the price of sheet, Canadian mica would undoubtedly have secured a better reputation and established itself more firmly in the world market had this system of trimming never been introduced as a standard grade. As a device of the producer to increase his sales, and also his profits, the system was tolerated in the earlier days of the industry when competition was less keen, standards lower, and the demand for Canadian amber mica more insistent. To-day, its continuance is against the best interests of the industry, which could not but benefit if it were discarded in favour of knife- or sickle-trimming.[1]

[1] Note.—In the trade, the terms "knife-trimmed" and "sickle-trimmed" are used to designate the *style* of trimming rather than necessarily the implement by which the trimming is done. "Knife-trimmed" mica is mica that has square, unbevelled edges, and from which all waste has been removed by either a mechanical knife, guillotine, or shears. "Shear-trimmed" is an alternative term to "knife-trimmed". "Sickle-trimmed" mica is clear sheet whose edges have been trimmed by a hand knife or sickle, which gives them a bevel, since mica can only be cut readily by such means when the tool is held on the bias, so as to slice the mica at an angle: the term owes its adoption to the use in the Bihar or Bengal mica field of a sickle for trimming mica.



Samples of commercial grades of mica from different countries, illustrating standard methods of trimming practised: 1. Madras muscovite (knife-trimmed). 2. Bihar or Bengal "ruby" muscovite (sickle-trimmed). 3. Rhodesian muscovite (knife-trimmed). 4. Guatemala muscovite (sickle-trimmed). 5. Argentina muscovite (sickle-trimmed). 6. Brazilian muscovite (sickle-trimmed). 7. Madagascar phlogopite (sickle-trimmed). 8. Canadian phlogopite, dark and light amber grades (thumb-trimmed). Sample 2 shows the close trimming ("Calcutta trimming") practised in the Bihar field, whereby all waste is removed, even to the extent of cutting re-entrant angles into the sheet. (Mica outlined in black to show up the edges. One-seventh natural size.)

Sizing

The Canadian mica industry has its own individual system of sizing mica for the market, which differs from that followed in India and the United States. The Canadian and American classifications are alike in that they are based on, and named according to, the dimensions in inches of the rectangular pieces that the sheets will yield, while the Indian classification specifies the area in square inches of such rectangles. In India, also, a different scale of size is used in the Bihar and Madras fields.

The Canadian classification is as follows:—

1 x 1 inches	2 x 4 inches
1 x 2 "	3 x 5 "
1 x 3 "	4 x 6 "
2 x 3 "	5 x 8 ", and over

The following table shows the approximate equivalents of the various market sizes produced in India, the United States, and Canada.

TABLE XV

Standard Sizes of Sheet Mica as Produced in India, the United States, and Canada

India				United States	Canada
Bihar (Bengal)		Madras			
Class	Sq. ins.	Class	Sq. ins.	Ins.	Ins.
	....	IX	96—112	....	....
	....	VIII	90— 96	8 x 10	....
Extra specials..	48 and up	VII	64— 80		....
	....	VI	48— 64	....	....
Specials........	36-48	V	32— 48	6 x 8	5 x 8
No. 1..........	24-36	....	....	6 x 6	....
No. 2..........	15-24	IV	16—32	4 x 6	4 x 6
No. 3..........	10-15	III	8—16	3 x 5	3 x 5
No. 4..........	6-10	....	....	3 x 4	....
No. 5..........	3- 6	II	4— 8	3 x 3	2 x 4
No. 5½.........	2½- 3	....	....	2 x 3	2 x 3
	....	I	4 and under	2 x 2	1 x 3
No. 6..........	1- 2½	....	....	1½ x 2	1 x 2
No. 7..........	1 and under	....	....	....	1 x 1

Mica is sold by the pound, and the value increases rapidly with the size of the sheets. The market is difficult to gauge, and quotations are only an approximate index of value owing to the practice of allowing large trade discounts. Also, many of the largest consumers operate their own mines and are financially interested in the mining end, or have established close trade connexions with important producers in order to protect themselves against market fluctuations and shortages.

Before the war, the world's chief mica market was located in London, where regular auction sales of mica shipments from all over the world were held. This system no longer prevails, and the business, outside of the important volume represented in the closed market of the larger consumers, is mainly in the hands of brokers and dealers. Such dealers constitute virtually the only market for the output of the small operator, who usually disposes of his production in the rough-cobbed or thumb-trimmed state. A list of the principal Canadian mica dealers is given on page 133.

CHAPTER V

PHLOGOPITE OR AMBER MICA MINES AND OCCURRENCES IN CANADA

A very comprehensive survey of the mica mines and known occurrences of mica in Canada was made by the writer in 1910, and the results were published,[1] in 1912, in the form of a monograph dealing with all phases of the mica industry. There have been few mica mining developments of major importance since the above report was issued. Very few new mines have been opened, and the production of mica in the interval has come mainly from a small number of large mines that have been in more or less continuous operation for many years. Small-scale operations have been renewed from time to time at some of the smaller mines described in the report referred to, and desultory prospecting has led to the working in a small way of a few new properties. There has also been a considerable amount of dump turning conducted in many sections of the mica field; and, in addition to the scrap mica recovered during these operations and sold for grinding purposes, important amounts of small-sized sheet have been secured and have helped to swell the production derived from mining operations.

At the time of writing (1928), there are not more than two or three amber mica mines of any importance in operation. Since the outstanding data relating to the older and now idle mines are already on record in the report mentioned in the footnote, detailed reference will be made here only to those properties which have been actively worked in recent years and which have contributed most of the recorded output. The less important or idle mines in each township are listed by range or concession and lot number.

QUEBEC

Active mining[2] for amber mica in the province of Quebec has been chiefly confined to the region bordering on, and lying between, the Lièvre and Gatineau rivers, in the counties of Hull and Papineau.

The mica-bearing pyroxenites find probably their greatest development in the region immediately to the north of the city of Ottawa, and outcrops occur on many of the hills, knolls, and ridges in the townships of Templeton, Wakefield, Hull, and Portland. Marine clay covers many of the depressions and valleys between the hills, and much of the area is occupied by lakes (*see* Plate I). In addition, glacial drift often conceals the flanks of hills and ridges beneath a heavy mantle of sand or till, so that outcrops of the underlying crystalline rocks are found only at higher elevations, or where erosion has removed the clay or drift cover.

[1] "Mica, Its Occurrence, Exploitation, and Uses"; Mines Branch, Dept. of Mines, Canada, Rept. 118 (1912). This report is out of print, but it may be consulted in any of the larger public and technical libraries.

[2] For details of mica mining operations in the province, *see* Annual Reports on Mining Operations, Department of Colonization, Mines and Fisheries, Quebec.

Westward, the pyroxenites are known to extend as far as the townships of Bryson and Waltham, in Pontiac county; while, eastward, mica deposits associated with similar rock have been located in Wentworth, Harrington, and Grenville townships, in Argenteuil county. The mica occurrences in these outlying districts have thus far proved relatively small and unimportant; yet they indicate the wide distribution of the pyroxenite series and suggest the possible existence of larger deposits outside the present main producing area.

Northward, the limit of the mica-bearing region has not been determined. Deposits have been worked as far north as the townships of Cameron and Bouchette, and occurrences are also reported in Egan, Aumond, and Lytton townships, still farther to the north.

Physiographically, the mica-bearing region is a rough, broken terrain of medium relief, the general elevation ranging between 300 and 600 feet above sea-level. It is dotted with individual eminences and ridges that rise around 1,000 feet.

Much of the surface is occupied by lakes. Bounded on the south by the Ottawa river, the district is drained by two principal and parallel streams, the Gatineau and Lièvre rivers, which flow south about 15 to 20 miles apart and join the Ottawa at Gatineau Point and Masson, respectively.

The region is densely wooded with second-growth timber, both hard and soft, the former supplying ample fuel for mining purposes. Most of the low-lying and more level land has been cleared for farming purposes, and it is from the farms that most of the labour employed in mining is drawn.

Both the Gatineau and Lièvre rivers have been developed for hydroelectric power purposes, though as yet none of the power is available for local public use.

The Gatineau is not a navigable stream, but the Lièvre is navigable for scows for a distance of about 20 miles north of Buckingham, to which point rail transportation extends. Much of the phosphate and feldspar mined in the Lièvre valley has been shipped out to rail by scow.

The district is served by three branch railroads, having their central terminus at Ottawa. These are the Ottawa–Waltham, or Pontiac, line, running westward up the Ottawa river; the Ottawa–Maniwaki, or Gatineau Valley, line, running northward up the Gatineau river; and the Ottawa–Montreal, or North Shore, line, running eastward down the Ottawa river. All belong to the Canadian Pacific Railway system.

The condition of the main roads serving the district has been much improved in recent years, and transport by light motor truck is now possible in many of the more settled sections.

The geology of the Quebec mica field has been described by M. E. Wilson[1], who has also prepared a geological map of the region[2].

[1] Geol. Surv., Canada, Sum. Repts. 1913, pp. 196–207; 1915, pp. 156–162; Mem. 136, Arnprior-Quyon and Maniwaki Areas, Ontario and Quebec (1924).
[2] Map No. 1691, Buckingham; Hull and Labelle Counties, Que., 1920.

Hull County

Township of East Hull

The township of Hull, which lies immediately to the north of the city of Ottawa, is bisected transversely from the northwest to the southeast corners by the Gatineau river, which divides it into East Hull and West Hull. Mica showings are numerous throughout the area of crystalline rocks exposed north of range V, and extensive mining has taken place. There has been little activity in recent years, however, and most of the mines have been closed down for some time.

The most important mining centres were on lots 10 and 11 in ranges X, XI, and XII, and on lots 12 to 16 in ranges XV and XVI. Here, important bodies of mica-bearing pyroxenite occur, and have been worked at various times by different operators. While numerous openings have been made on these properties, few of them have been carried to important depths. The deepest pit is probably on the Nellis, or Vavasour, mine, on lot 10 in range XII, where a depth of 180 feet is reported to have been reached. There is an unusual development of parallel mica leads on this property, which has produced a large quantity of excellent mica and is still considered to possess important mica reserves.[1]

The only important, recent mining in the township has been conducted during the past few years by Mr. A. G. Martin, of Ottawa, who has worked the Dacey mine, on lot 12 in range XV. Work was chiefly confined to deepening one of the old pits and drifting on a lead of medium- to light-amber mica associated with pink calcite. A small amount of work was also done on surface showings northeast of the old workings. Both sheet and scrap mica were produced.

A small quantity of mica was also produced in 1925-26 by Messrs. Blackburn Bros., of Ottawa, from workings adjoining the Vavasour mine in range XII, and by W. Ahearn, of Ottawa, who operated the Nellie and Blanche mine, on lots 10, ranges X and XI.

The more important mica workings in the township are:—

Range X, lot 4; lot 7—Foley mine; lot 9.

Range XI, lots 5a and 6a—Kearney mine; lot 5b—Cashman mine; lot 6b—Burke mine; lot 7.

Ranges X and XI, lots 10—Nellie and Blanche mine.

Range XII, lot 1 S½—Burke mine; lot 10—Vavasour or Nellis mine; lot 11a—Brown mine; lot 12.

Range XIII, lots 3 and 4; lots 11, 12, 13, and 15.

Range XIV, lot 10N½—McClelland mine.

Range XV, lot 12a—Dacey mine; lot 12b—McAllister mine; lot 13—Connor mine; lots 15E½, 16.

Range XVI, lot 13—Stewart mine; lots 15 N½, 16 N½, and 17—Horseshoe mine; lots 15 S½ and 16 S½—Cassidy mine.

[1] The geological relationships of the mica deposit at this mine, with a map showing the rock association, are described in Guide Book No. 3, Twelfth International Geological Congress, 1913, pp. 111–113. The description (without map) has been printed also in Ann. Rept., Mines Branch, Province of Quebec, 1913, pp. 142–4.

Township of West Hull

Most of the mica produced in this township has come from mines on lots 18 to 20 in ranges VI and VII, near Kingsmere, and from range XV, near Cascades. At both places, important bodies of mica-bearing pyroxenite occur and have been worked by various operators. The larger mines, however, were closed down a number of years ago, and there has been no recent production of any importance.

Mica mines in the township include the following:—

Range VI, lot 19—Wallingford mine; lot 20—Cliff mine.

Range VII, lot 15—Headley mine; lot 18 S½.—Fortin and Gravelle mine; lot 19—Laurentide mine; lot 20 S½—Fleury mine.

Range VIII, lots 17 and 18.

Range IX, lots 14 and 15.

Range X, lot 11; lots 15, 16, and 19.

Range XI, lot 16—Connor mine; lot 17.

Range XII, lots 14, 15, and 16—Connor mine.

Range XIV, lot 22.

Range XV, lot 23—Cascades mine; lot 25—Moore mine; lot 27—Flynn mine.

Range XVI, lots 26, 27, and 28—Carman mine.

Township of Eardley

Mica occurrences are reported on the following lots, the principal work having been conducted on lot 2 in range X and lot 6 in range XI:—

Range IX, lots 1, 2, and 3. *Range X,* lot 2 N½—Flynn mine. *Range XI,* lot 3; lot 6 N½. *Range XII,* lot 6. *Range XIII,* lot 9.

Township of Masham

Mica occurs on lot 17, range III, and was worked in a small way some years ago. Other occurrences are reported on:

Range I, lot 34. *Range III,* lots 10 and 11. *Range IV,* lot 1.

Township of Wakefield

Most of the mica mining in this township has been conducted in the southern part, on the first and second ranges. The Lake Girard mine was formerly a very important producer, employing a large number of men and maintaining an extensive trimming establishment in Ottawa. It was finally closed down in 1904. During the five years of most active operation, from 1891 to 1896, this property is reported to have produced 3,000 tons of sheet mica. A number of mines have also been opened in a zone of mica-bearing pyroxenite that runs in a northeasterly direction from lot 12 in range I to lot 18 in range II. Outside of mica recovered from old dumps, there has been little production from the township in recent years. The most important workings include the following:

Range I, lot 6 N½—McBride mine; lot 12—Haldane mine; lot 14—Allan mine; lot 15 S½—Comet mine; lot 16.

Range II, lot 16—Kodak mine; lot 17 E½—Kitty Lynch mine; lot 18 —Seybold mine; lots 23 and 24—Lake Girard mine.

Range III, lot 16—Thompson mine.

Range IV, lots 23 and 25.

Range V, lots 27 and 28.

Range VI, lots 26 and 27—McGlashan mine.

Range VIII, lot 25.

Township of Low

Large sheets of mica were formerly obtained from the Brock mine, on lot 36 in range XII.

Township of Denholm

Mica was worked a number of years ago on lots 18 and 19, range B, and occurrences are reported on:

Range I, lot 1. *Range V,* lots 20, 21, and 22. *Range VI,* lots 26 and 27. *Range VIII,* lots 18 and 19.

Township of Aylwin

Mica has been mined at various times on lot 7, range III, by the owner, Mr. H. Flynn, of Hull. There are also small workings on:

Range IV, lot 7—Ryan mine. *Range X,* lot 35. *Range XI,* lots 40 and 43.

Township of Hincks

Amber mica of a very dark shade, some of it almost black and resembling biotite, has been mined on lot 22, range II, and lot 23, range III. The mines have not been operated for many years. The mica secured on range II was often of very large size, sheets measuring over 4 feet across having been obtained.

On lot 31, range IV, a light cinnamon-brown mica occurs, associated with pale-coloured pyroxene and crystalline limestone. The deposit is evidently of the contact class, described on page 43, owing its origin to an intrusion of igneous rock into limestone. A small quantity of mica was mined on this property many years ago, but there has been no recent work. Other small mica workings include:

Range II, lot 21. *Range III,* lot 25. *Range IV,* lot 3—Paquet mine; lot 6; lots 17, 18, 30, 36, 37, and 38. *Range X,* lots 32 and 33. *Range XIII,* lots 48 and 49.

Township of Wright

A rather extensive development of mica-bearing pyroxenite occurs in this township, and several fairly large mines were in operation a number of years ago. There has been no recent mining of any consequence.

The Chaibee mine, on lot 6, range A, was worked successively by several large mica companies, and a 75-foot shaft was sunk. Considerable diamond-drilling is also reported to have been done.

The Father Guay mine, on lot 15, range D, was also a former important producer, and has extensive workings. Considerable mica has also been taken from the adjoining property, on lot 16.

Mica has also been worked on the following:

Range V, lot 12—Moore mine. *Range VI,* lot 5—Thayer mine. *Range B,* lot 19.

Township of Northfield

Mica has been mined in Northfield township on the following properties. None of the workings are extensive, and the total production of mica has been small. There is no record of any recent work of importance.

Range I, lot 6—Ellard mine. *Range II,* lots 25, 32, and 33. *Range III,* lots 31 and 32. *Ranges A,* lot 1, *and B,* lots 12 and 13—Ethier mine. *Range A,* lot 8. *Range B,* lot 19.

Township of Blake

Mica workings in this township are small, and there has been no production of any consequence. The following properties have been worked, but there is no record of any recent mining:

Range IX, lot 16; lot 22—O'Brien and Fowler mine.

Township of Bouchette

Range IX, lot 35.

Township of Cameron

Small-scale mining has been conducted at the following localities in Cameron township:

Range II, lot 10—Cleland mine; lots 11 and 12, lot 13—Lacroix mine; lot 14—Marguerite mine.

Range III, lot 50.

Township of Maniwaki

A little mica has been mined at various times on the following lots:

Road range east, lot 20.

Road range west, lots 14 and 21.

Range IV, lot 21.

Township of Egan

Mica has been mined on the Joanis property, on lot 28 in range II.

Township of Aumond

Mica is reported to occur on lot 6 in range B.

Township of Lytton

Mica was formerly mined on the Ethier property, on lot 21 in range II.

Papineau County

Township of Templeton

Mica and phosphate are widely distributed throughout this township, the more important deposits and largest mines lying in the Perkins–McGregor Lake section, north of the seventh range. This district was formerly the seat of important phosphate mining operations, and many of the properties have subsequently been worked for mica. The larger part of the mica production of the province has come from mines in this township and in the adjoining townships of Hull and Wakefield. The Blackburn and Wallingford mines have for many years been the most important producers.

Range VIII, Lot 16W½—Wallingford Mine. Opened originally for phosphate, this mine was later acquired by the present owner, Mr. E. Wallingford, of Perkins. The property has been kept in fairly steady operation for a number of years past and has produced a large quantity of excellent mica.

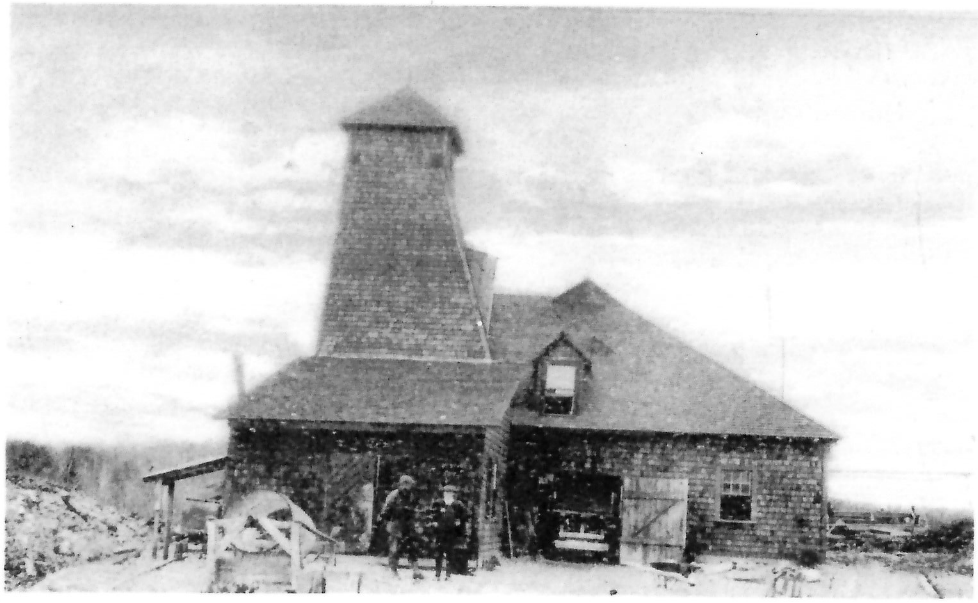
The property is equipped with a considerable plant, and extensive mining has been conducted. The workings consist of a number of open pits, some of which have been carried to depths of 125 to 150 feet, sunk on pockets and leads, and one large excavation, 170 feet long by 40 feet wide, and over 200 feet deep.

The mica is a first class grade of light amber, and some very large crystals have been found. One crystal is stated to have yielded $33,000 worth of trimmed sheet. The mica is rough-cobbed at the mine, and is then shipped to the trimming shop at Perkins, where it is prepared for the market.

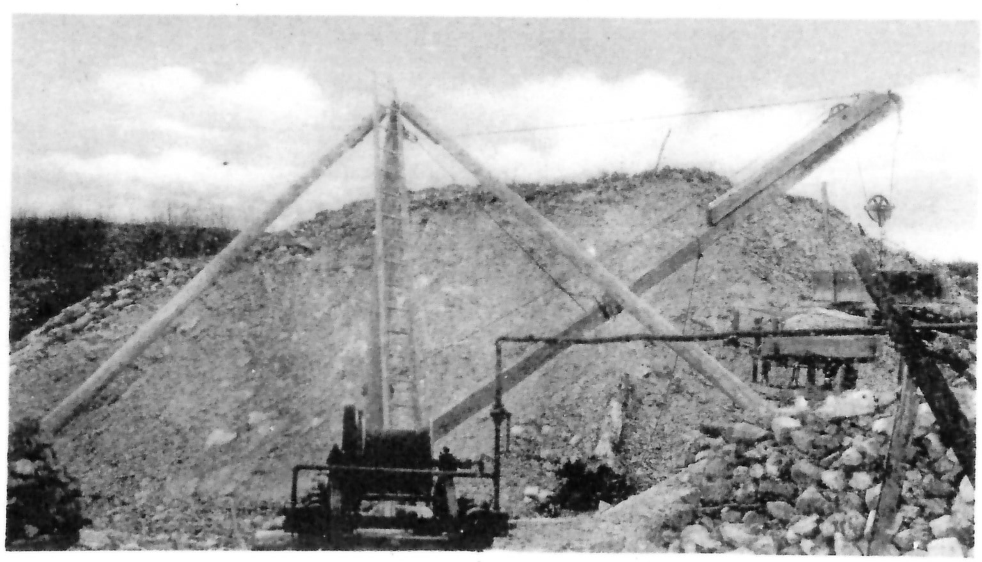
The property lies 2 miles southwest of the village of Perkins and 10 miles from East Templeton station, on the Ottawa–Montreal, North Shore, line of the Canadian Pacific railway. It embraces a portion of what is evidently a large body of mica-bearing pyroxenite, and adjoins two important old phosphate properties, the Rainville and Phosphate King mines, which lie on the next lot to the east (lot 15 E½, and lot 15 W½, respectively). These properties have also been worked extensively for mica, which occurs associated with the apatite, the general mode of occurrences being similar to that at Wallingford mine.

Range XI, Lot 9—Blackburn Mine. Owned by Messrs. Blackburn Bros., of Ottawa. One of the largest mica mines in Canada, this property lies 13 miles north of East Templeton station, on the North Shore, Ottawa–Montreal line of the Canadian Pacific railway, and 4 miles from the village of Perkins. The distance from Ottawa is 22 miles.

Originally opened for phosphate, about the year 1886, by the East Templeton District Phosphate Mining Syndicate, the mine has produced a large quantity of that mineral. When the demand for phosphate declined, mining was continued by the present owners for mica, which occurs in close association with large, pockety apatite bodies. With short intervals of idleness, when the workings became flooded, the mine has been a steady producer of mica for many years. At the present time, the force employed



A. New shaft-house at Blackburn mine, range XI, lot 9, Templeton township, Que. The mica is rough-picked in the pit and dumped to the cobbing house in front of the hoist-tower, the clean, cobbed mica being shipped to the company's mica shop at Hull, Que.



B. Dump-turning operations at Blackburn mine, range XI, lot 9, Templeton township, Que. The rock dump in the background, containing smaller sizes of mica discarded as waste in earlier days, is being worked over. The rock is picked out and the finer material passed over a coarse-mesh rotary screen. This removes the sand and grit, the mica recovered being used to make splittings.

numbers about 25, part being engaged in mining, and part in turning the old waste dumps. The mine dumps have yielded a large amount of small-sized sheet and scrap mica, discarded in the days when only large-sized mica was marketable. The mica yield by this mine is a light silver-amber of the best quality. The phosphate is both massively crystalline and of the soft, powdery type, termed "sugar" phosphate.

Numerous openings exist on the property, which has been extensively prospected for both phosphate and mica. The principal excavation is a large open pit, or glory-hole, nearly 400 feet long, 180 feet wide at its southeast end, and 150 feet deep. Mining in recent years has been confined to the ground adjacent to the southeast end of this pit, where a number of old underground workings have been picked up and extended. These old workings consisted of three main drifts and stopes, 300 to 500 feet long, on the 180-, 240-, and 280-foot levels, and entered from a shaft 160 feet deep, sunk from a drift run from the bottom of the open pit. The mica occurs in large, pockety bodies, which have been stoped out from staging erected in the drift, the large, open stopes being in places 40 to 50 feet high. The drifts have been run mainly to the north and south, following irregular pockets of mica and phosphate enclosed in a matrix of green pyroxene.

A few years ago, a new vertical shaft, 8 by 12 feet, was put down 100 feet to the west of the south end of the open pit, to pick up the underground workings, and has been carried to a depth of 240 feet. Short drifts, run at the 100-, 150-, 200-, and 240-foot levels, connect the shaft with the workings. A shaft-house (*see* Plate XIIIA) has been erected at this point, and ore is raised by bucket and air-driven hoist.

The mica and phosphate bodies disclosed in the present workings are unusually large, and the mine contains large reserves of both minerals. The proportion of valuable mica to the total amount mined is also unusually high, about 50 per cent being marketable sheet.

The run-of-mine mica undergoes a rough cobbing in a cobbing shed at the shaft head, and is then run on a short tramway to a loading pocket, from which it is drawn into trucks and taken to the company's trimming shop at Hull. The phosphate encountered in mining is stock-piled and disposed of as occasion offers.

The deposit is associated with a pyroxenite body of undetermined extent, enclosed in reddish gneiss; several narrow pegmatite dykes are exposed in the walls of the open pit.

The property has a well-equipped plant, which includes a hydro-electric power station on the creek between Dam and McGregor lakes, 2½ miles from the mine. The head used is 22 feet, and the developed power, 150 h.p. current, is transmitted at 2,400 volts by a 3-phase line to the mine, where it is stepped down and used to drive pumps, compressor, and various other mine equipment. A boarding and bunk house at the mine has accommodation for 80 men.

Range XI, Lot 10—North Hill Mine. Also owned by Messrs. Blackburn Bros., of Ottawa. The workings lie one-half mile northeast of the company's main pit on lot 9. This is one of the few mica properties where systematic underground mining operations have been employed from the start in the exploitation of the ore-body, the system of work having been facilitated by the nature of the mica lead, which proved to be unusually regular and persistent. Work was commenced on the deposit about 1908 and has been continued intermittently to the present time. At the moment of writing, the mine is closed down.

The deposit consists of a well-defined vein, dipping at an angle of about 60 degrees, carrying medium-sized mica crystals associated with pink calcite and apatite. The mica is of a light, silver-amber shade, and the vein has an average width of about 5 feet. Work has been conducted from an inclined shaft, 8 by 6 feet, sunk on the lead. This shaft has reached a depth of 325 feet, and six levels have been run at 50-foot intervals, the first being at 60 feet. The lead has been drifted on for a maximum distance of 300 feet from the shaft, the mica being extracted by overhand stoping methods.

The mine is equipped with a shaft-house and electric hoist, ore being raised on an inclined skipway. Air is piped from the plant at the main mine to run drills, and the mine is lit by electricity supplied from the company's power plant at the outlet of Dam lake.

Other mica mines in Templeton township which have been worked in the past, but upon which little or no important work has been conducted in recent years, include the following:

Range IV, lot 1; lot 22—McVeity mine.

Range V, lot 18.

Range VI, lot 15—Brady mine; lot 18 S½—Cobey mine; lot 18 N½; lot 22 N½—McElroy mine.

Range VII, lot 10—Stevenson mine; lot 16 W½.

Range VIII, lot 10—Barbutte mine; lot 13 S½—Dwyer mine.

Range IX, lot 4—Sophia mine; lot 11 S½—Prudhomme mine; lot 14 S½; lot 15—Laurentide mine; lots 17 and 18—Goldring mine; lot 20.

Range X, lot 2—Gilmour mine; lot 8—Marsolais mine; lot 9 E½—Post mine; lot 9 W½—Jackson Rae mine; lot 10 N½—Jubilee or Smith mine; lot 10 S½—Murphy mine; lots 15 W½ and 16 N½—Victoria mine; lot 28.

Range XI, lot 12—Stewart mine; lot 14—Cornu mine.

Range XII, lots 4, 5, 8, 11, 12, 13, 20, and 21.

Range XIII, lots 4 and 5—Battle Lake mine; lots 11, 14, and 15.

Gore, lot 3—Rheaume Lake mine; lot 6; lot 8—King Edward mine; lot 18—Blackburn mine; lot 38—Murphy mine; lot 39—Briggs mine.

Township of Buckingham

Mining on a small scale has been conducted intermittently at scattered localities in this township, chiefly west of the Lièvre river. A little mica was also found associated with the large phosphate bodies mined years ago at the Ætna, Squaw Hill, and Emerald mines, on lots 17 to 19 in range XII. There is no record of any recent work. Among the properties worked are:—

Range IV, lots 21 and 25 N½.

Range XII, lots 12, 13, and 14.

Township of Lochaber

Range VIII, lot 19.

Township of Portland West

This township, like that of Portland East which adjoins it across the Lièvre river, contains few important mica workings, although both townships were formerly the centre of extensive phosphate mining operations. Only a small amount of mining has been conducted in recent years.

The mines in the township include:—

Range II, lot 6.

Range III, lots 12 and 13—Lake Terror mine; lots 14 S½ and 15—Chabot mine; lot 24—Lila mine.

Range IV, lot 15—Mud Lake mine; lots 27 and 28—Fleming and Allan mine.

Range VI, lots 4 and 21.

Range IX, lots 5 and 6.

Range X, lots 2, 4, 5, 6, 7, 8, 11, and 12.

Township of Portland East

In Portland East township, mica has been mined intermittently in a small way, and various old phosphate mines have been re-worked for mica. The production in recent years has been small. The principal mines include:—

Range I, lots 1 and 2—Poupore mine; lots 6 and 7—Little Rapids mine.

Range III, lots 1 and 2—O'Brien and Fowler mine.

Range V, lot 7.

Range VII, lot 18.

Range VIII, lots 16 and 17—Tamo Lake mine.

Range IX, lots 4 and 9; lots 30, 31, and 32—Little Chute mine.

Township of Derry

Mica was formerly worked in a small way in Derry township, principally in the southwest corner. The mines include:

Range I, lot 1; lot 5—Cameron mine; lot 9—Daisy mine.

Range II, lot 7—Allan mine; lots 23 and 31.

Range V, lot 1.

Township of Ripon

Mica was formerly mined on lots 13 and 14 in range VIII.

Township of Bowman

Range III, lot 17. *Range V*, lots 27 and 28.

Township of Villeneuve

A few mica mines have been opened in this township, but there has been no important production. The principal workings are the following:

Range II, lot 2—Gauthier mine; lot 6.

Range IV, lot 1—Moose Lake mine.

Township of Blake

Range IV, lot 43—Teeples mine.

Township of Bigelow

A deposit of dark amber mica was formerly worked at the Parker mine on lot 52, range V. There is an unusual association with the mica of olivine, hornblende, and spinel.

Range V, lot 10.

Township of Wells

Mine workings in this township include:

Range I, lot 46. *Range III,* lot 14—Oriole mine.

Pontiac County

Most of the mica workings in Pontiac county are small and unimportant. The most important mining has taken place in the townships of Alleyn, Cawood, and Huddersfield, though scattered deposits have been worked in a small way in a number of other townships. There has been little recent mining of any consequence.

Township of Alleyn

Most of the mica mined in this township has come from mines in the southeast corner, near Danford lake. The largest mines are the Moore and Marks, on lot 4, range II, and the Ellard mine on lot 10 in the same range. The mica from the first-named property is a dark amber, and sheets of a remarkable size have been obtained; some crystals being reported to have measured as much as 4 feet across. Most of the mines in the township have been closed down for some years. Other workings include:

Range I, lot 12—Haycock mine. *Range II,* lot 3—Anderson mine. *Range III,* lot 4—Jamieson mine.

Township of Cawood

Mica has been mined in a small way in Cawood township on:

Range VI, lot 13—Priestly mine; lot 14; lot 18—Brock and Pritchard mine; lot 43—Stephens mine.

Township of Huddersfield

On lots 20 and 22 in range IV, and lot 22 in range V, a peculiar type of amber mica has been worked at various times. The mine has been closed down for some years, and was last worked by Mr. A. G. Martin, of Ottawa. The mica is a greenish amber, mottled with silver, and quite different in appearance from typical phlogopite. The association with it of dark purple fluorite, and of allanite, is also unusual, and the deposit exhibits characteristics quite distinct from those of the usual run of amber mica occurrences.

Mica has also been worked on the Farrell property, on lot 25 in range IV.

A small amount of mica has been obtained from the following townships:

Township of Litchfield

Range IX, lot 26—Bowling mine.

Township of Thorne

Range III, lots 2 and 3; lot 51—Ferary mine. *Range VII,* lots 13 and 14. *Range East,* lot 33.

Township of Onslow

Range VII, lots 17 N½ and 22.

Township of Waltham

Range A, lots 7 and 8.

Township of Mansfield

Range V, lots 19 and 20.

Argenteuil County

A few scattered occurrences of amber mica are reported from Grenville, Harrington, Wentworth, and Arundel townships, but very little mining has been conducted on the deposits.

On lots 19 and 20, range X, township of Wentworth, mica was formerly worked over a period of years by William and Thomas Argall, of Laurel, Que. Most of the work was done on lot 19, where an open-cut, 100 by 40 by 40 feet, has been made on a body of pyroxenite carrying leads of medium-sized, wine-amber mica associated with a little calcite. There is no apatite present. After being idle for a number of years the property was taken over in 1928 by the Laurel Mining Company, Ltd., of Three Rivers, who have since had half a dozen men employed in mining and preparing mica for market. The entire output is die-cut into heater shapes at the mine, the work being done by hand. Power for mining is supplied by a Sullivan, two-drill, portable compressor. The company reports that it is considering the installation of a grinding plant to manufacture powdered mica from its mine and shop scrap. The property lies 1¼ miles from Laurel station, on the Montreal–St. Remi branch of the Canadian National railway.

Mr. Chevrier, of Rockland, reports working old waste dumps on lot 9, range VI, Grenville township, in 1927.

Montmorency County

An occurrence of amber mica near Petit Pré, 18 miles below Quebec, was opened up in 1914 and worked on a small scale for a few years by Louis Richard, of L'Ange Gardien.[1] The deposit lies about two miles from the St. Lawrence river, on the south slope of the ridge of crystalline rocks that forms the uplands north of the river.

The occurrence is interesting as showing the existence of mica-bearing pyroxenite at a point some 200 miles east of the main productive mica district lying to the north of Ottawa. Except for this isolated occurrence, no deposits of amber mica are known to have been reported in Canada east of the Grenville district, on the north bank of the Ottawa river.

[1] Ann. Rept., Mines Branch, Province of Quebec, 1914, p. 147.

The property was visited by the writer in 1919, but was then idle. The mica is a dark amber, of small to medium size. It occurs in a belt of pyroxenite, similar in general character to that of the main mica field to the west, and the deposit appears to be of vein type. No calcite nor apatite was noticed. The workings consist of a single pit, 75 feet long and reported to be 65 feet deep.

ONTARIO

The Ontario amber mica field[1] extends in a southwesterly direction from the town of Perth, in Lanark county, to Sydenham, in Frontenac county, a distance of about 35 miles. The width of the main mica belt is from 15 to 20 miles, though small, scattered deposits are also found in several of the outlying townships.

As in the province of Quebec, phosphate often occurs in association with the mica, and many of the mines since worked for mica were originally opened for phosphate.

From north to south, the belt extends from the townships of North and South Burgess, through South Sherbrooke and North Crosby, Oso, Bedford, and Storrington, into the north half of Lougborough. South of Sydenham, in the latter township, the crystalline rocks are concealed beneath a belt of Palæozoic sediments, which extends to lake Ontario.

The most important developments of mica-bearing pyroxenite are found in the southern portion of the belt, in Loughborough township, a few miles north of Sydenham, where is situated the large mine of the General Electric Company, and in the northern section, in the townships of North and South Burgess.

Small occurrences of pyroxenite and amphibolite, carrying both mica and phosphate, are also found about 70 miles to the northwest of the main productive field, in Monmouth and Cardiff townships, Haliburton county, and in Brudenell and Sebastopol townships, Renfrew county. Minor amounts of both phosphate and mica were formerly obtained from small mines in these districts.

The physiographic features of the Ontario mica field resemble broadly those of the Quebec field. The mean elevation ranges from 400 to 600 feet, but there are fewer high ridges and hills, and the general character of the region is not so mountainous as that of the Quebec field. The area, and especially the southern portion, contains a network of lakes and small streams, which, however, do not lie much below the general level of the surrounding country. Large stretches of comparatively level farm lands are separated by areas of low hills and rounded ridges, covered with second-growth timber. Much of the area adjacent to the Rideau Lakes system is occupied by swamps, formed by the drowning of land at the construction of the Rideau Canal locks. There are no important streams, draining of the region being by way of the lakes and connecting small creeks.

The region supports a considerable farming population, and the large number of lakes makes it an important summer resort. It is served by good roads and has excellent railroad facilities. The Kingston–Pembroke branch of the Canadian Pacific railway runs north, along the

[1] For details of mica mining operations in the province, *see* Annual Reports, Ontario Department of Mines, Toronto.

western fringe of the field. The two Montreal–Toronto main lines of the same system cross the northern portion, while the southern section is served by the Ottawa–Toronto line of the Canadian National railway.

The geology of the region has been described by W. G. Miller and C. W. Knight,[1] and by M. B. Baker.[2]

Frontenac County

Township of Portland

A little, hard and light-coloured mica has been mined on lot 1 in concession X. The deposit belongs to the contact type (*see* page 43), and is similar to that worked on the adjoining property, lot 1 in concession X of Loughborough township.

Township of Loughborough.

Extensive mica mining has been conducted in the north half of Loughborough township. The largest deposit of amber mica ever found in Canada occurs on the seventh concession, just north of the belt of Palæozoic sediments that overlies the extension of the crystalline rocks southward. Many of the mica mines were originally opened for phosphate. Intermittent mining has been conducted at various points, but the only steady, large-scale producer has been the Lacey mine, operated by the General Electric Company.

Concession VII, Lot 11—Lacey Mine. Owned by the General Electric Company, of Schenectady, N.Y., who mine under the name of the Lougborough Mining Company. The property lies 4 miles northeast of Sydenham.

Before the present owners commenced mining, in 1903, the deposit had already been worked for mica by various operators. It was the development work by the present company, however, that first gave an indication of the magnitude of the ore-body, and led to the property becoming the largest mica producer in Canada, and possibly in the world. The mine has been in almost steady operation from 1903 to the present time, and has produced a very large proportion of the total mica output of the province.

Mining has been centred on a single, very large and almost vertical vein deposit, consisting of a solid mass of mica crystals, with very little associated calcite or apatite. In places, the vein attained a width of 25 feet. The individual mica crystals are very large, and one is reported to have been encountered that measured 9 feet across the plates.

The deposit was originally worked from a shaft, 185 feet deep, with drifts run at 22-foot intervals along the vein. The longest drift was on the fourth level, this being carried 150 feet to the southeast and 65 feet to the northwest, a total of 215 feet. A crosscut was also driven 60 feet to the southwest on this level, to pick up a parallel vein which was followed by drifts for a distance of 160 feet to the southeast. From the second level, a crosscut to the northeast encountered a third vein at 55 feet, and this was followed for 80 feet to the southeast.

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[1] "The Pre-Cambrian Geology of Southeastern Ontario", Ont. Bur. Min., vol. XXII, pt. II, 1914.

[2] "Geology of Kingston and Vicinity", Ont. Bur. Min., vol. XXV, pt. III, 1916; with map of the southern part of Frontenac county; "Geology and Minerals of the County of Leeds", Ont. Dept. of Mines, vol. XXXI, pt. VI, 1922; with map.

Later, it was decided to glory-hole the workings, and a large open pit, 60 by 70 feet, was sunk upon the main and northeast parallel veins. Most of the work in recent years has been carried out from this excavation, and has consisted in drawing the pillars and caving the ground between the old stopes, the mica being recovered during mucking operations. In 1923, a new shaft was sunk south of the main shaft to a depth of 180 feet.

The mica is rough-cobbed at the mine and is then shipped to the company's trimming and splitting shops at Sorel and St. Raymond, in Quebec.

The mine was closed down for the greater part of 1928, operations being confined to drawing the large dumps of scrap mica. These contain thousands of tons of waste mica from the cobbing sheds, accumulated over a long period of years. The material is passed through a gasoline-driven trommel with 1½-inch holes, the throughs being shipped for grinding scrap and the overs saved as sheet mica.

Two types of mica are yielded by this mine, one a first-class clear, dark, wine amber, and the other an opaque, milky amber. An analysis of the clear variety yielded[1]:

Silica	39·66
Titanium oxide	0·56
Alumina	17·00
Iron oxide	4·70
Magnesia	26·49
Soda	0·60
Potash	9·97
Barium oxide	0·62
Fluorine	2·24
Water	2·99
	104·83

Concession X, Lot 1.—This property has been idle for many years, and is mentioned chiefly on account of its carrying a mica deposit of the unusual type described on page 43. The same type of mica occurs on the adjoining lots, lot 1 in concession IX of Loughborough and lot 1 in concession X of Portland, and also on lot 5 in concession II of the township of Bedford, about 6 miles to the north.

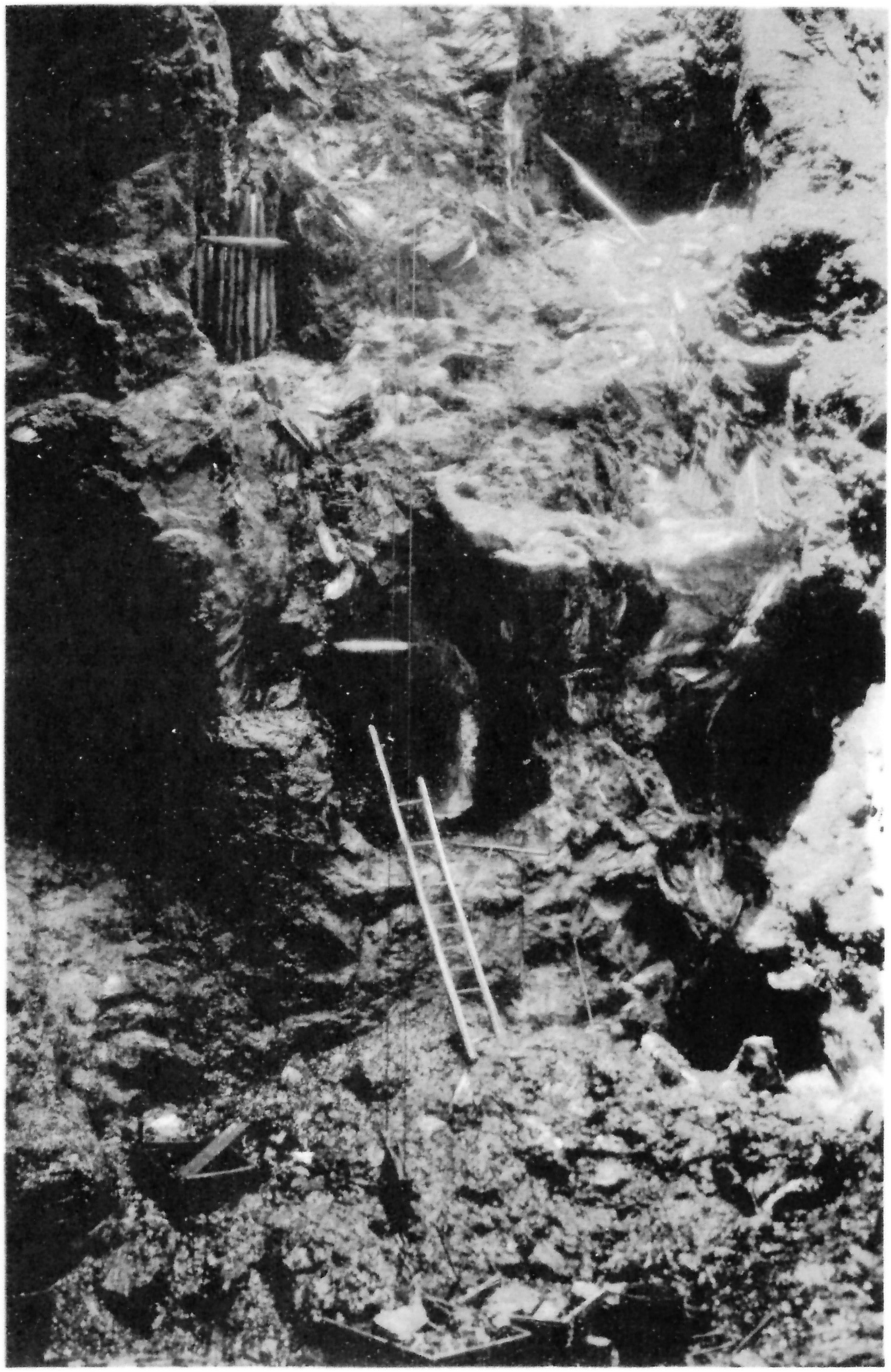
The deposits on these lots are alike in the mineral association they carry, yielding a pale, honey-yellow mica, which occurs with a brownish grey, altered pyroxene, green fibrous tremolite, actinolite, and masses of brown, magnesia tourmaline. They occur in white, Grenville crystalline limestone, and apparently have been formed along the contacts of an acid intrusive into the limestone. In this report this type of deposit has been referred to as the contact class, to differentiate it from the ordinary run of amber mica occurrences. A fine-grained, grey rock, observed in quantity on the waste dumps, has been determined as aplite, and is probably the source of the mica-forming solutions.

While the mica is quite distinct in appearance from ordinary phlogopite, chemically it is almost identical. The mean of two analyses, differing very slightly, made in the Mines Branch Chemical Laboratories on

[1] Jour. Can. Min. Inst., vol. 7, p. 284.

A. View of main pit, Lacey mine, concession VII, lot 11, Loughborough township, Ont. The strike of the mica leads is towards the hoist-house in the background, the principal vein (*see* Plate XV) passing approximately across the centre of the pit.

B. Portion of large dump, containing thousands of tons of shop-scrap mica, at Lacey mine, concession VII, lot 11, Loughborough township, Ont. The material of this dump, representing the accumulated waste from the trimming shop, is passed through the gasoline-driven screen, the oversize being shipped for grinding



View taken at the bottom of main pit (*see* Plate XIVA) at Lacey mine, concession VII, lot 11, Loughborough township, Ont., showing principal mica lead. The vertical vein extends across almost the entire width of the face shown, and mica is now won by caving of the old stopes and drifts.

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[1] Analy

samples of the mica from lot 1 in concession X of Loughborough township, and from lot 5 in concession II of Bedford, gave the following results[1]:

Silica	39·60
Titanium oxide	0·26
Alumina	16·57
Iron oxide	1·52
Magnesia	29·00
Soda	0·93
Potash	9·50
Fluorine	2·48
Water	1·25
	101·11
Less O=F	1·07
	100·04

Compared with the analysis of the mica from the Lacey mine, given on the preceding page, the important points of difference are the lower iron and higher magnesia content.

The other principal mica workings in the township, most of which have long been idle or worked only intermittently in a small way, include:—

Concession V, lot 13.

Concession VII, lot 3 W½—Freebern mine.

Concession VIII, lot 6—Scriven and White mine; lot 7—Foxton mine; lot 8—Folger mine; lots 10, 12, and 14—Orser mine; lot 13—Amey mine.

Concession IX, lot 1—Martin mine; lots 6, 7, 9, 10, and 12.

Concession X, lot 6 S½—Gould Lake mine; lot 7 E½; lot 8—McClatchey mine; lot 10.

Concession XI, lot 18—Bear Lake mine; lots 20 and 22.

Concession XII, lot 23.

Concession XIV, lot 14—Birch Lake mine.

Township of Storrington

A little mica has been mined in the north of this township, on lots 1 and 15 in concession XV, between Buck and Opinicon lakes, and on lot 8 in concession XIV.

Township of Hinchinbrooke

Mica has been worked in a small way on lot 2 in concession I, and on lots 27 and 28 in concession II. Biotite mica occurs in a quartz vein on lot 25 in concession I.

Township of Bedford

Mica has been mined at scattered locations throughout the township.

The Bobs Lake, or Taggart, mine, on lot 30 in concession VI, has for many years been the most important producer and was in fairly steady operation until 1925. This mine is conspicuous for the large number of parallel mica leads encountered. These have been worked by individual

[1] Analyst, E. A. Thompson.

narrow pits, the deepest of which is stated to be down 100 feet. The mica is a dark amber, and large-size sheets have been secured. The property has been operated by the owners, Messrs. Kent Bros., of Kingston, who maintain a mica shop at the latter point, where the cobbed mica from this and other mines in the district is prepared for market.

The Stoness mine, on lot 4 in concession XIII, was also formerly an important and steady producer, but has been closed down for many years. The deposit was worked from an inclined shaft, said to be 450 feet deep, and the property was equipped with a large plant.

Other mica mines in the township, some of which have been worked intermittently in recent years, include:—

Concession II, lot 5—Orser mine.
Concession III, lot 32.
Concession IV, lot 17—Williams and Adams mine.
Concession V, lot 15—Murphy mine.
Concession VI, lots 4 and 35.
Concession VII, lot 19—Robison mine.
Concession VIII, lot 4—Tett mine; lots 5 and 6; lot 33.
Concession IX, lot 7 E$\frac{1}{2}$—Antoine mine; lot 9.
Concession XI, lot 10—Poole mine; lot 27.
Concession XIII, lot 6—Smythe mine.

Township of Oso

There are a few small mica workings around Crow lake, in the southeast corner of the township, but there has been little mining in recent years. The properties worked include:—

Concession V, lot 2.
Concession VII, lots 2 and 3.
Concession VIII, lots 1, 2, and 3—McEwen mine.

Lanark County

Township of South Sherbrooke

Mica has been worked in a small way on several lots in the southwest corner of the township, near the village of Bolingbroke. The principal mines are on the following properties:—

Concession II, lot 7—Fowler mine; lot 9.
Concession III, lot 4; lot 7.
Concession IV, lots 2, 3, and 4; lot 8.

Township of Bathurst

A few small mica mines have been operated in this township, the properties worked including:—

Concession II, lots 21 and 22—Mendels mine.
Concessions IX and X, lot 19.

Township of North Elmsley

Mica has been worked at the Gibson mine, on lot 25 in concession IX, and on lot 25 in concession VIII.

Township of South Elmsley

Concession III, lot 30 W½.

Township of North Burgess

A number of important mica mines were formerly worked in this township, many of them having been originally opened for phosphate. There has been comparatively little mining on any of the properties in recent years, but a considerable tonnage of scrap mica has been secured from old waste dumps and shipped to the United States.

As in the case of Loughborough township, at the south end of the mica belt, some of the principal mines in North Burgess lie close to the fringe of the Palæozoic sediments, which conceal the crystalline rocks to the east and from which irregular tongues extend westward in the region of the Rideau lakes.

Among the principal mines are:—

Concession V, lot 3; lots 4 and 8—Rogers mine; *Concessions V and VI,* lot 9—Smith mine; *Concession V,* lot 10—Mahon mine; lot 11—Blackhall mine; lot 12; lot 13 E½—Silver Queen mine; lot 13 NW½—Baby mine; lot 16—Donnelly mine; lot 21 N½—McNally mine; lot 24—Byrnes mine; lot 26—Haughan mine.

Concession VI, lot 10—Old Anthony mine; lot 11—Hanlon mine; lot 12—Klondyke mine; lot 13 E½—Martha mine; lot 13 W½—Munslow mine; lots 18, 19, and 24; lots 20 and 21—Star Hill mine.

Concession VII, lot 9; lot 11—McLaurin mine; lot 12—Byrnes mine; lots 24 and 25.

Concession VIII, lot 1—McConnell mine; lot 2—Kent mine; lot 3—Cordick mine; lots 4, 5, and 6—McLaren mine; lot 7—Adams mine; lot 25—McParland mine.

Concession IX, lot 4—Atcheson mine; lots 6 E½ and 7 E½; lot 14—Murphy mine; lot 15; lots 16 and 17—Pike Lake mine; lot 26.

The Pike Lake mine, on lots 16 and 17 in concession IX, is said to be one of the earliest mica mines to be worked in the province. Records show that large mica sheets were shipped from it to France as far back as 1860. The deposit appears to belong to the contact class, the mica resembling that described from Lougborough, concession X, lot 1.

Leeds County

Township of North Crosby

There has been only a small production of mica from this township. The mines, all of which are small, include:—

Concession II, lot 7—Kane mine; lot 16—Egan mine; lot 21—Smith mine. *Concession III,* lot 8—Drysdale mine. *Concession V,* lot 9—Foley mine. *Concession IX,* lot 22—Webster mine.

Township of South Crosby

The only important mine ever worked in South Crosby is the old Sand Lake mine, on lots 14 and 15 in concession VII. The property has been idle for a number of years.

Township of South Burgess

There were formerly several mica mines in this township, but there has been little work of any consequence in late years. Lot 4 in concession IV was worked in 1926-27 by Mr. D. Smith, of Cataraqui, Ont. The properties worked include the following, the Cantin mine having been the largest producer:—

Concession I, lot 5—Heffron mine; lot 7—Webster mine. *Concession III,* lot 3. *Concession IV,* lot 1—Cantin mine; lots 3 and 4.

Township of Bastard

Mica has been worked from time to time at the Rogers mine, on lot 14 of concession III.

Carleton County

Township of March

Concession I, Lot 10 SE½. Operations for scrap mica were conducted on this property in 1923-24 by Mr. A. G. Martin, of Ottawa.

The deposit lies on a narrow, eroded tongue of crystalline rocks, that protrudes eastward into the Palæozoic sediments from the vicinity of Fitzroy Harbour, on the Ottawa river. It consists of a lead of crushed mica, having a width of 10 to 12 feet and of undetermined length. An open-cut, 15 feet deep, was sunk from which 700 tons of scrap were mined and shipped.

The owner reports that very little sheet mica of merchantable grade is present, but that the deposit is capable of yielding a very large tonnage of excellent grinding scrap.

Haliburton County

Township of Monmouth

Concession XV, Lot 34. A small deposit of amber mica occurs on this property, which lies one mile from Wilberforce station, and is owned by Mr. Andrew Liscombe. The mica is a small-sized, light amber, and occurs with scapolite and small, bright crystals of apatite in a narrow calcite lead. The chief opening is a cut, 8 feet wide, carried 25 feet into the base of a small ridge; a shaft, said to be 100 feet deep, was later sunk at the entrance to the cut.

Intermittent mining has been carried out by various operators during the past thirty years, the last work being in 1925, when Mr. S. Orser, of Bancroft, took out a little sheet mica and a carload of scrap.

Mica is also reported[1] to have been worked in a small way many years ago on the Hales property, on lot 16 of concession X, near Tory Hill.

Pyroxenite, carrying small amounts of mica, phosphate, and sometimes molybdenite and fluorite, occurs on a number of lots in the vicinity of Wilberforce, and a considerable amount of prospecting and some mining

[1] Geol. Surv., Canada, Mem. 6, p. 367 (1910).

for molybdenite was conducted in the district during the war years.[1] A deposit of dark purple fluorite has been worked on a small scale on lot 8, concession XXII, of the township of Cardiff, a few miles east of Wilberforce, and a little mica has been taken from lot 7 in concession XII, lot 30 in concession XIII, and lot 7 in concession XXII, of the same township.

In recent years, the occurrence of uraninite and other radioactive minerals has been reported from several properties in the district.

Hastings County

Township of Monteagle

A few small amber mica mines were operated many years ago in this township. Mr. S. Orser mined for a short time in 1924 on the Waddell property, on lot 18 in concession II.

[1] "Molybdenum", Mines Branch, Dept. of Mines, Canada, Rept. 592, pp. 73–76 (1925).

CHAPTER VI

MUSCOVITE OR WHITE MICA MINES AND OCCURRENCES IN CANADA

As already indicated elsewhere in this report (page 38), muscovite mica is widely distributed in Canada, but there has been little mining for it. In general no concentration of deposits in any one particular field is found, as in the case of amber mica, and the known occurrences, in eastern Canada at least, are scattered irregularly over a wide territory stretching from the Lake of the Woods district in western Ontario to Labrador and the Arctic coasts. In British Columbia, indications point to the possible existence of a more regular and defined mica belt, which may prove to be persistent from the Big Bend of Columbia river in a northwesterly direction at least as far north as Fort Grahame, on the Finlay river, a distance of over 400 miles. The known deposits in this latter region lie at high altitudes and are difficult of access, so that their exploitation presents difficulties.

With the exception of a few hundred pounds shipped from the Fort Grahame district in 1926-27, there is no record of any recent production of sheet muscovite in Canada. A little muscovite scrap is occasionally sold by operators of feldspar mines in Ontario and Quebec. The principal muscovite mines and occurrences are listed in the following pages.

BRITISH COLUMBIA

Big Bend and Tête Jaune Districts

White mica occurrences have been known in British Columbia for many years, and claims were staked and worked in the vicinity of Mica mountain, near Tête Jaune, as far back as 1898.[1] The writer visited this district in 1913 and reported on the deposits and on those of the Big Bend district to the south, in the Summary Report of the Mines Branch for that year.[2]

No serious mining has ever been conducted on the above occurrences, though a little prospecting has been done from time to time.[3] A small amount of mica is reported to have been secured, most of which was taken off the surface and from loose, float boulders of pegmatite. A large proportion of this surface mica was found to be spoiled by staining due to weathering. Development of the deposits is hindered by the high altitude at which they lie, most of the claims being located below the summits, or on the upper slopes, of mountains rising to 7,000 feet above sea-level. The claims are difficult of access and are snow-covered for the greater part of the year, the open season being only from June to September.

[1] Geol. Surv., Canada, Ann. Rept., vol. XI, pp. 80A, 38D (1898).
[2] Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1913, pp. 42–49.
[3] Ann. Rept. Minister of Mines, B.C., 1914, p. 56; 1921, p. 95; 1924, p. 152.

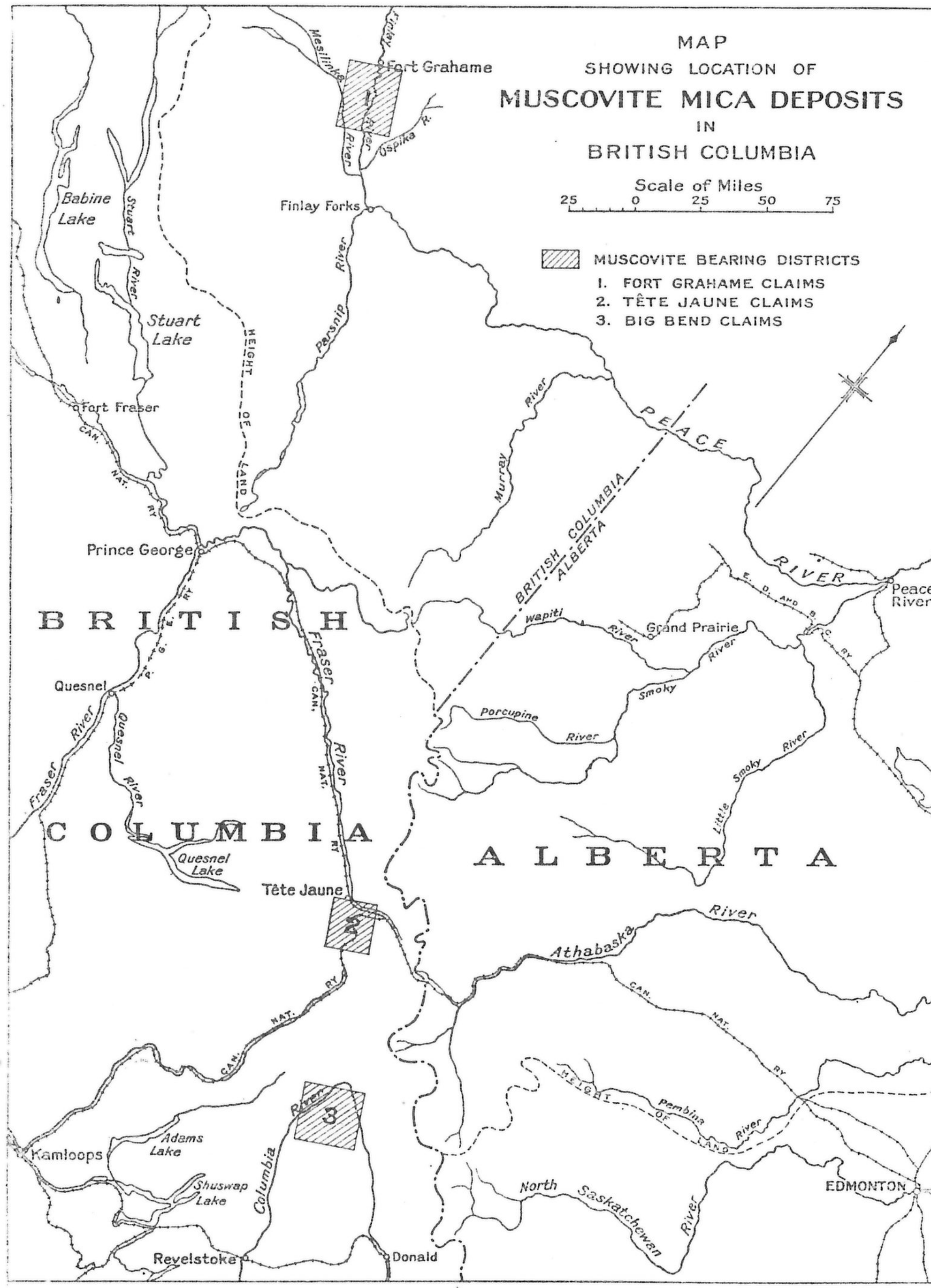
MAP
SHOWING LOCATION OF
MUSCOVITE MICA DEPOSITS
IN
BRITISH COLUMBIA
Scale of Miles
25 0 25 50 75
MUSCOVITE BEARING DISTRICTS
1. FORT GRAHAME CLAIMS
2. TÊTE JAUNE CLAIMS
3. BIG BEND CLAIMS
Fort Grahame
Finlay Forks
Babine Lake
Stuart Lake
Fort Fraser
Prince George
Quesnel
Quesnel Lake
Tête Jaune
Kamloops
Adams Lake
Shuswap Lake
Revelstoke
Donald
Grand Prairie
Peace River
EDMONTON
BRITISH
COLUMBIA
ALBERTA
BRITISH COLUMBIA
ALBERTA
PEACE
RIVER
Parsnip River
Murray River
Wapiti River
Smoky River
Little Smoky River
Porcupine River
Fraser River
Quesnel River
Athabaska River
Pembina River
North Saskatchewan River
Columbia River
HEIGHT OF LAND
Ospika R.

Figure 4.

The fresh mica of these deposits is a clear, greenish or brown muscovite of excellent quality, and is comparatively free from spots or stains. Sheets up to 16 by 10 inches are reported to have been found. Samples submitted during the war to the Ministry of Munitions, in London, were reported to be of good quality and suitable for condenser purposes.

The deposits on Mica mountain, near Tête Jaune, in the Cariboo mining division, lie a few miles south of the Edmonton-Prince Rupert main line of the Canadian National railway, and can be reached by pack trail in one day. The Big Bend (Columbia river) deposits, situated on the divides between Mica, End, and Yellow creeks, in the Revelstoke mining division, lie 70 miles southeast of the foregoing and are much more difficult of access. They can be reached from Beavermouth or Revelstoke, on the main line of the Canadian Pacific railway, by way of the Columbia river and pack trail.

Fort Grahame District

General Holding Company's Claims. During the past few years, white mica deposits near Fort Grahame, on the Finlay river, in the Omineca mining division, have been the object of development by the General Holding Company, Ltd., of Edmonton.

The claims lie about 10 miles southwest of Fort Grahame, at an elevation of 6,000 feet above sea-level. They may be reached from Prince George, on the Canadian National railway, via Summit lake and the Crooked, Parsnip, and Finlay rivers, this route being downstream to Finlay Forks; or from Peace River Crossing, on the Edmonton, Dunvegan, and British Columbia railway, up the Peace river. Owing to the rapids on the Peace, the first route is the more generally used. The distance to rail at Prince George is about 250 miles, the inward journey taking four days, and to Peace River Crossing, 400 miles.

The following details relating to the claims and work done are taken from the annual report of the company's engineer for 1927, kindly put at the writer's disposal by the Secretary, Mr. James Scott, of Edmonton.[1]

The company owns five groups of claims, comprising twenty-five claims in all, or a total of 1,293 acres. The mica-bearing pegmatites are found in a belt of mica schist about 6 miles wide and bordered on the east and west by grey and white quartzite containing bands of gneiss and siliceous limestone. The mica schist belt has been prospected for a distance of 9 miles south of West Mica mountain. Mica creek flows northwest in a deep gorge through the centre of the belt, and from it the mountains rise on both sides to an altitude of 7,000 feet.

The pegmatite dykes sometimes contain garnets and large crystals of hornblende, and the schist along the contacts also contains garnets and considerable biotite mica. The dykes in the western portion of the schist belt are predominantly quartz, while those in the eastern portion consist mainly of feldspar. The rocks have suffered considerable weathering, which has been found to persist to a depth of 50 feet and often seriously affects the quality of the mica.

[1] *See also* Ann. Rept. Minister of Mines, B.C., 1926, pp. 151–155; 1927, p. 161.

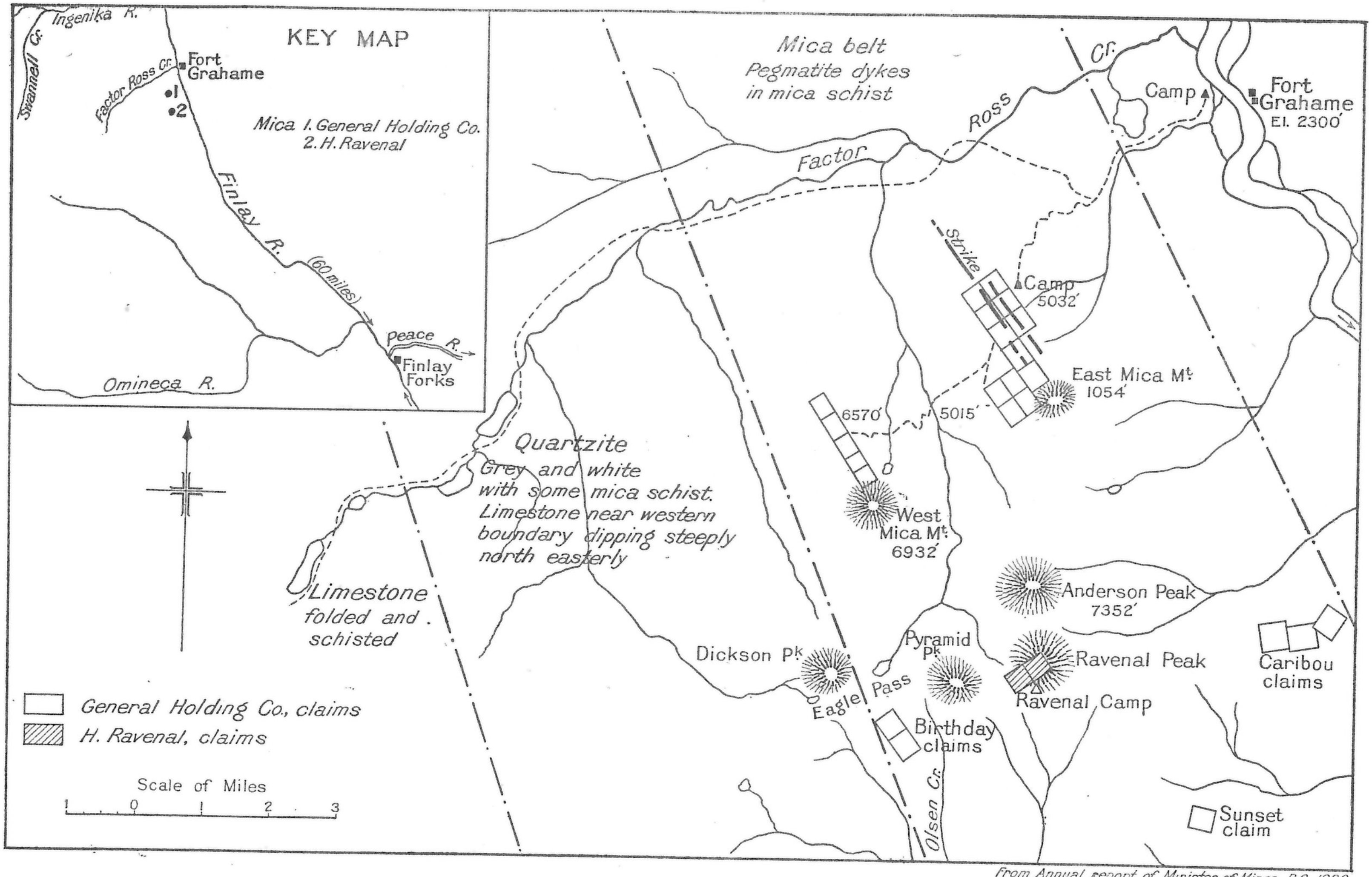

Figure 5. Plan showing location of muscovite mica claims near Fort Grahame, Finlay river, B.C.

The company commenced prospecting operations in 1924, and has since carried out considerable development work. Two camps have been established, and a number of open-cuts have been opened on mica outcrops. In addition, a tunnel 385 feet long has been driven into the west side of Low Mica mountain to pick up a mica lead exposed 130 feet higher up and upon which a 40-foot inclined shaft had already been sunk. A raise was put up at the end of this tunnel to connect with the shaft, and a 30-foot drift run from a crosscut off the raise to tap the vein. On West Mica mountain a slope has been driven for 65 feet along a mica lead and connects with a 20-foot shaft sunk upon it.

A quantity of mica was taken out in the course of the above work, some of it of large size, but a considerable proportion was found to have suffered staining from surface weathering. A small shipment, mostly sheets 2 by 3 inches and under, was made to New York and realized good prices.

A small plant has been installed on the property, including a 32 h.p. Climax gasoline engine, compressor, air-drills, etc.

Ravenal Claims. About 6 miles to the south of the above claims, on Mica mountain, mica outcrops have been staked and worked in a small way by Mr. H. Ravenal. Some large-sized sheets are reported to have been found, but there is no record of any production.

The above details regarding the general character and occurrence of the mica pegmatites and their associated rocks in this region indicate their close similarity with the deposits of the Tête Jaune and Big Bend districts, some 350 to 400 miles to the south, and it is therefore possible that the mica belt has a very considerable north and south development. An examination of the Fort Grahame region was made by V. A. Dolmage, of the Geological Survey, in 1927, and his report on the mica occurrences has recently been published.[1]

While important deposits of mica have been shown to occur in the districts described above, mining below the zone of weathering is necessary to secure mica free from staining by surface waters. The remoteness and high altitudes of the deposits are serious obstacles to their development and render small-scale operations impracticable for nine months of the year.

Vernon Mining Division

Sheets of mica measuring up to 7 by 10 inches are reported[2] to occur in a pegmatite dyke near Armstrong station, on the Sicamous-Okanagan Landing branch of the Canadian Pacific railway, 30 miles south of Sicamous. The dyke is about 100 feet wide and lies a short distance from a wagon road. No active development of the deposit has as yet taken place.

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. A, pp. 31–34.
[2] Ann. Rept. Minister of Mines, B.C., 1927, p. 213.

ONTARIO

Very little muscovite mica has been produced in Ontario in recent years. While feldspar is an important mining industry in the province, the dykes mined for this mineral are usually almost, if not entirely, barren of mica. A little muscovite, and some biotite, however, occur at certain of the feldspar mines in the Parry Sound, Nipissing, and Sudbury districts. The principal mines and occurrences of muscovite are the following:—

Lanark County

Township of North Burgess

Concession IX, lot 16.

Leeds County

Township of Escott

Muscovite is reported to occur on Yeo island, near the upper end of Tar island, one of the Thousand Islands group in the St. Lawrence river.

Frontenac County

Township of Clarendon

Concession II, lot 24.

Township of Miller

Concession XI, lots 4 and 5.

Township of Palmerston

Concession II, lot 24.

Lennox and Addington County

Township of Effingham

Concession V, lot 1. *Concession VI,* lots 1, 5, 6, and 7.

Township of Abinger

Muscovite was mined on a fairly large scale many years ago near the north end of Mazinaw lake.

Renfrew County

Township of Pembroke

Muscovite is reported to occur at several localities near the town of Pembroke, and also along the Petawawa river, farther to the west, but details respecting the deposits are lacking.

Hastings County

Township of Hungerford

Concession XII, lot 29.

Haliburton County

Township of Glamorgan

Concession XIII, lots 33 and 34.

Peterborough County

Township of Methuen

Small-sized muscovite, associated with some biotite, occurs in pegmatite dykes on lots 15 and 16, concession VII, of the township of Methuen, and was worked in a small way many years ago.[1]

Nipissing District

Township of Calvin

Concession I, lots 9 and 16. *Concession II,* lot 16. *Concession IX,* lots 19 and 21.

Township of Dickens

Concession XIII, Lot 9.—Muscovite was mined on this property during 1919-20 by Opeongo Mica Mines, Ltd., of Renfrew, who are reported to have secured a quantity of sheet mica and a small tonnage of scrap.

The deposit lies about one-quarter mile east of the north end of Aylen lake. It is reached from Opeongo Forks station, on the Ottawa–Parry Sound line of the Canadian National railway. The distance from rail to the boat landing on Aylen lake is 2½ miles, and from the latter point to the mine landing, 5 miles.

Only two shallow pits have been opened and no machinery was installed.

Township of Gladman

Muscovite occurrences are reported, but there is no record of the exact locality.

Township of Davis

Concession I, Lot 7. Brown muscovite occurs on this lot and was worked in a small way in 1919 by Messrs. Clarke and Lounsbury, of North Bay.

Township of Head

A little muscovite and biotite occur in a feldspar mine on lot 14 of concession A.

Parry Sound District

Township of Butt

Concessions VI and VII, lot 13.

Township of Christie

Muscovite is reported to have been worked many years ago at a point 4 miles from Edginton station, on the Ottawa–Parry Sound branch of the Canadian National railway.

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[1] Geol. Surv., Canada, Mem. No. 6, p. 368 (1910).

Township of Conger

Concession IX, Lot 10. Some muscovite and biotite occur on this lot in a pegmatite dyke carrying both potash and soda feldspar. Anthraxolite and uraninite are found in certain parts of the dyke, which has been prospected in a small way for radioactive minerals by Mr. H. F. McQuire and associates, of Parry Sound.

Township of Ferguson

Concession I, lots 2 and 11. *Concession II,* lot 18.

Township of Henvey

A little muscovite and biotite occur at feldspar mines on concessions I and II, near Byng inlet.

Township of McDougall

Concession X, lot 12. *Concession XII,* lot 8.

In addition to the above, muscovite occurrences are reported from the township of Proudfoot and from concessions IV, V, and VI of the township of McConkey. Some mining has been conducted on lots 18, 20, and 21 in concessions IV and V of the latter township.

Sudbury District

In the townships of Dill and Cleland, small amounts of muscovite are found in some of the reddish pegmatites worked for feldspar. In the feldspar workings on lots 2 and 3 in concession II of Dill township, spotted wedge muscovite and some biotite occur and are saved for scrap mica.

Lake of the Woods and Rainy River District

Mica-bearing pegmatites have been reported from a number of localities in the Lake of the Woods and in Rainy River district, but there is no record of any production.

Muscovite is recorded as having been worked many years ago on Falcon island, Lake of the Woods, and deposits are reported on Big island and around Sabaskong bay.

In the Rainy River district, mica-bearing pegmatites occur just south of Gull lake.

QUEBEC

Many of the more important muscovite occurrences in Quebec lie in the Saguenay district, on the north shore of the St. Lawrence. A few of the deposits were worked in a small way many years ago, but there is no record of any recent mining. The principal occurrences in the district are in the townships of Bergeronnes, Tadoussac, and Escoumains.

At the McGie mine, in block G of Bergeronnes township, 12 miles from Lac des Escoumains, mica of good quality was formerly mined. Well-crystallized tourmaline, beryl, and garnet are reported to occur with the mica. At the adjoining Moreau mine; at the Hall mine, situated in block

H of Bergeronnes township, at the head of Little Bergeronnes river and 18 miles north of Tadoussac; as well as at other points in the district, muscovite of high quality is reported to occur.

In the Lake St. John region, on the Peribonka and Batiscan rivers, muscovite outcrops are reported but are not known to have been worked.

On the north shore of the gulf of St. Lawrence, north of the island of Anticosti, important bodies of pegmatite occur in the neighbourhood of Quetachu bay. Muscovite occurs in certain of the dykes, which, however, have mainly attracted attention as a possible source of feldspar.

Muscovite is also reported to occur on Yeo island in the upper St. Maurice river, Portneuf county.

In Berthier county, muscovite was worked many years ago on lots 1 and 2 in range II of De Maisonneuve township, near Mica lake. Beryl and samarskite are reported to occur with the mica.

In Lacoste township, Charlevoix county, muscovite occurs near lake Pied des Monts, 17 miles northeast of Murray Bay. The property was worked on a small scale many years ago, when a power line was erected and an electric plant installed. Biotite occurs with the muscovite, the two varieties often being found in parallel intergrowth. Anthraxolite and cleveite occur in small amount in the dyke.

In Chicoutimi county, muscovite has been mined in a small way on lots 13 and 14 of the township of Taché.

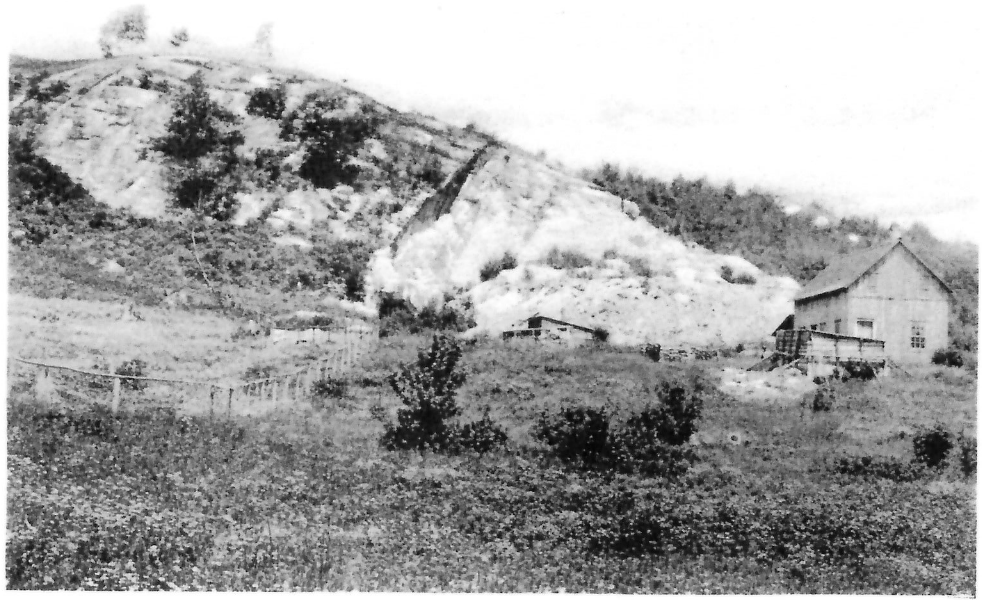
In Argenteuil county, muscovite was formerly mined on a small scale on lot 9, range VI, township of Grenville. It is also reported from lot 10, range V, and lot 1, range X, of the same township. A small amount of mining has also been conducted on lot 9 in range IV of Harrington.

In Labelle county, muscovite occurs on lot 25, range IV of the township of Robertson.

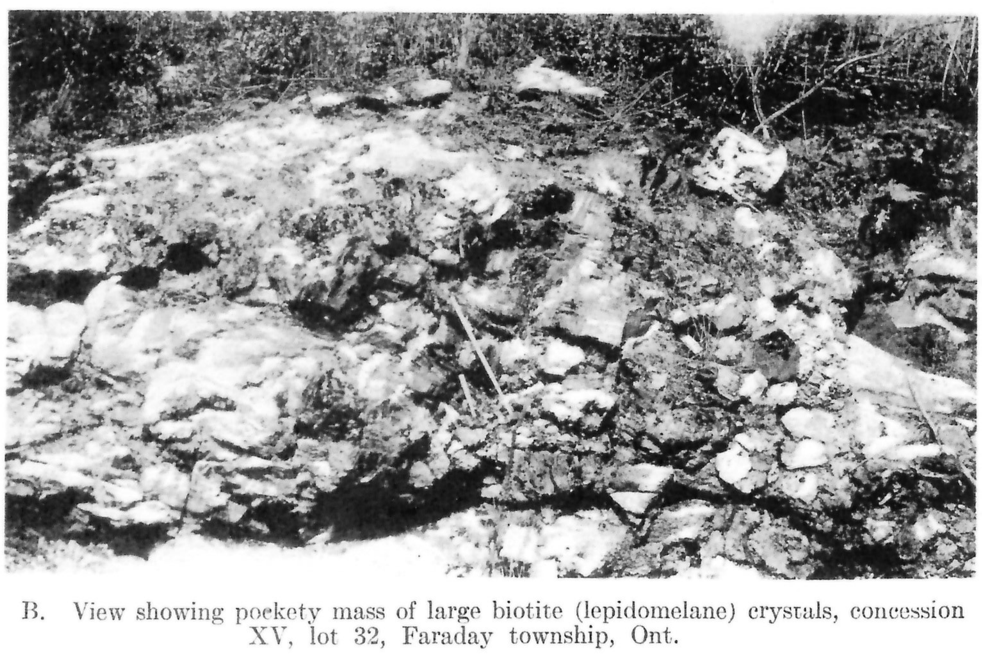
In Papineau county, considerable quantities of fair-sized but spotted muscovite were formerly obtained from the Villeneuve mine, on lot 31, range I of the township of Villeneuve. The property, which lies 20 miles north of Buckingham and near the Lièvre river, is crossed by a dyke of white pegmatite about 150 feet wide, which has been worked for both mica and feldspar. The latter mineral is an excellent quality of high-grade microcline, and most of the output has been shipped as dental spar. Peristerite, a variety of albite, or soda feldspar, is also found in the deposit, which, in addition, has yielded a small amount of uraninite, gummite, and monazite. The mine has not been worked for a number of years and is reported to be worked out.

Spotted muscovite also occurs at the Pearson mine, on lot 14, range XII of the township of Buckingham, in Papineau county, and small amounts, mostly of scrap quality, have been obtained from feldspar mines in the same district. A little mining for muscovite was formerly conducted on lot 7, range VI of East Portland township; on lot 1, range V of Derry township; and on lots 21 and 22 in range VI and lot 21 in range II, in West Portland.

In Témiscamingue county, about 150 tons of mine-run muscovite are reported to have been taken by the Mica Company of Canada from a property in the township of Boisclerc, on the east side of the Ottawa river,



A. Muscovite-bearing pegmatite cutting gneiss, Villeneuve mine, range I, lot 31, Villeneuve township, Que. This mine formerly yielded some of the largest muscovite produced in eastern Canada, as well as a high grade of white dental feldspar.



B. View showing pockety mass of large biotite (lepidomelane) crystals, concession XV, lot 32, Faraday township, Ont.

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near Mattawa. The mine lies in unsurveyed territory, 6 miles northeast of Mattawa and $1\frac{1}{2}$ miles by trail east of the Mattawa–Kippawa branch of the Canadian Pacific railway. When visited in 1928, it had long been idle, and all buildings and equipment had been removed or were in a dilapidated condition. The chief opening is a side-hill open-cut, 200 feet long by 35 feet deep and 15 feet wide, following a 15-foot pegmatite body carrying small crystals of clear, brownish green muscovite. Sheets up to 14 inches are stated to have been secured, but the average is much smaller. A few other minor openings have been made upon stringers from the main dyke, some of them disclosing a little biotite and garnet.

NORTHERN LATITUDES

Mica-bearing pegmatites have been reported at a number of scattered localities throughout the great Precambrian shield that forms the larger part of northeastern Canada. Some of the deposits have been worked in a small way in the past, but there is no record of any recent production. Among the recorded occurrences are:—

Lake Winokapau, on the lower Hamilton river.

Eastmain river, between Talking and Island falls.

Isonglass river, a tributary of the Eastmain river. (Mica is recorded as having been worked here in 1685.)

Cumberland sound, on the east coast of Baffin island.

Westbourne bay (Lake harbour), on the south shore of Baffin island, near Big island.

Chateau bay, strait of Belle Isle.

Cross lake, Saskatchewan.

Muscovite is believed to occur at a number of points along the shores of Hudson strait and the Labrador coast, and trading ships are reported to have secured small quantities.

CHAPTER VII

OTHER VARIETIES OF MICA IN CANADA

In addition to phlogopite and muscovite, which are chiefly of value as electrical or sheet mica, the varieties biotite (iron mica), fuchsite (chrome mica), and lepidolite (lithia mica) also occur in Canada and, in some instances, have been worked on a small scale.

Biotite frequently occurs associated in minor amount with muscovite in the granite pegmatites that have been worked for the latter variety, and also in certain red feldspar dykes, more especially those of the Parry Sound district, in Ontario. Biotite is of little value as sheet mica, and is chiefly utilized as grinding scrap.

Fuchsite is a comparatively rare mineral and has no particular use. It generally occurs in small flakes or scales having an attractive emerald green colour. A small amount has recently been mined in Manitoba and ground for decorative purposes as a stucco dash.

Lepidolite is chiefly of value as a source of lithia. It is also used as an ingredient of certain types of glass, to impart toughness and resistance to rapid changes of temperature. A number of occurrences of lithium-bearing pegmatite have recently been discovered in southeastern Manitoba and there has been a small production.

BIOTITE OR IRON MICA

Among the recorded occurrences of biotite mica are the following.

QUEBEC

An occurrence of dark mica (presumably biotite) in sheets measuring up to 2 feet across is reported near l'Anse à Caron, in range III of Jonquière township, Saguenay district.

ONTARIO

A band or dyke of coarsely crystallized biotite, about 100 feet wide, is exposed for a length of over 200 feet on lot 9, concession X of the township of Portland, Frontenac county, and has been worked in a small way since 1922 for scrap mica. Part of the production was shipped in the crude to the United States, and part has been ground locally in a small mill at Verona. The property is owned by Mr. H. Davey, of Verona, and lies only a few hundred feet from the railroad. Portions of the deposit carry unusually coarse-flaked mica, some of the leaves being over 2 inches across; while on joints and seams such leaves are sometimes arranged in parallel intergrowth to form pseudo-plates up to 6 inches across. None of the mica, however, is of sheet grade. The band is bordered on the west by crystalline limestone and on the east by pink pegmatite. Dark hornblende is the only other important mineral present, and in some zones may constitute up to 25 per cent of the rock. Accessory minerals present in quite subordinate amount are pyrite, apatite, and feldspar.

The band forms a low ridge bordering a small, winding creek, beneath which it passes at its north and south ends. The deposit is capable of yielding a very considerable tonnage of scrap mica and is well situated for development.

In Hastings county, black mica occurs in large crystals and in considerable quantity on lots 31 and 32 in concession XV, of the township of Faraday. About 100 tons are reported by the Bancroft Mica Company to have been mined in 1927 and shipped to the company's mill at Bancroft for grinding. All the production has been secured from small, surface pits, none of which is over 15 feet deep, and mining has been all hand work.

The mica crystals occur in large aggregates, often of well-developed individuals, associated with albite feldspar, black hornblende, tourmaline, sphene, magnetite, purple fluorite, apatite, and white calcite. Small amounts of euxenite were also noted. Plates of mica over 4 feet across have been obtained in the northerly workings.

The mica is a fair splitter, but the crystals are very likely to contain inclusions of calcite and apatite which spoil the sheets.

The occurrence has been described by Walker and Parsons,[1] who give the following analysis[2] of the mica:—

Silica	34·04
Titanium oxide	1·48
Alumina	15·60
Ferric oxide	4·22
Ferrous oxide	23·60
Magnesia	7·46
Manganese oxide	0·99
Potash	8·89
Soda	0·88
Water	1·26
Fluorine	2·02
	100·44
Less O=F	0·17
	100·27

Specific gravity=3·16.

The analysis indicates that the mica is to be classed as lepidomelane, rather than as ordinary biotite.

Biotite deposits have also been worked in the township of Monteagle.

In Haliburton county, biotite has been mined in the township of Minden; on lots 33 and 34, concession XIII, and lot 35, concession I of the township of Glamorgan; and on lot 19, concession VI of the township of Monmouth.

In Nipissing district, large plates of biotite up to 30 inches across occur in small feldspar quarries on lot 4 in concession A, and on lot 30 in concession B of the township of Cameron.

[1] University of Toronto Studies, No. 22, Contributions to Canadian Mineralogy, 1926, pp. 20-25.
[2] Analyst, H. C. Rickaby.

In Parry Sound district, large, thin sheets of altered and crushed biotite occur in some quantity in a red feldspar dyke on lot 4 in concession IX of the township of Conger. The mica is brittle and has a dull appearance. It is associated with large allanite crystals. The deposit, which lies alongside the track of the Toronto–Capreol line of the Canadian National railway, has been worked in a small way for feldspar. Biotite also occurs on lot 5, concession VIII, and on lot 10, concession IX of the same township.

FUCHSITE OR CHROME MICA

MANITOBA

A deposit of fuchsite schist was discovered a few years ago near Pointe du Bois, on the Winnipeg river, in southeastern Manitoba. Three claims were taken up by the Silver Leaf Mining Syndicate, of Winnipeg, on sections 13 and 14, township 16, range 15, east of the Principal Meridian, and in 1926 about 150 tons of schist were mined. Most of this production was shipped to Winnipeg to be crushed for stucco purposes. This is believed to be the only case on record of fuchsite being mined and utilized commercially.

The fuchsite ore consists of a compact aggregate of small flakes and has a distinctly schistose structure. In the mass, it exhibits a deep emerald green colour. It occurs as two narrow bands each about 3 feet wide, bordering a small pegmatite stringer which cuts schist and is exposed for a length of 60 feet across the face of a small knoll. Most of the exposed portion above ground level has been removed by quarrying back the rock face across the strike of the band and further mining would have to be conducted by sinking on the ore-body.

An analysis[1] of a representative sample of the fuchsite schist, made in the Mines Branch chemical laboratory, yielded:

Chromium oxide	3·6
Silica	48·0
Alumina	30·5
Iron oxide	1·5
Magnesia	0·8
Titanium oxide	1·7
Soda	1·0
Potash	8·9
Water	3·9
Total	99·99

LEPIDOLITE OR LITHIA MICA

QUEBEC

Previous to 1924, the only important recorded occurrence of lithium-bearing pegmatite in Canada was in Wakefield township, Quebec, where a small dyke carrying large wedge crystals of lepidolite and pink and green tourmaline was worked on a small scale some years ago in an endeavour to discover tourmaline of gem quality. Nothing of value was found, however, the tourmaline crystals being cloudy, flawed, and of poor colour, and the mine was closed down.

[1] Analyst, E. A. Thompson.

The deposit is situated on lot 25 E½, range VII, township of Wakefield, in Hull county, and is known as the Leduc mine. It was originally opened many years ago for its mica, which was thought to be muscovite, and sheets 2 feet across are reported to have been secured. The crystals, however, proved to yield only wedge mica of poor quality, the sheets being brittle, hard, and difficult to split. An analysis of the mica showed:—

Lithia	5·44
Silica	47·89
Alumina	21·16
Magnesia	0·36
Iron oxide	2·52
Manganese oxide	4·19
Soda	1·34
Potash	10·73
Fluorine	7·41
Water	1·90
Total	102·94

The principal dyke minerals are perthite and amazonite feldspar, quartz, lepidolite, and black, green, and pinkish tourmaline, the latter mineral often in stout, well-formed crystals. Small amounts of uraninite, gummite, and fluorite are also reported to have been found.

There is only one opening on the property, this being an open-cut 20 feet wide by 100 feet long, with a 10-foot drift carried into the face.[1]

MANITOBA

The discovery, in 1924, of lithium-bearing pegmatite on the property now under development by the Silver Leaf Mining Syndicate was the first indication of the existence in Canada of deposits of lepidolite and other lithium minerals which might prove of economic importance. This discovery stimulated prospecting for other similar deposits, and as a result, lithium minerals have been reported from a number of localities. These include Cat lake, 10 miles north of the Oiseau river, in township 19, range 15; Bernic lake, near the border of ranges 15 and 16, township 17; several claims near the original discovery point in township 16, range 16; and West Hawk lake, in township 9, range 17, all east of the Principal Meridian. The last-named is stiuated close to the Ontario boundary. Little beyond prospecting work has as yet been done on any of these properties, and the operations at the Silver Leaf mine constitute the only important development work carried out for lithia minerals.

In 1926, the Geological Survey placed an officer in the district to study and report on the geology of the lithium-bearing pegmatites.

SILVER LEAF SYNDICATE'S MINE

Situated in township 16, range 16, east of the Principal Meridian, 12 miles east of Pointe du Bois, the terminus of the Winnipeg Hydro Electric railway, and about one mile south of the Winnipeg river. The property comprises two claims, each 1,500 by 1,500 feet, and is owned by the Silver Leaf Mining Syndicate, of Bradford, England, with Canadian office at 704 McIntyre Block, Winnipeg.

[1] "Invest. of Min. Res. and the Min. Ind. 1926"; Mines Branch, Dept. of Mines, Canada, Rept. 669, p. 70.

The company has erected two camps, one, on the Winnipeg river, 8 miles above Pointe du Bois, and the other at the mine, which lies 3½ miles farther to the east. A pole-line tramway, on which a gasoline locomotive is used, connects the mine with the lower camp, which is situated at the limit of river navigation, and from which point all shipments to and from the mine are made. Ore is shipped to the railroad by scow in summer and by sleigh in winter, using a winter road on the ice.

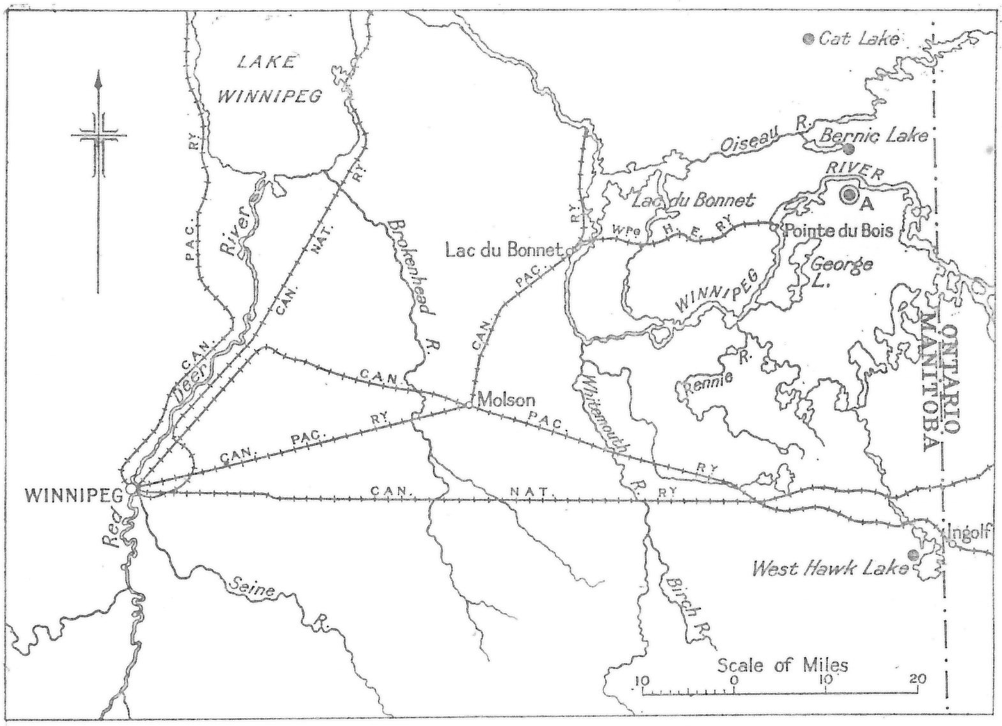


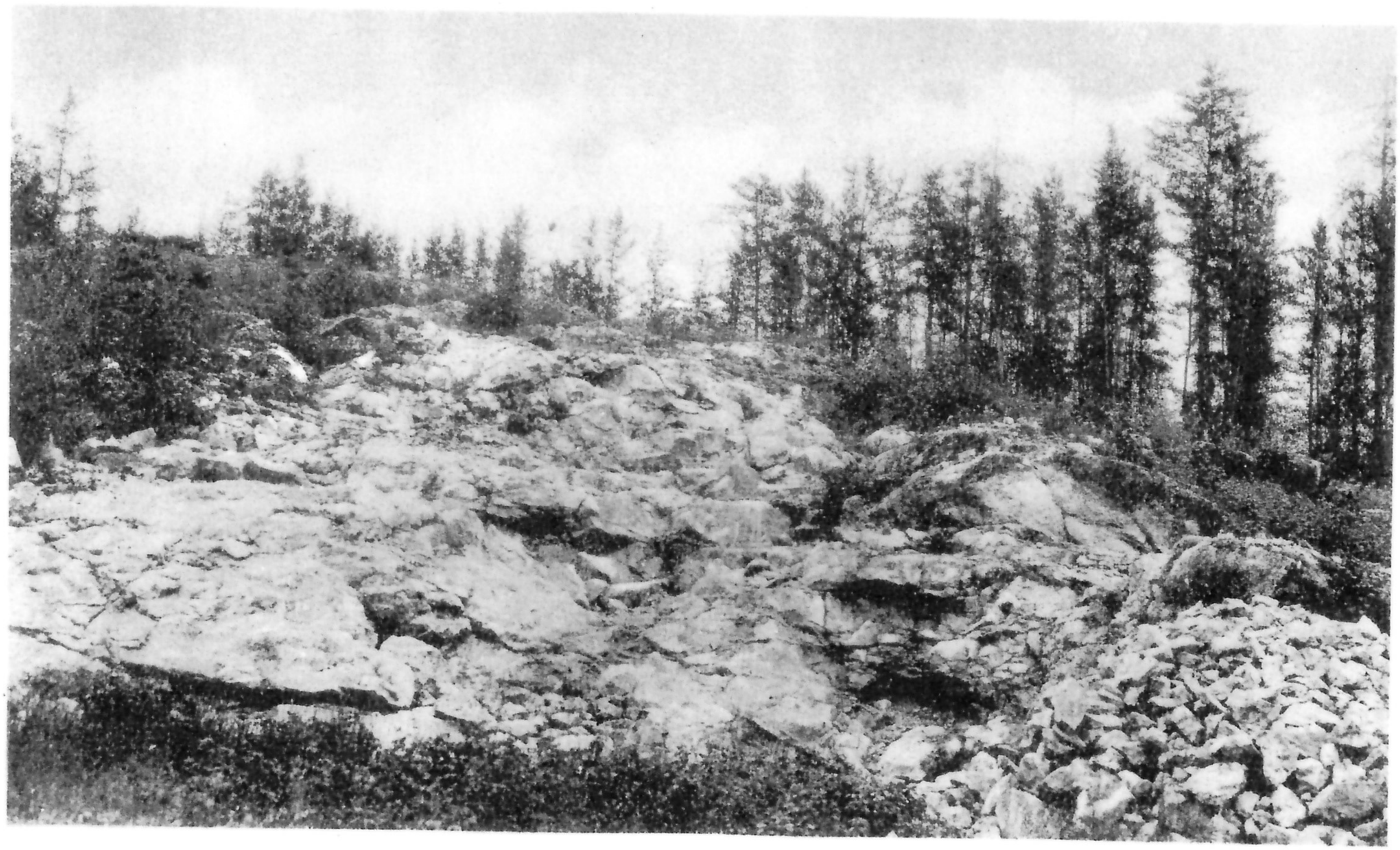
Figure 6. Sketch map showing occurrences of lithium minerals in southeastern Manitoba. A, mine of Silver Leaf Mining Syndicate.

Development Work

The initial development work was conducted during the latter part of 1925, and a little mining has been undertaken each winter since. The work done in 1926 consisted mainly of drainage operations on the muskeg area that covers the extension of the ore-body to the west. Test holes through this muskeg cover have shown that the pegmatite mass persists for a distance of at least 300 feet from the present workings, and it is intended to drain this area and remove the overburden.

No mining equipment has been installed on the property. A few hundred tons of lepidolite and a lesser amount of spodumene have been mined by hand-drilling, part of which has been shipped and part stock-piled at the river. Shipments have consisted mainly of sample lots for test purposes, but during the winter 1926-7, a carload of spodumene was consigned to

PLATE XVII



View of lepidolite workings in township 16, range 16, near Pointe du Bois, Manitoba, looking along the strike of the pegmatite dyke. The lepidolite occurs in large zonal aggregates, chiefly in the right-hand portion of the dyke. The latter extends, beneath muskeg, for a distance of at least 300 feet in rear of the camera.

Germany and a carload each of lepidolite and spodumene to an American glass works. All ore shipped is passed through an 18-inch jaw crusher, located at the river camp, and broken to 2 inches.

The work done indicates the existence at this point of a lithium-bearing pegmatite dyke of considerable size. The initial discovery was made on the west side of a low knoll which slopes gently into muskeg. Stripping has disclosed a pegmatite mass, having a width at the base of the knoll of 75 feet and extending 125 feet up the slope. Test pits put down in the swamp on the strike of the ore-body have shown the pegmatite to extend at least 300 feet farther to the west, though no data have been secured

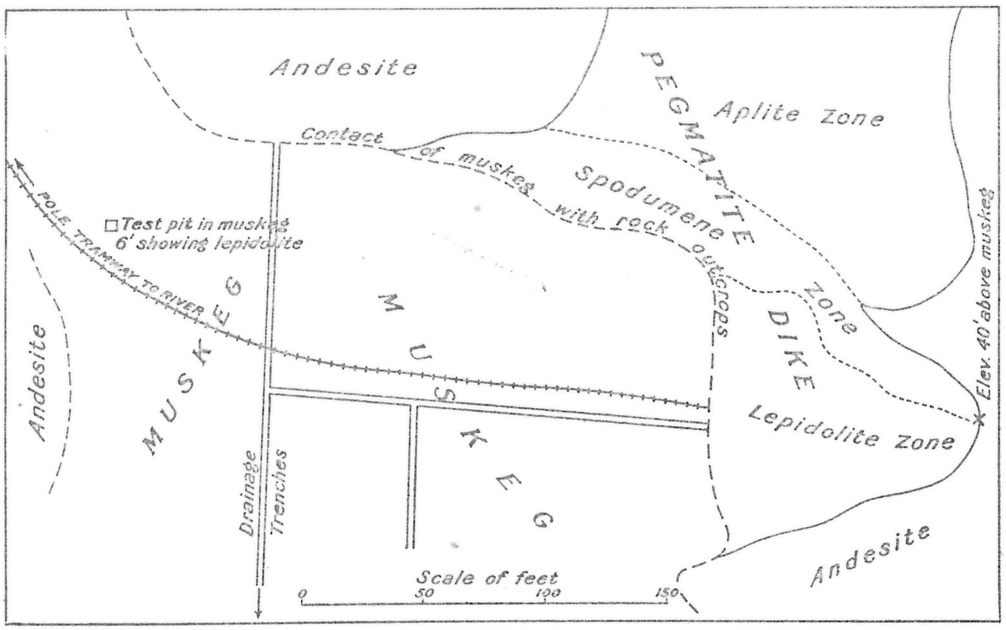


Figure 7. Sketch plan of property of Silver Leaf Mining Syndicate, Winnipeg river, Manitoba.

regarding the width over this distance. Whether this portion of the deposit can be worked, depends on the results of the attempt made to drain the swamp and enable the considerable peat cover to be stripped off.

All of the ore mined has been obtained by blasting out masses of clean lepidolite and spodumene that occur distributed irregularly throughout the dyke mass. Most of the work has been confined to the lower part of the hill, where the dyke is widest, and has proceeded bench-fashion up the slope. From a width of 75 feet at swamp level, the dyke gradually narrows up the hill, until at 125 feet it pinches out completely into the andesite country rock.

Minerals of the Deposit

The dyke mass consists of irregular masses of spodumene, lepidolite, quartz, and pink soda feldspar (cleavelandite). The two first-named occur as irregular zones or segregations of relatively clean mineral, while the quartz and feldspar fill the interspaces between such zones.

Throughout the dyke occur stringers and small nodular masses of a dark purple, and also of a blackish grey mica. These micas often have a fibrous, radiated structure, and are predominantly much coarser-flaked than the lepidolite, the flakes being one-half to three-quarter inch across; like lepidolite they contain lithia, but in rather less amount. Spectrographic examination has shown the presence in them of rubidium and gallium in appreciable amount.[1]

After lepidolite, spodumene is probably the next most abundant lithium mineral in the deposit. It occurs as large masses of closely intergrown crystals, which are sometimes as much as 5 feet long by 1 foot through; the average, however, is about 2 feet by 6 inches. The crystals seldom exhibit free faces or terminations. The mineral is grey to white in colour, and usually has a characteristic hackly or splintery fracture; there is also a hard, fine-grained variety. Quartz is the principal mineral occurring closely associated with the spodumene, and cobbing of the latter is often necessary to obtain clean mineral.

The lepidolite occurs as a compact aggregate of small scales, averaging about one-sixteenth inch across. In the mass, it possesses a dark, reddish-lilac colour. The ore contains very little in the way of admixed mineral, and the lepidolite zones yield practically clean material that requires no cobbing to make a shipping product. The lepidolite masses tend to occur distributed throughout the dyke mass adjacent to the south wall of the deposit, while the spodumene lies mostly in the central portion.

Amblygonite occurs in the deposit, but thus far has been found only in relatively small amount; about 1,000 pounds are reported to have been secured from mining operations to date. The amblygonite found here belongs to the variety montebrasite.

Rare accessory minerals in the dyke are tourmaline, massive green topaz, lithiophilite, beryl, and columbite. The presence of germanium in the topaz is reported by Papish.[2]

Analyses

The lepidolite ore from the Silver Leaf deposit consists of a compact aggregate of small flakes of a maximum diameter of about one-eighth inch. It was thought that possibly there might be some variation in the lithia content of the various-sized flakes; in which case, it should prove practicable to effect some degree of beneficiation of the run-of-mine ore by crushing and screening. A representative sample of the ore was therefore taken from the stock-pile at the mine and analysed in the Chemical Division of the Mines Branch. Part of the same sample was crushed down, care being taken to effect as little breaking down of the flakes as

[1] Private communication from Dr. Jacob Papish, Cornell University.
[2] Science, Oct. 12, 1928, p. 351.

possible. The crushed sample was then screened, so as to make the five fractions shown in the following table, and a lithia determination was run on each fraction. The results of the analysis, however, showed that there was little variation in the lithia content of the different-sized products.

Analyses Nos. 8 and 9 are of micas, other than the typical lepidolite ore, which occur distributed in minor amount throughout the pegmatite. No. 8 is a dark greyish, fibrous-bladed mica, found in radiated aggregates, measuring up to 2 inches along the fibres. No. 9 is an exceedingly fine-grained, almost massive mica of a lilac-rose colour, found occasionally associated with the normal lepidolite; the low lithia and high potash content of this mica indicate that it is near muscovite in composition.

TABLE XVI

Analyses of Lithia Micas from Manitoba*

—	1	2	3	4	5	6	7	8	9
Lithia	2·9	3·5	4·1	4·1	4·0	4·0	3·7	2·0	0·5
Silica	52·4	52·1	....	....	....	....	....	46·2	47·6
Alumina	27·1	26·3	....	....	....	....	....	29·4	36·3
Ferric iron	0·3	0·4	....	....	....	....	....	1·4	0·1
Ferrous iron	....	nil	....	....	....	....	....	0·6	0·3
Magnesite	nil	0·3	....	....	....	....	....	2·1	nil
Lime	0·3	nil	....	....	....	....	....	nil	nil
Soda	2·6	3·2	....	....	....	....	....	0·5	tr.
Potash	9·7	9·1	....	....	....	....	....	12·7	13·1
Fluorine	3·6	3·1	....	....	....	....	....	2·6	0·9
Manganese	0·3	0·9	....	....	....	....	....	2·1	tr.
Water at −105°C	....	0·3	....	....	....	....	....	....	....
Water at +105°C	2·0	1·3	....	....	....	....	....	1·2	1·6
	101·2	100·5	....	....	....	....	....	100·8	100·4

* No. 1, analysis furnished by Corning Glass Works, Corning, N.Y.
Nos. 2 to 9, analyses by E. A. Thompson and A. Sadler, Mines Branch.

1. Run-of-mine lepidolite ore, Silver Leaf mine.
2. " " " "
3. " " −20 + 35 mesh fraction.
4. " " −35 + 48 "
5. " " −48 + 65 "
6. " " −65 + 100 "
7. " " −100 + 200 "
8. Fibrous-bladed, blackish grey mica, Silver Leaf mine.
9. Massive, rose-coloured muscovite (?), Silver Leaf mine.

With respect to the commercial grade of the lepidolite and spodumene from this deposit, a prominent American glass works, to which representative samples of these minerals were furnished by the Mines Branch, wrote in April, 1927:—

The samples of lepidolite were quite high in oxides of iron and manganese, which may make this material objectionable for use in glass because of the high colour which will be produced. The oxide of iron content was 0·25 per cent and the manganese 0·5 per cent. We found the sample of spodumene to contain 4·0 per cent of lithia, with practically no other alkali. This material was also very free from impurities of manganese and iron. If the run-of-mine is as good as the sample we tested, we believe it can be used to advantage in glass work in place of lepidolite.

Summary

The development work conducted thus far on this property indicates that there exists here a deposit of lithium-bearing minerals having interesting economic possibilities. It also suggests similar possibilities for the other deposits discovered in the region that are as yet in the prospect stage.

While little can be said about that part of the deposit (possibly the larger) at the present time concealed by muskeg, sufficient pegmatite is exposed above swamp level to permit of a large tonnage of rock being broken without interference by water. Whether the lepidolite and spodumene zone prove to be large enough to permit of the simplest method of working this part of the deposit, by quarrying back the breast of the dyke across its entire width, with discarding of the intervening waste, remains to be demonstrated. Failing this, it will probably be necessary to run drifts into the face, following the lepidolite and spodumene zones and leaving the dead rock in place.

Before regular shipments can be undertaken, an improved system of transportation to the dock on the Winnipeg river will be required. The pole tramway installed during the initial development is only a temporary makeshift, incapable of handling any considerable tonnage, and has been little used. The swampy nature of the terrain to be traversed renders the maintenance of a more permanent tramway difficult and also makes impracticable the building of a wagon road that will be serviceable during the open season. For this reason, it may prove necessary, as hitherto, to confine shipments to the winter months, using teams or tractor; this would enable ore to be transported the entire distance to rail at Pointe du Bois, by way of a winter road on the river.

Favourable freight rates are obtainable from rail-head at Pointe du Bois. According to advice from the Canadian Pacific Railway's Winnipeg office, the rates from the above point to Atlantic seaboard are $12.53 per ton to St. John, N.B., and $11.65 to Quebec. Allowing $2.50 for haulage from mine to rail, the total freight charges to the above ports would be $15.05 and $14.15 respectively.

Following the discovery of lithium minerals in the Pointe du Bois region, research was undertaken by Winnipeg interests on a means of extraction of lithia from these minerals by a novel process, the idea being to treat the ores near the point of production, and build up a local chemical industry. It is claimed that a satisfactory method of treatment has been worked out, and the process has been patented in Canadian patents Nos. 265,449, November 2, 1926, and 268,639, March 1, 1927, issued to A. J. MacDougall.

Most of the world's production of lepidolite, the greater part of which is obtained in the United States, is employed in the glass industry. Manitoba lepidolite, for this purpose, will have to meet the competition of California, South Dakota, and New Mexico mineral, in all of which states important deposits occur.

Spodumene and amblygonite are the raw materials for the manufacture of lithium carbonate, which is the basic lithium compound employed in the lithium salts and chemicals trade. The extraction of lithia from its ores is confined to a few important firms, with plants in the United States, England, and Germany. Most of the spodumene used by these firms is furnished by deposits in South Dakota, which state also produces a large proportion of the amblygonite used. The European supply of this latter mineral is derived principally from France and Spain.

CHAPTER VIII

MARKETING OF MICA

SHEET MICA

Mica is a mineral varying so widely in quality, and consequently in its suitability for electrical and other industrial uses, that it is often difficult for the small producer to deal directly with consumers. Colour, hardness, heat resistance, di-electric strength, splitting quality, as well as freedom from physical imperfections, such as mineral inclusions, cracks, creases, etc., are all important factors in deciding the value of mica to the manufacturer, and call for expert knowledge in sizing and grading and the filling of orders.

Much of the mica of commerce is handled through small dealers who buy up parcels of mine-run or rough-cobbed mica and trim and grade the mineral according to individual customer's orders or to recognized trade standards, selling it in the thumb-trimmed or knife-trimmed state, or as thin splittings. The thumb-trimmed or knife-trimmed mica is marketed to concerns that work it up into finished forms which are sold to manufacturers of electrical and other equipment, or goes to the latter direct. Splittings are sold to the manufacturers of built-up mica plate, who supply the electrical trade with the various thicknesses and shapes required. Some of the larger electrical firms make their own plate from bought splittings, or may even maintain a splitting department of their own.

The larger mica producers, keeping one or more mines in steady operation, usually have considerable stocks of trimmed or split mica on hand, or have the facilities for supplying the trade at short notice. Through their established trade connexions, they are in a better position to gauge the market and customers' requirements than the small producer who mines intermittently and cannot afford to hold stocks over a dull period. Consequently, the larger producer sometimes functions also as a dealer, buying up the output of small mines and working it off with his own product. While the small operator may not secure the best price for his mica under this system, lacking the expert knowledge of trade requirements and market conditions, he has little other choice. The marketing of mica is so complex that the office of the intermediary dealer or middleman seems to be a necessity.[1]

The small producer, endeavouring to market his output direct in the trimmed or split state, must first gain the necessary expert knowledge as to what constitutes quality in mica. He must also exercise strict control over the grading, trimming, and sizing operations. Failure in these respects may easily lead to refusal of shipments.

[1] Bowles, O.: "The Marketing of Mica"; Eng. & Min. Jour., Jan. 13, 1923. Also in Spurr and Wormser, "The Marketing of Metals and Minerals", 1925, pp. 427–38.

In attempting to market cut sizes (pattern mica), he is under an even greater difficulty, since he is not in a position to manufacture to advantage. Situated often in a remote locality, he is unfamiliar with the location of his market and the requirements of his customers, whose specifications are liable to sudden and radical change. Consequently, he cannot stock up with any definite range of sizes, since he has no certainty that they will be called for and the next order may be for smaller or larger sheets.

The dealer (in trimmed sheet) and the manufacturer (of cut sheet, punched mica, etc.) are familiar with the market requirements, with the relative demand for the various sizes and grades, and with the trade quality and characteristics of mica from various localities. Thus they form a useful link between producer and ultimate consumer.

The above remarks apply particularly to conditions as they obtain in Canada and the United States. They are probably applicable to most countries producing mica for export, with the exception of India which, owing to her dominating position as the world's principal source of sheet mica, has developed special marketing channels.

Most of the Canadian mica production finds a foreign market, chiefly through established dealers who are familiar with market conditions. Consumers and foreign brokers are usually loath to buy direct from small and unknown producers, having learnt by experience that shipments often are not up to the standard of samples furnished and that much waste and worthless material is included. Complaint on this score has reached the Mines Branch at various times from London brokerage houses, and the following excerpt from a letter received from a prominent London mica firm in September, 1928, illustrates the point.

> As we pointed out to you some time ago, Canadian mica has no chance against amber mica that is mined in places such as Madagascar, because it is not trimmed and prepared as well; it is too rough and involves too much waste as compared with the properly-trimmed amber micas from other sources, and it could only have a chance of competing if it could be sold at about half the price of other ambers . . . We do not think it is necessary to look far for the decline of the Canadian mica industry; it is solely due to the bad quality of trimming and grading, as compared to amber mica from other sources. The large quantities of Madagascar amber mica that have come into the market during the last few years, of good quality and well trimmed, have undoubtedly educated a large number of firms into using this class of mica. We do foresee a possibility of a revival of the Canadian amber mica industry in the future if the miners will only try to improve their product and remove the bad name that it undoubtedly has at present.

Small producers, therefore, unfamiliar with trade requirements, would be well advised, both in their own interest and in that of the Canadian mica industry generally, to dispose of their output through recognized and established dealers in Canada, rather than to risk bringing additional discredit on the industry through ignorance of the proper methods of trimming and grading. A list of the principal Canadian mica dealers is given on page 133.

The large, steady producer is sometimes tied up to one or more consumers, who contract for his entire output of trimmed and sized sheet mica. This enables him to keep his mine and shop in operation through periods of depression—to which the mica market is peculiarly subject—and to dispose of his full range of sizes, some of which are often difficult to sell in the open market.

Some of the larger producer-dealers are also manufacturers in a small way, in that their shops are equipped with power presses on which they punch out finished segments, disks, and washers for sale to the electrical trade direct.

Value and Prices

Sheet mica in the trimmed state is sold by the pound, the unit value rising with the size of the sheet. Sheet mica cut to specified rectangular dimensions is also sold by the pound, as also are mica splittings for mica plate manufacture. Punched shapes, such as segments, disks, and washers are sold by the thousand.

Quality, as defined by colour, hardness, heat resistance, di-electric strength, low surface conductivity, ease of splitting, etc., is important as affecting price. In the case of muscovite mica, spotting or staining may materially affect value, and this class of mica is also particularly subject to physical defects caused by imperfect crystallization, which impair the splitting quality. Mica that does not split evenly and uniformly is practically valueless for sheet purposes and is only suitable for grinding scrap.

The most valuable mica is the best quality muscovite, which finds employment in condenser films and for optical purposes. Such mica must be absolutely clear and flawless, and for the former purpose, must possess high di-electric strength.

Owing to the universal adoption of built-up mica plate and the development of heat resistant plate, which now fill most of the requirements of the electrical industry, there is no longer the same demand for large-sized amber mica, the value of which has considerably decreased in recent years. It has been stated by prominent manufacturers of mica plate that it is very unlikely that there will be any improvement in this situation, and that the principal outlet for amber mica in the future will be in the form of small sizes, 1 by 3 inches and down, for the manufacture of splittings. Canadian producers report the market for the larger sizes of amber mica as very dull for some time past, and it appears probable that the prices heretofore obtained for these sizes may have to be reduced very materially. It has even been suggested that it may prove necessary to cut the sheets up into small sizes suitable for splittings, a course which producers are naturally loath to adopt, since it would result in depreciating their product manyfold.

Muscovite mica has not suffered to the same extent as amber mica in the above respect, since large-sized, clear sheets are in demand for other than electrical purposes.

Market quotations for mica are usually only an approximate indication of the actual value, since this is dependent on quality, as outlined above, and only the experienced mica dealer, versed in the requirements of the market, can grade mica properly. Some apparently perfect amber micas swell up when subjected to heat and are thus unsuitable for use in heater plate. The di-electric strength of mica, also, varies widely, and the splitting quality is distinctly variable. Dealers usually rely on visual inspection in gauging the quality of mica, but the final consumer or manufacturer employs electrical and heat tests to determine its suitability for his purpose. Purchases of mica are made by sample, and the operator contemplating the development of a mica prospect is well advised to submit samples to a competent dealer for an opinion as to the value of his material before proceeding with the installation of extensive mining equipment.

The following prices give an approximate index of the current (1928) value of the various sizes of first quality, thumb-trimmed amber mica and of muscovite mica. Since only a negligible amount of muscovite is produced in Canada, there are no market quotations for this class of mica, and the prices quoted are based on the value of foreign muscovite:

Approximate Value of Thumb-Trimmed Amber Mica

Size	Value per pound
	$
1 x 1 inches	0·20
1 x 2 "	0·25
1 x 3 "	0·35
2 x 3 "	0·45
2 x 4 "	0·65
3 x 5 "	1·00
4 x 6 "	1·50
5 x 8 "	3·00

Approximate Value of Knife- or Sickle-Trimmed Muscovite Mica*

(Standard Gradings)

Grade	Square inches	Heavily or black-stained (Electrical)	Fair-stained (Condensers, etc.)
		$	$
A1	36 to 48	1·92	4·25
1	24 to 36	1·76	3·00
2	15 to 24	1·32	2·25
3	10 to 15	0·84	1·80
4	6 to 10	0·38	1·65
5	3 to 6	0·22	1·10
6	1 to 2½	0·11	0·31

* Prices c.i.f. United States or Canadian port.

The current price of amber mica splittings is:—

1 x 1 inches	65 cents per pound
1 x 2 inches	75 cents per pound
1 x 3 inches	85 cents per pound

SCRAP MICA

Scrap mica, for grinding purposes, falls into two main grades, mine scrap and shop scrap. The former may be mine-run muscovite, often obtained as a by-product of feldspar mining operations and sometimes, also, mined directly for the ground mica market. Such mica may be of little value as sheet owing to heavy spotting, wedge structure, or poor splitting quality, but may yet make a good grade of ground mica. Mine-run amber mica is a lower grade material, often consisting of crushed crystals intergrown with pyroxene, calcite or apatite gangue; its chief use is for low-grade roofing mica.

Shop scrap, consisting of the waste from trimming and punching operations, is preferred for the best grades of ground mica, and if free from grit, clay, oil, and other impurities, commands the best price. Shop waste should preferably be dry, since if exposed to the weather it entraps considerable water, resulting in loss to the grinder.

A third class of scrap is the dump mica recovered in considerable amount in recent years from old mine dumps in Canada. This mica consists mainly of the small-sized sheets discarded in the days when only the larger-sized mica was saleable. It is generally soft and open-textured, due to weathering, and is often so crushed or bruised as to be worthless as sheet.

Most of the Canadian scrap mica is handled by one or two dealers having contacts with grinding establishments in the United States. In addition to shipping their own shop scrap and that purchased from other trimming establishments, these dealers buy up mine-run scrap and sometimes also engage in dump-turning operations. The present market for scrap mica in Canada is small, the production of ground mica being inconsiderable and there being no mills in steady operation.[1] This is due to the relatively small consumption of ground mica in Canada, and to the United States tariff of 20 per cent ad valorem imposed on ground mica, which effectually prevents Canadian mills shipping to the American market.

The current (1929) price offered for clean scrap is $10 to $12 per ton, f.o.b. rail. Ground mica sells from around $35 per ton for the dry-ground roofing grades to as high as $125 per ton for the superfine, wet-ground quality.

The total consumption of ground mica for all purposes in the United States is estimated to be about 12,000 tons per annum. There are 17 mills, 7 of which are wet and the rest dry mills. The following is a list of the principal mica-grinding plants:

Principal Mica Mills in the United States

Dry Mills

Asheville Mica Co., Biltmore, North Carolina.
Hoyt Mineral Corporation, Las Tablas, New Mexico.
New England Minerals Co., 52 Devonshire Street, Boston, Mass.
New Hampshire Mica and Mining Co., Keene, New Hampshire.
J. B. Preston Co., Inc., Glens Falls, New York.
Standard Oil Co., 910 South Michigan Ave., Chicago, Ill.
U.S. Mica Manufacturing Co., Lytton Building, Chicago, Ill.
U.S. Mica Manufacturing Co., Rutherford, New Jersey.
Victor Mica Co., Spruce Pine, North Carolina.
Western Elaterite Roofing Co., Equitable Building, Denver, Colorado.

[1] See Appendix II, p. 133, for list of Canadian mica dealers and grinders.

Wet Mills

Biotite Mica Co., Spruce Pine, North Carolina.
English Mica Co., Spruce Pine, North Carolina.
Erwin Feldspar Co., Spruce Pine, North Carolina.
J. B. Preston Co., Glens Falls, New York.
Richmond Mica Co., Richmond, Virginia.
Southern Mica Co., Plumtree, North Carolina.
D. T. Vance, Plumtree, North Carolina.

UNITED STATES TARIFF ON MICA

By the Tariff Act of 1922, the following scale of duties was imposed upon mica and mica products entering the United States:

	Duty
Mica, unmanufactured, valued at not above 15 cents per pound	4 cents per pound
Mica, unmanufactured, valued above 15 cents per pound	25 per cent ad valorem
Mica, cut or trimmed, and mica splittings	30 per cent ad valorem
Mica plate and built-up mica, and all manufactures of mica or of which mica is the component material of chief value	40 per cent ad valorem
Ground mica	20 per cent ad valorem

The tariff on scrap mica imported into the United States is 10 per cent ad valorem.

CANADIAN TARIFF ON MICA

Mica is not specifically included in the Canadian Customs Tariff, but comes under general item No. 711. By this, mica and manufactures of mica pay the following duties:

15 per cent ad valorem; Preferential.
17½ per cent ad valorem; General.
17½ per cent ad valorem, less 10 per cent; France and Italy.

DISTRIBUTING CENTRES

The output of most of the Canadian mica mines is shipped to, and distributed from, shops located in towns in, or adjacent to, the mica fields. Ottawa, Hull, and Kingston are important distributing centres, most of the larger permanent shops being located in these cities. Smaller establishments are operated intermittently at other points in the producing areas, but most of the output of these shops is disposed of to the larger dealers who supply the trade.

Most of the production finds its ultimate destination in the large consuming centres in the United States, the most important works being located in Schenectady, Boston, New York, Pittsburgh, Cleveland, and Chicago. A smaller amount is consigned to individual firms in Great Britain, but only a relatively small proportion finds its way onto the open market.

CHAPTER IX

USES AND MANUFACTURES OF MICA

SHEET MICA

Electrical Uses

By far the greater quantity of the world's production of sheet mica is employed as insulation in electrical equipment of various kinds.

No recent estimate of the proportion of the total sheet mica output (including splittings) used in the various industries has appeared. The following figures[1] relating to the consumption in the United States, and published in 1920, may, however, serve as an approximate index: though the amount credited to phonograph disks has decreased materially in the interval, and the same probably applies to the estimate for stoves.

Electrical insulation	86 per cent
Stoves	10 "
Phonograph disks	2 "
All other uses	2 "

Taking into consideration the considerable increase in production, the growth of the electrical industry, and the fact that no important new uses for mica have been developed since the above estimate was made, it is probable that to-day not far short of 95 per cent of the total world production of sheet mica is utilized for electrical insulation.

Of all known materials, mica is unique in having combined in it so many properties essential for electrical insulation purposes. Mechanically, it is soft, tough, and flexible; thermally, it resists high temperatures; chemically, it is stable and inert; while electrically, its specific insulation resistance is extremely high. Its occurrence in the form of flat, cleavable plates renders it easy to split the natural mica into sheets or films of any desired thickness, which can either be used in the natural state or built up with a suitable binder to form mica board or plate of any required dimensions and thickness.

Flexibility is not necessarily an index of softness, and some extremely flexible micas are among the hardest as respects their resistance to edge abrasion. Of the two electrical micas of commerce—muscovite (white mica) and phlogopite (amber mica)—phlogopite is the softer. The phlogopite known in the trade as "silver amber" is the softest and meets the wearing down requirements of commutator insulation the best. The very dark and very light phlogopites are somewhat harder, but practically all amber mica is softer than muscovite. Attempts have been made to soften the harder grades of mica by heat treatment, resulting in so-called calcined

[1] U.S. Geol. Surv., Mineral Resources of the United States, Mica, 1918, p. 640.

mica. This artificially softened mica is lighter and weaker in every way than the natural article and is not nearly so suitable for electrical insulation.

Condensers. An important use of mica is to interleave the foil in electrical condensers, the production of which has increased enormously with the development of the radio and automobile. Condenser mica is required to be of the finest quality muscovite, absolutely flawless and of high di-electric strength. The sheets required are not large, 2 by 3 inches being the maximum and the greater proportion much smaller. They are split by hand, with the aid of a knife or a heavy steel needle, to a thinness of one to two mils; and to ensure perfect quality, with no pin holes or weak spots, each thin film is tested by passing it through a high frequency, low potential spark gap.

Heater Appliances. Mica is an essential part of much domestic and electrical heater equipment, such as flat irons, toasters, percolators, etc., in which the wiring passes around a flat sheet of mica cut to the required shape and size and often notched along the edges so as to hold the wire in place. Special forms of such heater equipment may call for mica of large dimensions, which is expensive, and in consequence, natural mica has now largely been supplanted for the purpose by built-up mica plate cemented with a special binder.

Punched Shapes. An immense variety of shapes are punched out of sheet mica for different uses. Disks and washers, ranging in diameter from a fraction of an inch to several inches, are used in immense quantities in arc lights, electric lamp sockets, fuse plugs, aeroplane spark plugs, and for insulation purposes generally between the parts of all kinds of electrical machinery, fittings and appliances.

Other Uses

Phonographs, etc. Owing to its resonant and resilient properties, mica was formerly used extensively for the diaphragms of the reproducers of phonographs. Only hard, perfect mica could be employed, most of it muscovite, though sheet lepidolite proved even superior. The use of mica for this purpose has to-day largely disappeared, owing to the introduction of machines employing a new type of diaphragm.

Mica diaphragms have also been used in certain makes of head phones and loud speakers.

Stoves, Lamps, etc. Clear, transparent mica, mostly muscovite, serves an important use for the fronts and windows of stoves and lanterns, and in the peep holes of furnaces and ovens. It is also used for lamp chimneys, canopies, and shields, mica for such purposes being sometimes termed "micalite" in the trade. A recent development is the use of large circular, mica sheets as lantern slides for projection purposes. The sheets may be as much as 18 inches in diameter, and since very little mica of such dimensions is available, they usually have to be built up out of smaller material.

Mica is employed for the lenses of goggles, smoke helmets, gas masks, etc.; for compass dials and gauge fronts; for glazing purposes, where the risk of breakage from shock or combustion precludes the use of glass or inflammable substances

MICA PLATE, MICA TUBING, MICA PAPER, ETC.

Mica Plate

Description. Mica plate (micanite[1]) was invented many years ago to replace natural sheet mica for insulation purposes in electrical equipment. The immense variety of shapes and sizes of insulation required for different purposes led to a demand for mica in a more adaptable form than the natural sheet; in addition, the supply of large mica proved insufficient, and its price too high. Accordingly, the demand was met by the splitting of small sheet mica into thin films (so-called "splittings"), one thousandth of an inch thick, and building these films up with a shellac binder into layers of the required size and thickness. These are then compressed in steam-heated presses, with the production of a hard, compact, board-like material that can be sawn, punched or moulded into any form required.

Depending on the use to which the plate is to be put, binders of various types are employed. Shellac was the cementing medium originally used, and it is still extensively employed for all except heater plate. Latterly, however, synthetic binders have been developed, which have many advantages over shellac, including resistance to carbonization, and their use is increasing for all types of plate. One of the most important of such synthetic products is a glycerine resin known as "glyptal," a compound of glycerine and phthalic anhydride, dissolved in alcohol or acetone.[2]

Tests made to determine the relative efficiency of shellac-pasted and glyptal-pasted mica plate have yielded the following results, the values for the former being expressed as 100.

	Glyptal-pasted	*Shellac-pasted*
Di-electric strength	100 to 160	100
Resistivity	200	100
Surface resistivity	400	100
Di-electric power loss	66	100
Physical Properties—		
Density	107	100
Compressibility	Slight	Slight
Slippage	None	Mica may slip
Transverse strength	150 to 200	100
Translucency	Considerable	Slight
Resistance to abrasion	100	100
Chemical Properties—		
Carbonizing tendency	Slight	Marked
Products of decomposition	Non-conducting	Conducting
" "	Do not attack copper	Attack copper
Effect of mineral oils	None	None
Effect of moisture	Very slight	Slight
Effect of heat	Slight	Marked

[1] Micanite is the name given in 1892 to built-up mica plate or board by its introducers, C. W. Jefferson and A. H. S. Dyer. It remains the trade-name of the products of the Mica Insulator Company, of Schenectady and New York, and of the Micanite and Insulators Company, of London, England, and cannot properly be used by other firms, though products identical in character are made by many manufacturers.

[2] L. E. Barringer: "A Revolutionary Development in Mica Insulation". General Electric Review, vol. 29, No. 11, pp. 757–62, Nov., 1926. L. E. Barringer and C. F. Peterson, U.S. Patent No. 1,589,094, June 15, 1926.

Note: The patent rights covering the use of glyptal as a binder in built-up mica plate limit its employment exclusively to the products of the General Electric Company, the Westinghouse Company, the Mica Insulator Company, and the Micanite and Insulators Company.

Manufacture. In earlier practice, all mica plate was built up by hand. In such work, the building up is done on thin iron sheets, 36 inches square. A layer of mica splittings is laid on the sheet, brushed over with binder, and successive layers of mica and binder are added until the requisite thickness is attained. The mass of splittings is then carefully separated from the laying plate and placed on a steam-heated plate to set the binder, thus enabling the mica sheet to be handled without disturbing the individual splittings. The sheets are afterwards placed on top of the patching box, consisting of a wooden frame containing a strong light. The illumination shows up any inequalities in the sheet, and the thin spots are patched with additional splittings until an even thickness is attained. This system is still followed in small works and for building up plate designed for special large shapes, particularly curved segments of large commutator rings, where the cutting of the segments out of square plate would entail great waste.

The increased consumption of mica plate, however, has required the development of a more rapid mechanical method of laying the plate, and this is achieved by various means.

The underlying principle of all mechanical laying entails the employment of what are termed "snowing towers," or modifications thereof. The earliest type of such towers consisted of a fixed tower, about 36 by 18 inches square and 8 to 10 feet high. At the top of the tower is a hopper to receive a weighed quantity of splittings, sufficient for the laying of a plate of the required thickness. The hopper feeds to a revolving or shaking screen of a large enough mesh to permit the passage of the splittings. The object of the screen is to drop the mica in an even shower down through the tower, so that the splittings deposit uniformly on the laying screen inserted at the bottom. The similarity of the fall of the mica to that of snow flakes prompted the use of the term snowing towers. The screen may be replaced by baffles, which also serve to cascade the mica in an even shower. After all the splittings in the hopper have fallen, the laying screen with its load of mica is removed, a fresh one inserted, and the process repeated. Each screen, after removal, is placed on top of the ones already removed until a stack has accumulated. They are then clamped together, lifted and dropped into a tank of shellac. They are then drained, dried, and removed to the patching bench.

By another system, the splittings are placed in a hopper, from which they can fall into a square chamber, or box, 36 by 36 inches. Above this box, is set a suction funnel, the mouth of which is the same size and against which a fine wire screen fits. The box can be raised by a lever and counterweight to fit snugly against the mouth of the funnel. In operation, the empty box is raised to meet the funnel, mica is fed down into the box, and the exhaust up through the funnel causes the mica splittings to fly up and adhere to the screen. When the latter is completely sealed by mica, the box is dropped and an iron table carrying a square wire frame is swung in to take its place and raised to meet the funnel. The suction is now turned off, and the layer of mica adhering to the screen drops and deposits on the wire frame. The table and frame are then dropped and swung out, the box raised again, and the suction turned on. As the table swings out,

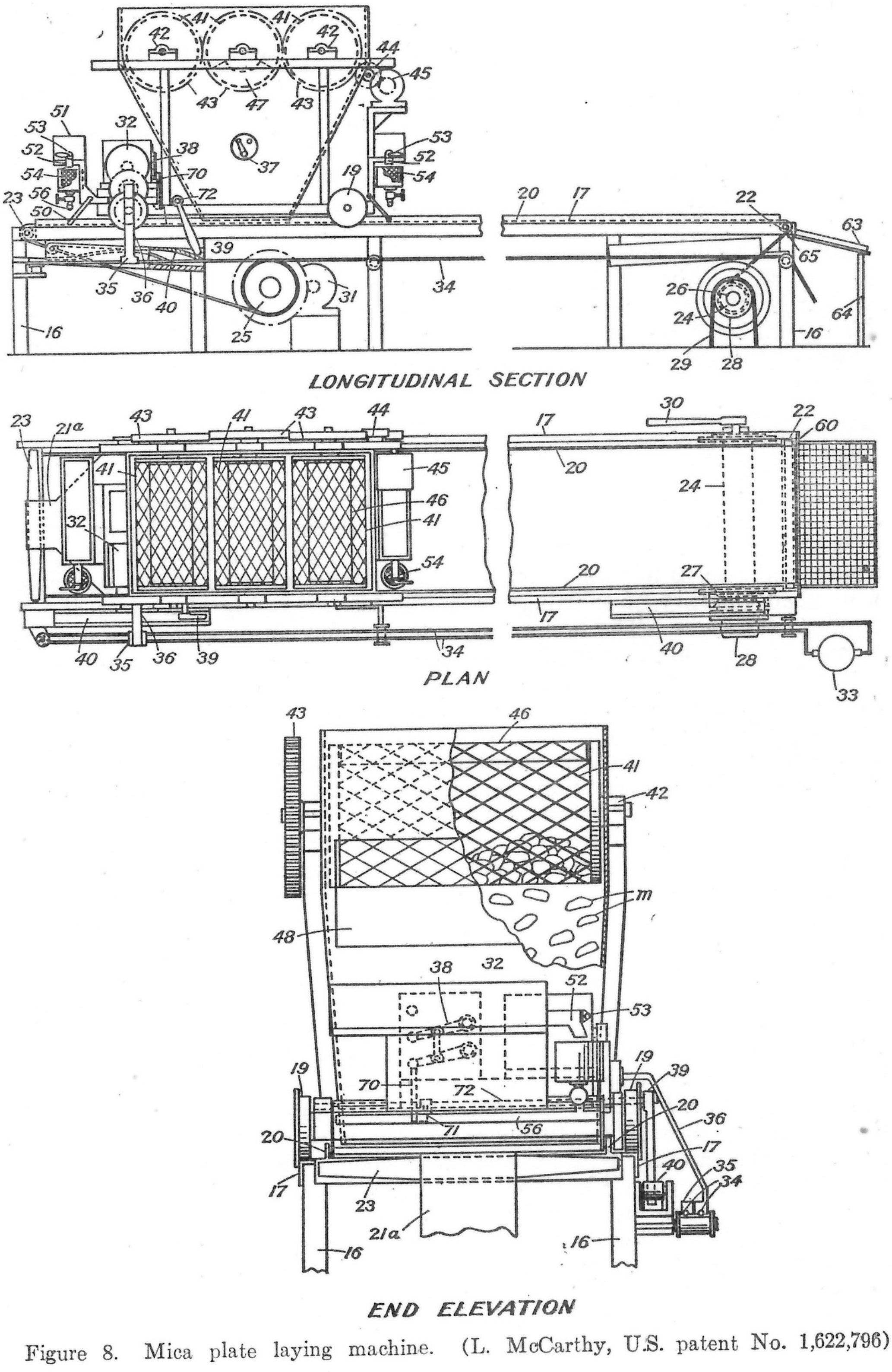


Figure 8. Mica plate laying machine. (L. McCarthy, U.S. patent No. 1,622,796)

a layer of binder is dropped onto the mica from a tank equipped with needle valves, which lift as the table passes beneath them. The process is repeated until the desired thickness of mica is built up, when the frame is removed and another substituted.

Later, further improvements were made, and now laying devices have been perfected whereby the operation has been greatly speeded up and simplified. One such system (Figure 8) employs a narrow table, 50 to 75 feet long. Over this table, 15, passes an endless, woven wire screen belt, 21. The belt remains stationary during the actual laying process. Laying is done by an electrically driven, travelling snowing tower, 18, which passes backwards and forwards over the table, and showers the mica down onto the belt. The carriage is fitted with a tank, 51, which feeds streams of binder across the successive layers, and with a roller, 50, which presses the binder in between the films. After the plate is built up to the desired thickness, the belt is set in motion and carries it forward beneath a heavy knife, 61, which cuts off sections. These fall onto screen frames, 62, which are then removed to the patching bench.[1]

After the plate has been built up as described, the square sections are placed in vacuum drying ovens, to drive off the solvent. They are then laid between wire gauze mats, separated by light steel sheets, and pressed in heavy, steam-heated hydraulic presses. A single assemblage of mica plate with its enclosing wire cloth and steel sheets is termed a " unit," and as many units may be superimposed on one another in the press as will permit of the thorough transmission throughout the pile of heat from the press platens. In practice, nine or ten such units may be pressed at one operation, but to make a plate of even surface, two units only are placed between each pair of platens, since this results in each of the two pieces of plate having one surface as smooth as that of the platen next it. Various arrangements of wire cloth and steel sheets may be used in a unit, depending on the type of plate being pressed and the nature and amount of binder employed therein. Mats of coarse mesh wire cloth are sometimes placed between individual units and between these and the press platens. The introduction of mats of fine wire mesh, asbestos cloth or paper, felt, or other resilient material, between the different layers of plate (so-called " cushion-pressing ") serves to prevent the work sticking and also compensates for any unevenness that may have occurred during the laying of the plate.

The pressure to which the plate is subjected in the presses is about 1,000 pounds per square inch, and the temperature as high as 370° F., though the latter is dependent upon the type of binder used. Pressing under heat is continued for 20 to 30 minutes after which the steam is turned off and cold water circulated through the press, the work being allowed to remain in the press until cooled. The entire operation, including loading and unloading of the press, occupies about an hour. The pressed plate is finished by passing it through " sanders "—or carborundum rolls—which smooth the surfaces and make the sheets of absolutely uniform thickness.

A method of subjecting mica plate to repeated pressings, with sanding of the sheets between each, and the use of progressively finer mesh wire

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[1] Further methods of laying mica plate and modifications of the systems described above will be found outlined in the list of patents in Appendix I, page 121.

mats, is described in a recent patent.[1] It is claimed that by such means sticking of the work is entirely overcome and a plate of greater strength and density is produced, owing to the ability of surplus binder to pass uniformly from the work into the mesh spaces of the screen cloth.

After sanding, the plate is ready for trimming and sawing or stamping into the desired shapes and sizes. For sawing, high-speed, fine-toothed band saws are employed, and strips of various widths are cut on machines fitted with revolving knives.

The following types of mica plate are known in the trade.

Moulding Plate

Moulding or "cone" plate, which is not required to withstand any great degree of heat, may be cemented with a binder of the shellac type. Such plate, when placed on a steam table, or on a heater plate, heated to about 140° C., becomes plastic and can be readily moulded. It is extensively used to form such articles as commutator rings and cones, armature slots or troughs, and round, square, or rectangular tubes. On cooling, the plate regains its rigidity. It is also suitable for flat work, such as for transformer partitions, field coils, etc. In moulding plate, it is necessary to use more shellac (about 12 per cent) than in segment or "side" plate, in order to secure uniform pliability.

In the manufacture of moulded articles such as commutator cones, using a binder of the "glyptal" type, such articles may be formed from plate in the semi-baked state, the final reaction in the binder being completed during subsequent operations. The solvent is first evaporated, and the plate is then heated in a press to a temperature of about 1,750° C., at which point the reaction in the glycerine ester takes place. Continued heating will result in the binder becoming hard and infusible, which is not desired, so that the plate is removed from the press while the binder is still in an intermediate, thermoplastic state.[2] The plate is then machined into blanks of the required shape, which are placed in moulds heated to 250° C. and pressed. The moulds are finally placed in an oven and heated to 300° C., at which temperature polymerization of the binder is completed.

Segment or "Side" Plate

This is intended to be used in the flat state, and is principally employed for making commutator segments. In its manufacture, only 3 to 5 per cent of shellac is used; the content of binder being kept to a minimum in order to impart low compressibility, and to prevent slipping of the mica and oozing of the cement in use. Large commutator segments are sawn from heavy plate; the smaller sizes are stamped out from lighter plate on power presses. Plate of this type is also used for all sorts of flat work, and for punched, drilled, and turned articles that are not required to withstand a high degree of heat. To ensure freedom from flaws and weak spots,

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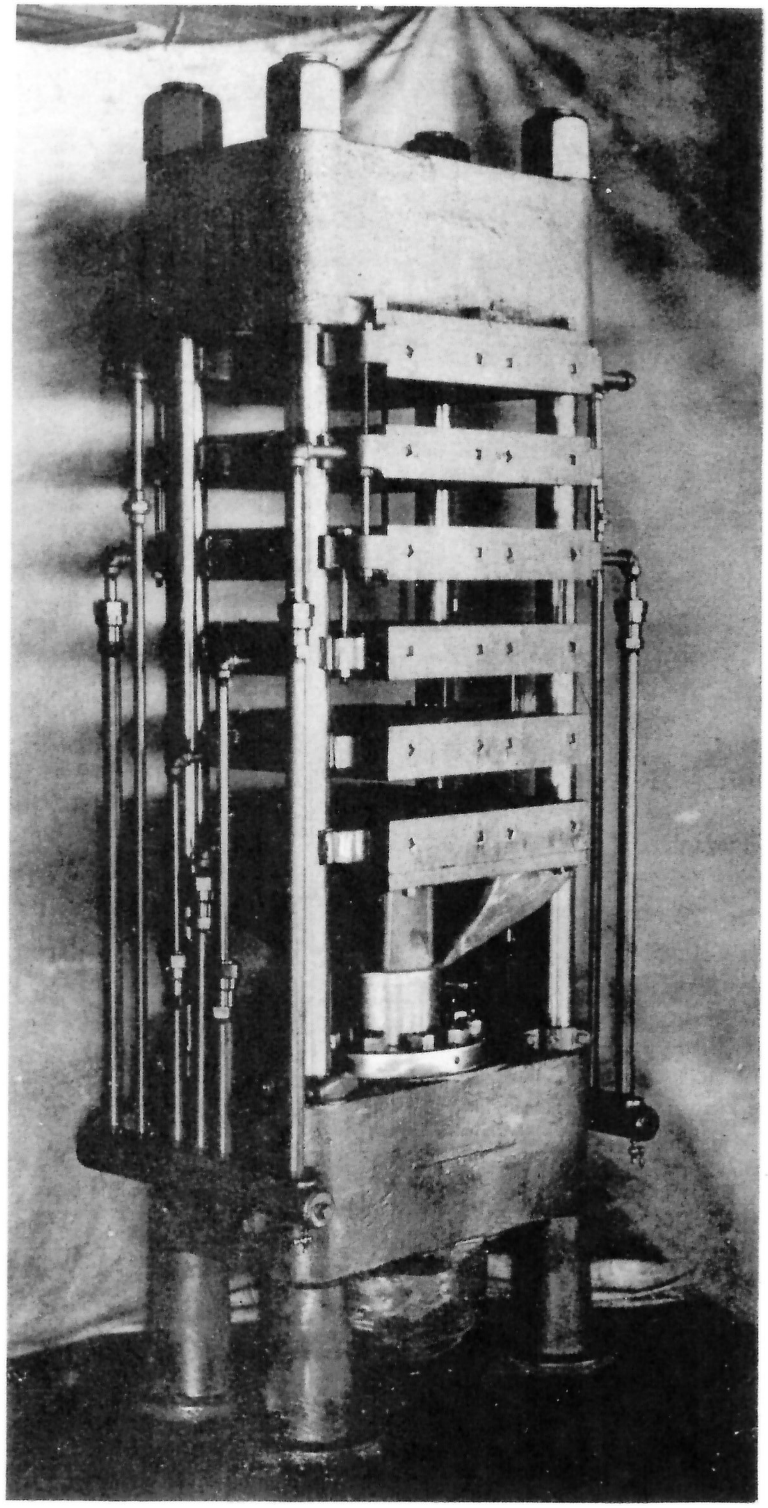
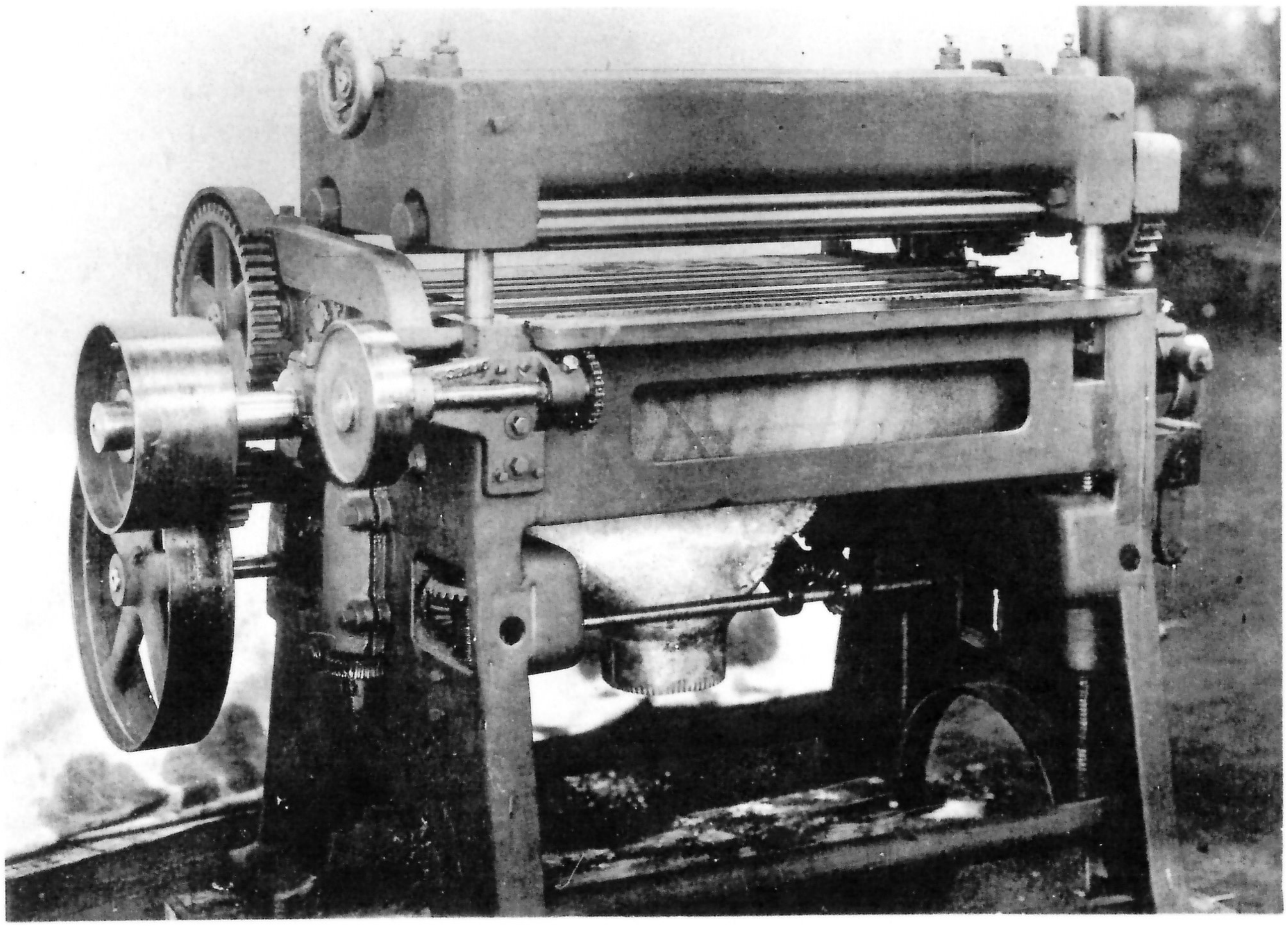
[1] U.S. Patent No. 1,588,600, June 15, 1926, L. McCarthy.
[2] U.S. Patent No. 1,589,094, June 15, 1926, L. E. Barringer and C. F. Peterson.



(*Photo by Dunning & Boschert Co., Inc., manufacturers.*)
Hydraulic, multiple, steam-heated press for making mica plate.

Plate XIX



(Photo by Yates-American Co., manufacturers.)

Sanding machine for smoothing and finishing mica plate.

segment plate is visually inspected with the aid of X-rays, which show up the presence of any foreign inclusions. The position of the inclusion is spotted on the plate, which is repaired or the piece cut out.

Flexible Plate

Flexible plate, which can be formed or bent in the cold, is cemented with a binder containing a non-drying medium. This type of plate is used for winding or wrapping into special shapes, and for forming collars, channels, and rings.

Heater Plate

Heater plate, used for winding the resistance on in electrical heating units, is bonded either with an inorganic, refractory cement that will resist the temperatures reached, or with a minimum of organic binder that will burn out at the first heating. The latter is used only where the heating element is supported firmly and does not require to be mechanically strong. Muscovite mica is used for heater plate that is not to be subjected to temperatures over 1,000° F. Phlogopite, which will withstand temperatures up 1,800° F., is used for special units involving high heat.

Art Plate

In the last few years, a considerable demand has developed for art mica plate, for use in electric lamp shades, chimneys, panels, and cylinders. The plate serves no insulating purpose, being merely used as decorative material on account of its pleasing appearance and the mellow quality of the transmitted light. Muscovite mica, on account of its greater translucency, is generally used for art plate, and various colours, from almost white to dark reddish brown tones, are obtained by the use of pale or dark binders. A wide variety of forms and sizes of shades are made, from small, one-piece, torchere cylinders and moulded shapes to large drop-light cylinders and polygonal shades, the latter made by lacing together panels. The use of art plate has also been extended to other ornamental purposes, and it has been employed as a moulded covering for the body of lighting fixtures.

Mica Tubing

Mica tubing is made either by forming the tube from moulding plate, or by wrapping a layer of splittings, pasted with shellac, around a steel rod in a special machine. Such wrapped tubes usually have a covering of thin paper rolled around them. Wrapper tubes are also made of mica and various grades of paper in varying proportions, and in some types a mixture of mica and asbestos is used.

Mica Paper

Mica paper consists of one, two, or three layers of splittings, cemented with a minimum of binder, and held between sheets of Japanese rice paper. It is manufactured in rolls 36 inches wide and 16 feet long. Other composite mica-paper materials include rope paper and mica; fish paper and mica, and pressboard and mica. These consist of two layers of mica, faced with the materials mentioned, and are made in sheets 36 by 36 inches.

Mica Cloth

Mica cloth is made in the same way as mica paper, only with muslin cloth replacing one of the layers of paper. Like mica paper, it is made in 16 by 3-foot rolls.

Mica Tape

Mica tape is made from a layer of splittings, faced on one or both sides with paper and bonded with a glyptal or asphalt base cement. It is made in 12-inch to 36-inch widths, which are then cut into strips of any desired width, usually $\frac{3}{4}$ inch and 1 inch.

Mica paper and cloth are used in the insulation of commutator cores, transformers, field magnets, armature cores and slots, etc., and mica tape for strap- and bar-wound armatures, coils, etc., where higher temperatures are involved.[1]

POWDERED MICA

Consumption, Uses, etc.

The use of powdered[2] mica has increased very materially in recent years, particularly in the United States, owing principally to its growing employment by the roofing industry, where it serves to replace the talc formerly used. The total consumption of ground mica in the United States is estimated to be around 12,000 tons per annum. By far the greater part of the production is consumed in roofing materials. An estimate,[3] made in 1922, of the proportion of ground mica used for various purposes showed the following figures:

	Per cent
Roofing	60
Wall paper	21
Automobile tires	8
Paints, Christmas "snow", concrete and stucco facing	3
Moulded electrical insulation	3
Annealing, printing, lithographing, sizing, loading or filling	3
Lubricants	2
	100

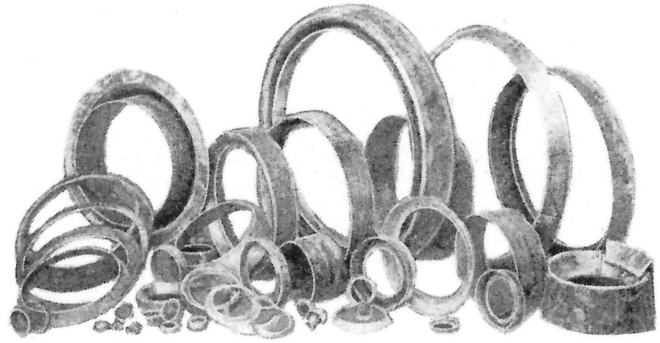
The raw material, or scrap mica, is obtained from various sources. While formerly the waste from mica trimming shops sufficed to supply the demand for scrap, increased consumption has led to the recovery of considerable tonnages of small flake mica from schist rock and from kaolin washing plants. Pegmatite dykes, also, carrying little or no marketable sheet mica, have been worked for scrap, and in Canada a few years ago, a deposit of crushed phlogopite was similarly worked. Flake chlorite, a greenish mineral resembling mica, is also recovered from schist, and serves many of the same purposes as mica. Large quantities of scrap mica also

[1] For further information on the manufacture, properties, and uses of mica plate and other built-mica products, *see* "Electrical Insulating Materials", by Allan Monkhouse (1926), pp. 174–187. "Die Isolierstoffe der Elektrotechnik", by H. Schering (1924), Chapter III, pp. 83–108.

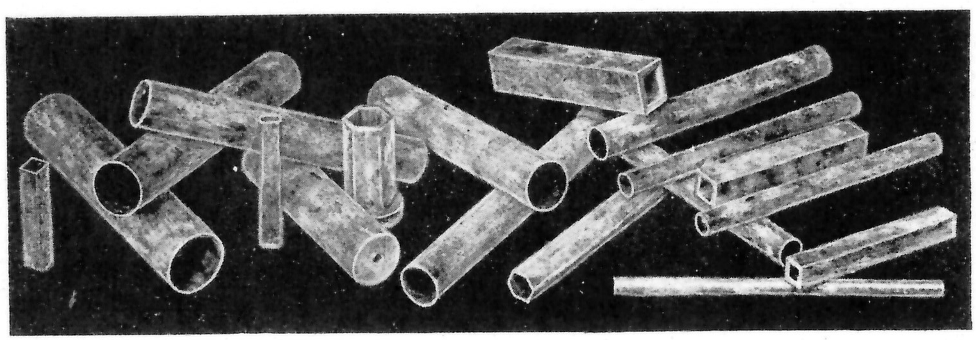
[2] Under this heading is included here also natural, fine flake mica.

[3] Bowles, O.: U.S. Bureau of Mines, Reports of Investigations, Mica, 1922, p. 16.

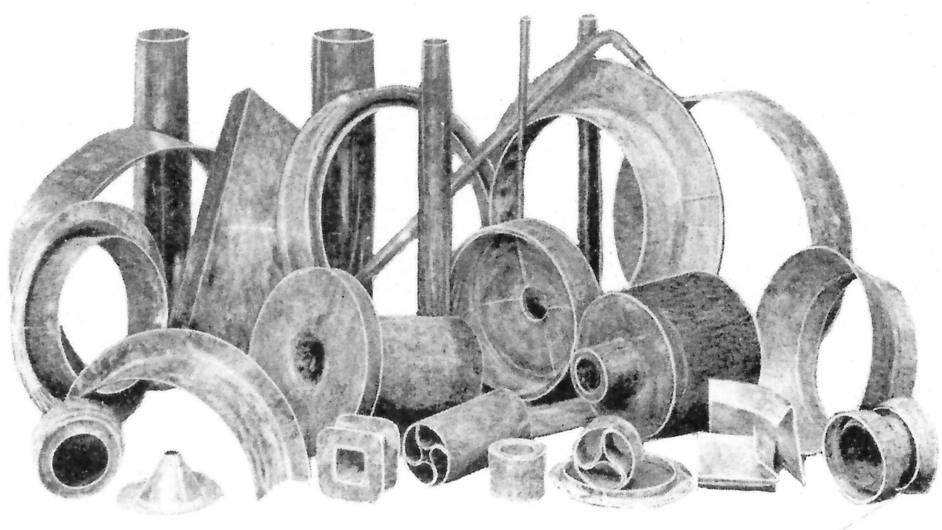
PLATE XX



A. Commutator rings and cones.



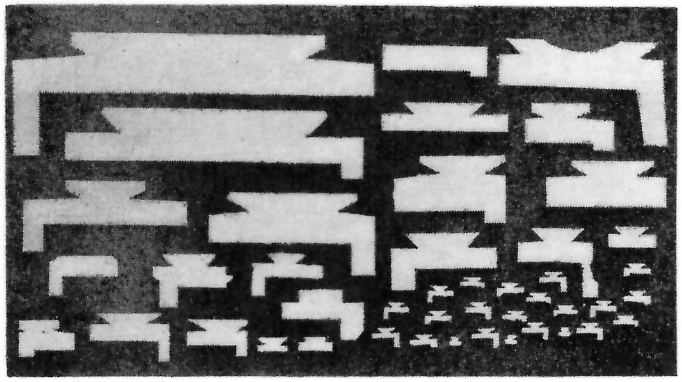
B. Tubing.



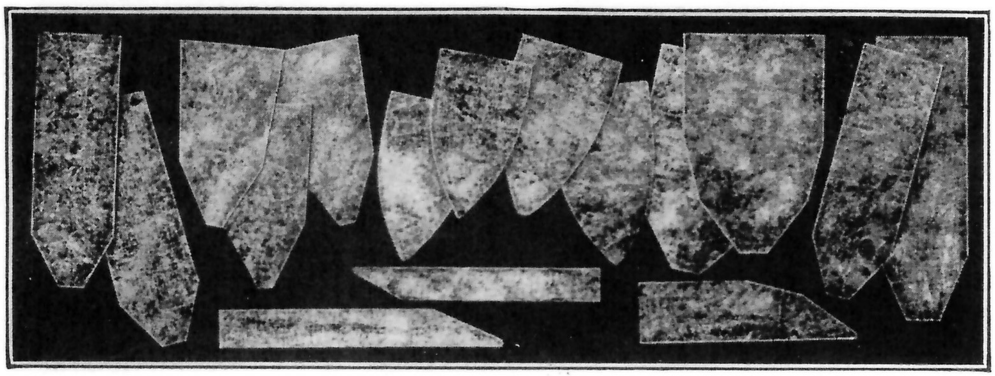
C. Commutator rings and cones, cable joint tubing, coil forms, etc.

(Photos by Mica Insulator Co.)

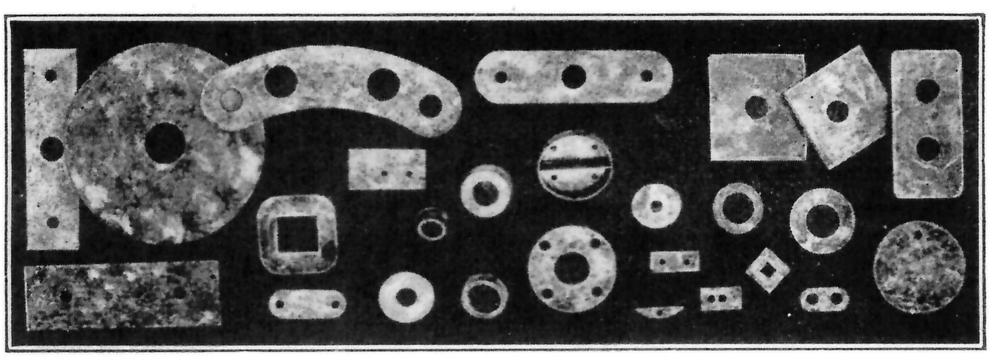
Types of moulded electrical insulation manufactured from mica plate.



A. Commutator segments.



B. Shapes for electrical heater appliances.



C. Washers.

(Photos by Mica Insulator Co.)

Types of flat electrical insulation manufactured from mica plate.

have been recovered from the rock dumps of phlogopite and phosphate mines in Canada as well as from those of feldspar and muscovite mines in the United States.

The recovery of small flake mica from rocks of the mica schist type has been practised in recent years at various localities in the United States.

The stocks of scrap mica available at the mines and trimming establishments throughout the world, particularly in India, are doubtless sufficient to supply the growing demand for grinding mica for a long time; but with their exhaustion (the Canadian reserves of scrap have been very heavily drawn upon in recent years) the recovery of flake mica on an important scale, particularly from mica-rich rocks that have undergone deep weathering, may be looked for. Already, the installation of classifiers and screens in kaolin washing plants in North Carolina has permitted the recovery of a considerable tonnage of flake mica and the quantity seems likely to be increased.

The method of recovering flake mica from kaolin tailings in the Spruce Pine district in North Carolina is briefly as follows[1]. The tailing material from the sand wheels, and consisting of a mixture of sand, coarse grit, and mica, is washed into classifiers, where the coarser particles are dropped, the

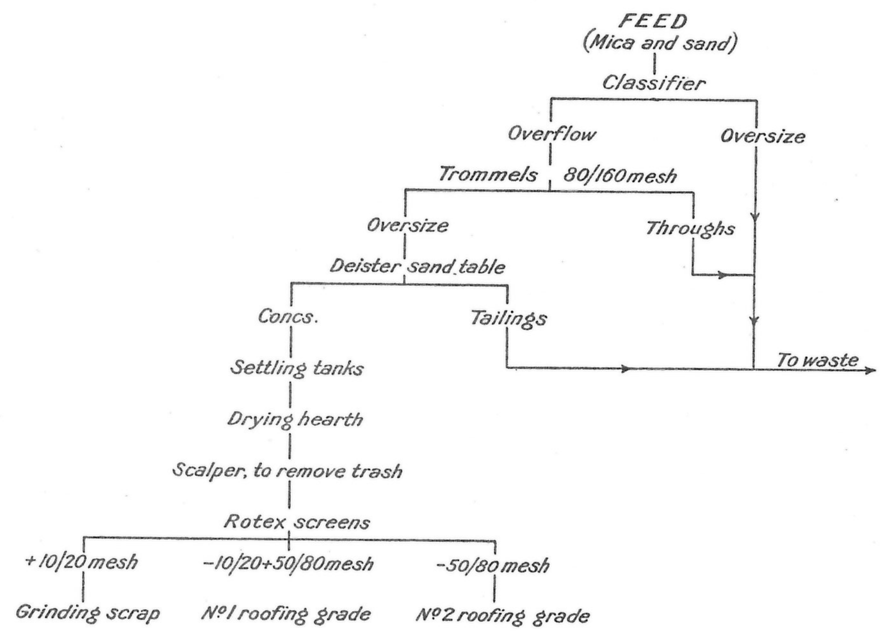


Figure 9. Flow-sheet showing method of recovering flake mica from kaolin tailings, Spruce Pine district, North Carolina.

fine sand and mica passing over. In the larger plants Dorr classifiers are used, but wooden tanks of the spitzkasten type are also in use. The overflow passes to screening trommels, fitted with 80-mesh screens. The fine sand and mica are washed through to waste and the overs pass to

[1] *See also* Eng. & Min. Jour., vol. 127, No. 16, April 20, 1929, pp. 630-1; Ceramic Age, March, 1929, pp. 79-81.

Deister sand tables. These deliver a mica concentrate consisting of flakes that may range up to ½-inch. The concentrate is washed into settling-tanks and the water allowed to drain off. The mica is then shovelled, or dumped from travelling carriers, onto drying hearths, which average about 6 by 50 feet. These hearths may be coal-fired or heated by steam, and in some cases, they are provided with wooden covers which can be dropped after a charge has been spread, the moisture-laden air being drawn off to flues. The charge is stirred with a rake or hoe as drying proceeds and drying is complete in 12 hours. The dried mica is then elevated to coarse scalpers to remove trash, and bolted to the required size over Rotex screens. These screens are usually fitted with two decks of 10 or 20 mesh and 50 or 60 mesh respectively, though the meshes used in different plants vary considerably. The coarse product is sold as grinding scrap and the intermediate and fine products represent No. 1 and No. 2 grades of roofing mica. It is claimed that, due to the weathering it has undergone, such recovered flake is not bright enough for the wall-paper trade, and that it does not grind so easily as the coarse scrap and schist mica which constitute the principal raw material for the ground mica trade; hence its chief use up to the present has been for roofing. Figure 9 shows a flow-sheet of a flake mica recovery plant in the Spruce Pine district, North Carolina.

Of interest, also, is a project, now under way, to recover fine flake mica from weathered tin- and columbite-bearing pegmatite at Tinton, in the northern section of the Black hills, South Dakota. The recovery of such mica is one of the objects of the Black Hills Tin Company, Tinton, S.D., who have devised special methods of separating the mica from the accompanying minerals. The mica occurs in fairly compact masses of exceedingly fine flakes. It is probably muscovite, very soft, and the bulk of the scales are so small as to be almost colourless; in the mass, they are clear white. Separation of the various constituents of the ore is effected by differential crushing and screening[1]. When the rock is crushed, the quartz, feldspar, cassiterite, etc., break down into small particles, which are approximately of equidimensional form. The mica, on the other hand, being tough, suffers little reduction and retains its platey form. The crushed rock is then passed over a series of specially devised and patented vibrating screens, having mesh of different size and shape. The bulk of the associated minerals pass through these screens, while the mica flakes are retained on them, and a fairly clean mica concentrate is secured. The throughs from the screen are then treated to remove the cassiterite. A 300-ton mill has been erected by the above company, and it is estimated that several thousand tons of high-grade mica per annum can be produced.

Near Franklin, North Carolina, scrap mica is recovered[2] from a weathered pegmatite dyke (locally termed "flukin"), the mica content of which is said to be about 20 per cent. The run-of-mine ore is first broken down in a hammer mill with ¾-inch grate discharge, the throughs being sluiced into a log washer which washes out the kaolin. The coarse

[1] *See* "The Mineral Wealth of the Black Hills," Bull. No. 16, South Dakota School of Mines, 1929, p. 252.
[2] *See* Eng. & Min. Jour., vol. 122, No. 23, Dec. 4, 1926, p. 896.

material passes through a screw classifier to remove the fine mica and sand, and then goes to a $\frac{1}{2}$-inch trommel, the overs from which pass to a set of light rolls discharging to a $\frac{1}{8}$-inch trommel. The overs from this last trommel are scrap mica, and the throughs go to waste. The throughs from the first ($\frac{1}{2}$-inch) trommel are further screened over $\frac{1}{8}$-inch, the fines going to waste and the oversize being delivered to a set of heavy rolls, the discharge from which joins that from the light rolls. The sand contained in the fines from the screw classifier is settled in a cone classifier, the mica passing off in the overflow. This is passed over a 100-mesh screen, to remove any coarse flake, and then goes to settling-tanks, from which it is pumped to a filter press. The filter cake is dried and shipped as finished product.

In 1919, a deposit of chlorite schist was opened up near Spruce Pine, North Carolina, and a mill built for treating the rock. After grinding, the material was calcined, which resulted in changing the dull green colour to a silvery white. Mica schist, also, is mined for its flake mica content in North Carolina, deposits being worked in three counties. Most of the production, however, comes from the Spruce Pine district, in Mitchell county.

Chlorite schist has been worked for a number of years near Canton, Georgia, and the flake recovered and sold for roofing and other purposes.

In 1924, a deposit of weathered, mica-bearing rock, containing 15 to 25 per cent of mica, was worked near Hollywood, Georgia. The run-of-mine material was passed through a log washer to remove the clay and was then milled in a Hardinge mill with an abundance of water.[1] The milled product was then passed over tables, which effected a separation of the quartz and mica and yielded a fairly clean mica concentrate. This concentrate underwent a final cleaning in a pulsating classifier, which furnished a marketable grade of flake mica.

Scrap phlogopite for grinding purposes sold for about $12 per ton, f.o.b. cars, in 1928; while clean shop-scrap muscovite was quoted at $25 per ton at New Hampshire points.

While several small mica grinding plants have been operated in Canada at various times, there has never been an important production of the ground product. The principal market for scrap is in the United States, which country is the world's largest producer of ground mica, importing large amounts of Canadian and South African scrap, in addition to the domestic production. On account of contamination by clay and oil, much of the available Indian scrap is reported to be unsuitable for grinding purposes.

Depending on the use to which it is to be put, powdered mica may be prepared from any of the common varieties—muscovite, phlogopite, biotite, etc.—and chlorite and sericite (a variety of muscovite) are also used to make an essentially similar product.

Prepared Roofing. In the manufacture of rolled roofing and asphalt shingles, ground mica is used to coat the under side, in order to prevent sticking. On account of its flaky form, mica has proved more economical than the talc formerly used, the relative covering power being consider-

[1] Mineral Industry, 1924, p. 491.

ably greater. About 0·60 to 0·75 pound of mica is required per square of 108 square feet. The mica used is ground to about 60 mesh, and sells for $25 to $30 per ton, f.o.b. mills. Practically any quality of mica is suitable for roofing purposes, and the product is dry ground.

Wall-paper. Considerable quantities of ground mica are used in the manufacture of wall-paper, where it serves to impart a lustre or sheen to the decorated surface. The mica is made into a thin slurry with water and size, and the mixture is placed in a trough set at the end of the printing machine. A 4-inch brass roller revolves half-immersed in the slurry and presses against a short endless felt band (the "sieve cloth"). This band takes the mica off the roller and transfers it to the printing roller upon which the pattern is incised.

No suitable substitute for mica for this purpose has been found, since other materials do not possess or retain the desired lustre. Only the highest quality of white mica is used, which is finely ground in wet mills and water-floated to ensure a clean, uniform product. The best grades of ground mica used for wall-paper sell for as much as $125 per ton.

Lubrication. As an addition to lubricating greases, ground mica serves to give body to the grease, as well as having lubricating value in itself. Powdered mica, dusted on wooden bearings, decreases friction, and it is used, either dry or mixed with oil, for lubricating parts where the use of graphite or an excess of grease or oil is objectionable. In the manufacture of rubber tires, powdered mica is used to dust the tires before they are placed in the moulds for vulcanizing, and also before they are packed for shipment. Mica powder, placed between the casing and inner tube of tires, serves to prevent friction and sticking. Mica for lubricating purposes must be grit-free and finely ground, specifications calling for 100 per cent through 100 mesh and 88 per cent through 200 mesh.

Moulded Electrical Insulation. A recently developed use for powdered mica is in the production of moulded electrical insulation,[1] using binders of various types, such as synthetic and natural resins and gums, asphalts, rubber, and silicate cements. The product known as "mycalex" consists of ground mica and lead borate. This mixture is heated to the softening point of the binder—about 675°C.—and compressed in the soft, plastic state. During the moulding process, the fused lead borate combines with a proportion of the mica to form lead boro-silicate, a compound having a greater degree of insolubility and a higher softening point than that of the original binder. The moulded articles are cooled under compression, and may thus have metal parts, possessing a different coefficient of expansion to that of the insulation, firmly moulded into them. Mica serves to impart both high heat resistance and high di-electric strength to this type of insulation, which is particularly adapted to high frequency apparatus. Care must be taken to ensure that mica used for this purpose is of good quality, contains no metallic iron particles, and that the powder is of a uniform degree of fineness. Careful control of ingredient proportions, and of temperature, pressure, and time during manufacture, is also essential.

[1] L. E. Barringer: General Electric Review, vol. 30, No. 8, August 1927, pp. 387–395.

Miscellaneous Uses. Powdered mica is used as an inert filler in hard rubber, gramophone records, certain types of rubber goods, and in decorative and other paints. It is also used to give an ornamental finish to concrete, tile, and stucco surfaces.

It is reported to be used in the annealing of steel, as a component of explosives, in calico printing and sizing, and in lithographing.

Coarsely ground mica is employed in Christmas decorations to give the effect of snow. Either alone, or mixed with other powdered materials, such as cork, wood fibre, etc., it has been proposed as a puncture-sealing material in pneumatic tires.[1]

Powdered mica, as well as scrap sheet mica, has been used as a heat insulating material for pipes and boilers. For such purposes, however, mica has now been almost entirely supplanted by asbestos, diatomaceous earth, etc.

On account of its potash content (theoretical, 11·8 per cent K_2O), it has been suggested that ground muscovite mica, and also its variety sericite, might be employed as a fertilizer. The mineral, however, is decomposed with extreme difficulty, and is very resistant to weathering agencies, so that there is little likelihood that the potash content can become available as plant food to any useful extent.

While not strictly powdered mica, the material bearing the trade name of " zonolite " may be mentioned here. Zonolite[2] is a trade name given to the product obtained by the heat treatment of jefferisite, or vermiculite, a peculiar variety of altered phlogopite mica, possessing the property of expanding tremendously on heating. The only recorded occurrences of this type of mica in commercial quantity are near Libby, Montana, and near Westcliffe and Hecla, Colorado.

A small plant was erected in 1924 by the Zonolite Company, of Libby, to treat the material of an extensive deposit of jefferisite occurring near that place. Treatment consisted merely in heating the run-of-mine mica in a rotary kiln to 1,400° F. and separating the expanded product from any admixed gangue material by air suction. The mica does not break down greatly in the heating process, the crystals merely puffing up to about fifteen times their original bulk to form an extremely light, spongy material, about 75 per cent of which will pass a quarter-inch screen and practically all, a half-inch screen. The expanded product has a specific gravity of about 0·087, and weighs about 8 to 12 pounds per cubic foot.

Heating of the mica in air yields a product having a light golden bronze appearance, while if air be excluded, the colour is silvery white.

It is not known that any important market has yet developed for zonolite. Listed uses include: for the dry packing of wall spaces, as an insulating and sound-deadening material; for pipe and boiler covering; for the manufacture of sheet or slab insulation, using a proportion of finely ground zonolite and water as a binder for the coarse material—(in the wet state, such a mixture may be used for plastering and will adhere well to brick or stone surfaces); as a decorative finish for plastered walls and other

[1] *See* U.S. Bureau of Standards, Circular No. 320, 1927.
[2] *See* Eng. & Min. Jour., Nov. 21, 1925, pp. 819–20; U. S. Geol. Surv., Bull. 805–B, 1929, pp. 22–24.

surfaces); as a fire-proofing or fire-retarding addition to packings of an inflammable nature; for wall paper; in paints; as a lubricant in oils and greases.

The price quoted for zonolite by the producers in 1925 was $25 per ton, and the cost of production was reported as $13.75.

Methods of Manufacture

Various trade names[1] have been applied to ground mica products. "Micolith" and "micamina" are coarsely ground mica used as facing material on concrete blocks, in order to give them the appearance of natural rock. A pure, finely ground mica used as pneumatic tire dusting and lubricating agent, is sold under the name "rimco." A calcined vermiculite was formerly produced by a Denver firm and marketed under the name "tung ash." Calcining of the mica drove out part of the water and changed the colour to a metallic bronzy tone.

While mica is a soft mineral, it is difficult to grind owing to its perfect cleavage and toughness. Consequently, grinding has to be effected by machines that will exert a shredding or tearing action upon the flakes. Depending upon the use to which the ground product is to be put, grinding may be dry or wet. Dry grinding is used for the coarser and cheaper grades, such as those employed for roofing, concrete surfacing and fillers, while the high-grade, fine powders, possessing a bright lustre, are produced by wet grinding methods. Dry grinding is considerably more rapid and less costly than wet grinding.

Dry Grinding

Various means of reducing mica to a fine powder have been employed. In the early days of the industry, use was made of rudimentary tube mills, consisting of a punched iron cylinder, carrying a charge of steel slugs. The fine mica passed through the holes, and was bolted to various sizes, the oversize being returned to the mill. High speed disintegrators or hammer mills were also used, and gave the best results.

Attempts have also been made to effect an initial opening up of the mica leaves by heat, followed in some cases, by pulverizing in a machine connected with a steam jet, but such methods have not come into general practice.

Grinders of the hammer-mill or cage-disintegrator type, equipped with screens or with an air separation device, are the machines in general use to-day. Screen pulverizers are usually preferred, the mill being equipped with screens of any desired mesh, and the discharge through the screens being bolted to various sizes. For the grinders, a table feed is found superior to other types, which are apt to become clogged by the mica sheets.

A grinding plant in Georgia, producing chiefly a roofing grade of mica, passes the scrap first to a Sturtevant coffee-mill type of crusher, and then through a Jeffrey No. 3 hammer mill, the product from which is passed to

[1] Bowles, O.: U. S. Bureau of Mines, Reports of Investigations, Serial No. 2357, Mica, 1922, p. 30.

inclined screens, making four sizes—60 to 80 mesh, 80 to 120 mesh, 120 to 200 mesh, and -200 mesh. The capacity of the plant is 5 tons per 24 hours.

A mill in North Carolina, running on a coarse- to fine-grained mica schist, crushes the ore in a coffee-mill type of crusher, after which it is passed through a direct-heat rotary dryer. Considerable fine dust is eliminated in the drying process, being carried by the furnace draught into a collecting chamber or up the stack. The dried product is lifted to a Williams hammer mill and then screened to remove fine dust. The oversize passes to a series of smaller hammer mills connected to a cyclone system, which lifts the fine product to a collector and discharges the dust. The mills and collector are in closed circuit with a series of Rotex screens delivering a No. 1 (—20 +50 mesh) product and a No. 2 (—50 mesh) product. Both products go to the roofing trade.

A Canadian mill, running on mine and shop scrap, uses a KEK grinder in which the mica is shredded between two horizontal steel disks carrying rows of studs or teeth, the upper plate rotating at high speed and the lower plate being stationary. The fines are discharged through a side opening, and pass to bolting trommels, the oversize being returned to the grinder. The coarser grades of product find employment in roofing, and the finer grades in the rubber industry.[1]

Wet Grinding

Wet-ground mica being, in general, a higher grade and more costly material than dry-ground mica, more care is required to ensure a clean mill feed. Before grinding, the scrap may be washed, usually in a trommel type of washer, to remove adhering sand, clay, etc. To ensure an absolutely grit-free product, fresh waste from cutting and trimming shops is the best type of scrap to use, but clean mine scrap is also suitable. The quartz, feldspar, and other minerals often contained in mine scrap are sometimes removed by agitating the scrap in wooden tubs with water. This breaks up the mica, but not the other minerals, which settle in the bottoms of the tubs, and the clean mica can then be drawn off. In the production of finely ground mica from schist, by either wet or dry milling methods, removal of the quartz and other associated minerals is usually effected during the grinding operation or after this is complete. In dry mills, such mineral matter is reduced much more readily than the mica and may be removed by dust-collecting devices at one or more stages of the milling system. In wet mills, the gritty impurities assist in the grinding of the mica and are removed from the finished product in the first settling-tanks.

In the wet grinding of mica, owing to the softness and toughness of the mineral, machines differing radically from those used in reducing other non-metallic minerals are employed. Burrstones were found to give fairly satisfactory service, generally in closed circuit with classifying screens, but are now seldom used. The best success has been had with wooden grinders and most of the highest grade of wet-ground mica produced in the United States is prepared in mills of this type.

[1] For a detailed description of dry mica milling practice at a mill in North Carolina, *see* Eng. & Min. Jour., vol. 122, No. 23, Dec. 4, 1926, pp. 894-6.

The earlier of such mills[1] consisted of low vertical tubs, about 3 feet in diameter and 3 feet high, the walls being built of wooden blocks, laid end on, so as to oppose the greatest resistance to wear. The impeller, for stirring the charge of scrap mica, consisted of a solid wooden cylinder, similarly constructed, and fitting loosely within the tub. It was revolved by a vertical shaft. The tub was charged with mica and water, enough water being added to permit free motion of the charge. The impeller was then lowered onto the mass and put in motion. The friction of the cylinder churned the mass around, and breaking down of the mica flakes was effected principally by the wearing action of one flake on another under pressure. Considerable heat was developed by the friction within the charge, so that prolonged operation raised the temperature to near boiling point. Grinding was slow, a charge of 300 to 400 pounds of mica commonly requiring 8 hours.

The capacity of these mills being small, a number of them were usually erected in line, so that they could all be driven from a single horizontal shaft. Cheap power is a prime essential for the operation of wet mills, and water power is generally used.

Attempts to increase the capacity and efficiency of this type of mill have resulted in the adoption in recent years of larger units, in which the impeller has been replaced by wooden rollers of the chaser type. In the newer type of mill, large circular steel tanks take the place of the wooden tubs, the walls being 3 to 4 feet high and the diameter as much as 10 feet. The tanks are provided with bottoms of wooden blocks, laid end on. A central, vertical shaft, hung on ball bearings and gear-driven, carries a frame, on which are mounted four wooden rollers, 30 to 40 inches in diameter and with 20- to 24-inch faces. The axle-bearings of these rollers are free to slide vertically, so that the rollers automatically adjust themselves to the level of the charge in the tank. Steel deflecting plates, carried on the frame, throw the charge in the path of the rollers. The rollers revolve at a comparatively low speed and churn the charge of mica and water in the same way as the single cylinder in the old type of mill, but the grinding efficiency is much higher. The mills take a charge of 1 to 1½ tons of scrap, and grinding is complete in from 6 to 10 hours, depending on the character of the feed.

After grinding is complete, the charge is sluiced out of the tanks into sand launders or tanks, where the gritty impurities sink, the mica passing on to settling-basins. The size, number, and arrangement of the sand launders or tanks vary with the class of material ground and the consequent amount of sand to be removed. One mill employs a sand launder, 10 x 10 inches x 30 feet long, with baffles every 5 feet. The overflow from this discharges into a tank, 10 x 4 x 2 feet deep, where it is agitated by jets of water forced through a perforated pipe laid along the bottom. The coarse mica and fine sand are caught in this tank, the fine mica being carried over to settling-basins. Other mills employ one or a series of sand tanks in place of launders, a common size being 6 x 4 x 3 feet deep.

[1] Myers, W. M.: U.S. Bureau of Mines, Information Circulars, Nos. 2798 and 6044 (1927).

Some wet mills report that a large proportion of the finest mica is carried off in the effluent water from the settling-basins, the percentage of the charge thus lost being estimated by one operator at as high as 35 per cent. A study of means to prevent these losses was instituted by the U.S. Bureau of Mines, and the use of flocculating reagents, such as sulphuric acid or alum, was suggested. Laboratory tests showed that these

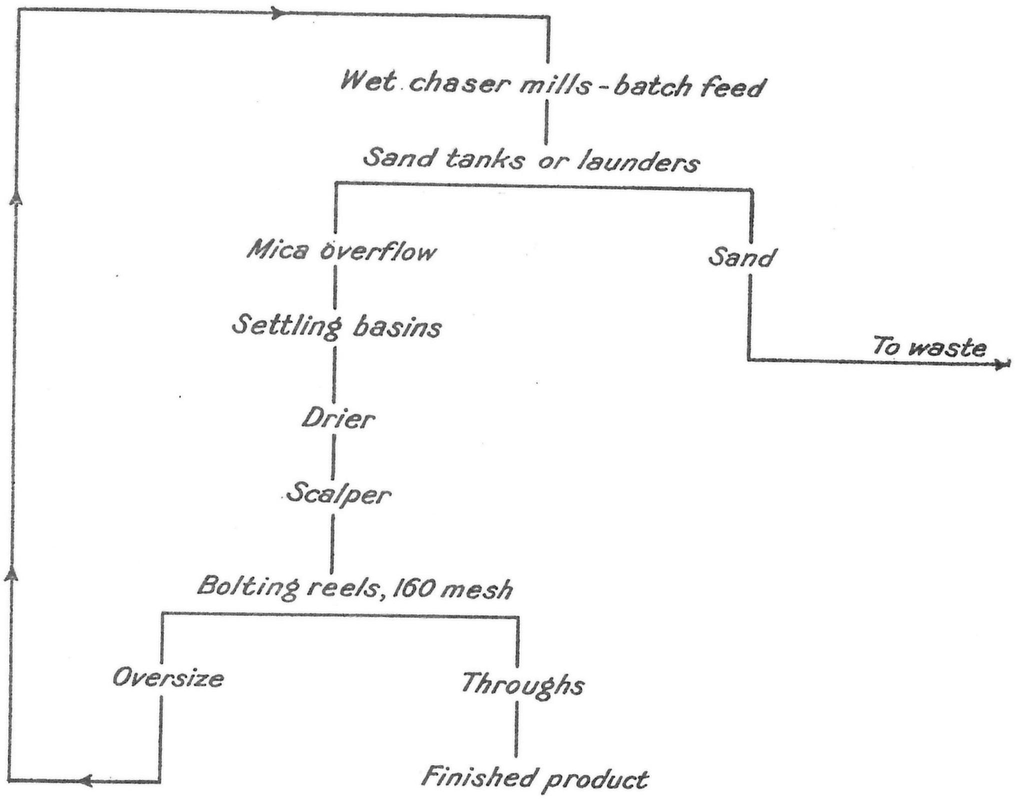


Figure 10. Flow-sheet of wet grinding mill for mica.

reagents materially aided settling of fine mica suspensions,[1] but it is not known that their use has been adopted in commercial practice. In the report of the investigation, it was suggested that the use of launders and tanks built of concrete in place of wood might be an important contributory cause of fine mica losses, due to the leaching of soluble deflocculating salts from the concrete.[2]

The settled mica is either pumped to filter presses or shovelled to some form of dryer. If filter presses are used, the cake is dried on steam-heated racks. For drying the wet sludge various forms of equipment are employed, including hearths similar to those described on page 112 for

[1] U.S. Bureau of Mines, Reports of Investigations, Serial No. 2793, March 1927.

[2] Note.—The tendency of fine mica particles to form a persistent suspension in the mill wash water possibly is due to the presence in the water of soluble potash leached from the mica during grinding. Muscovite contains about 10 per cent of potash, and sufficient may be released and go into solution as the hydrate (which is a powerful deflocculating electrolyte) to affect settling materially.

drying flake mica; ovens, into which cars stacked with tiers of shallow trays are run; and steam-jacketed kettles fitted with mechanical stirrers and exhaust flues. The latter take a wet charge of about 5,000 pounds, and drying requires 24 hours.

From the dryers, the mica passes to coarse scalpers to remove any trash, and is then bolted through reels fitted with 160-mesh cloth. The oversize from the bolters is returned for regrinding and the fines constitute finished product for the wall-paper and rubber trades.

In the making of the highest grade of ground mica, care has to be taken to avoid destroying the lustre and "life" of the flakes by excessive abrasion and also the producing of an excessive amount of fines (—250 mesh), the latter lacking the required brilliancy and sheen.

It is reported that a system of grinding mica wet in a ball mill has been developed by an American company, but it is not known with what success. It is claimed that grinding by such means is more rapid than by chaser mills, that a finer product can be made, and that the lustre of the mica is not impaired.

APPENDIX I

PATENTS RELATING TO MICA AND MICA PRODUCTS

Numerous patents have been taken out on methods of treating and handling mica and on devices for the manufacture of mica products. Most of such patents relate to mechanical devices for building mica plate or for splitting mica mechanically, while a few cover methods of treating mica to render it softer and more flexible, or of reducing mica to powder.

The chief difficulty in the mechanical laying of mica plate has been to effect a perfectly even distribution of the splittings over the entire surface of the laying bed, and a great many patents have been taken out on a variety of methods for achieving this end.

The following comprise the principal patents relating to mica and manufactures of mica issued in Great Britain, Canada, and the United States up to **1928.**

MICA PLATE AND OTHER INSULATING MATERIALS OR ARTICLES MADE OF MICA

British Patents

No. 23,671, Oct. 20, 1909, C. F. Peterson. Method of pressing mica plate by the introduction of a sheet of yielding material, such as asbestos, between the plates, so as to achieve uniform density of the finished product.

No. 28,069, Dec. 2, 1910, O. V. Thomas. A plastic composition, consisting of powdered mica and resin, for impregnating insulating materials.

No. 28,834, Dec. 12, 1910, H. P. Rasmussen. A plastic composition consisting of ground mica, asbestos, sulphur, and shellac, heated and moulded under pressure.

No. 27,759, Dec. 11, 1911, W. McLaughlin. Method of making insulating articles from mica.

No. 17,332, July 25, 1912, M. Meirowsky. Method of making mica plate by drawing the splittings by an air current from the bin or hopper to a screen. Dust, etc., pass through the screen, and the mica falls to a sheet beneath it.

No. 21,445, Sept. 20, 1912, F. Bölling. Method of making plastic compositions by mixing mica with lead borate or boro-silicate and heating the mixture under pressure.

No. 23,869, Oct. 18, 1912, C. Fischer. Method of making electric resistances by sewing together sheets of mica by the resistance wire.

89619—9½

No. 15,568, July 22, 1913, Meirowsky and Co. Method of making mica composition by placing splittings in a rotary sieve. The flakes fall through the sieve onto a carrier which distributes them to an adhesive backing.

No. 15,014, Nov. 13, 1913, L. W. Campbell. Method of making insulating cores by threading mica washers, pasted with a binder, on a rod, and compressing them by nuts. The article is then heated, smoothed on a lathe, and threaded.

No. 28,331, Dec. 9, 1913, J. E. Owen. Heat-insulation material formed by sticking mica sheets on a paper backing by means of rubber solution.

No. 23,067, Nov. 25, 1914, P. G. Palmer and J. J. Robinson. Method of making glass substitutes by applying to sheet mica a ceramic flux, which, when heated to 2,000° F., forms a vitreous glaze.

No. 153,612, Feb. 25, 1918, British Thomas-Houston Co. Method of building mica plate. Mica splittings are deposited on a perforated travelling screen by means of a current of air sucked through the screen, which travels over a perforated drum connected with an exhaust. The screen with its layer of mica passes between perforated rollers which coat the mica with binder.

No. 151,962, Sept. 29, 1919, H. Hermann. Method of making mica plate by heating a mixture of mica splittings and powdered shellac under pressure. The splittings are lifted by air suction from a bin or hopper against a perforated plate, from which they fall, when the suction is cut off, onto a tray. The operation is repeated until the required thickness of mica has been deposited, dry shellac being sprinkled on each successive layer. The whole is then hot-pressed and then cold-pressed. (*See also* No. 173,216, Dec. 21, 1920.)

No. 164,298, June 4, 1920, H. Hermann. An electrical insulating material formed of alternate layers of powdered mica mixed with a powdered binder and mica splittings and a powdered binder, the whole being hot-pressed. (*See also* Canadian Patent No. 214,233, June 7, 1921.)

No. 169,769, June 23, 1920, P. B. Crossley. Method of joining mica sheets by bringing the edges into contact, applying a mica solvent and subjecting the joint to heat and pressure. Solvents mentioned are glasses with the oxides of cobalt, lead, etc., or boric acid, borates or boro-silicates.

No. 168,508, Aug. 4, 1920, R. S. Mull. Method of building up electric insulators out of thin-split mica sheets, the sheets being rotated so that the defects in one will not be opposite the defects in the next.

No. 177,241, Dec. 21, 1920, M. Hepner. Method of building mica diaphragms out of thin sheets of mica united by varnish under heat and pressure.

No. 203,232, Nov. 8, 1922, British Thomas-Houston Co. Plastic compositions formed of powdered or flake mica with glycerine and phthalic anhydride, the whole being hardened under heat and pressure.

No. 220,949, Aug. 20, 1923, Consortium für Elektrochemische Industrie Ges. Method of forming plastic mica plate with the aid of an artificial resin as a binder. The resin, obtained by the polymerization of aldehydes, may be used alone or in solution in benzine, acetone, etc.

No. 280,189, Aug. 2, 1928, British Thomas-Houston Co. A laminated insulating material consisting of alternate layers of mica held together and coated with an oxidized ("degelled") oil. The mica is enclosed between outer layers of paper impregnated with the same binder, and the material is pressed between heated rollers and finally baked at 140°C.

Canadian Patents

No. 44,094, Aug. 28, 1893, C. W. Jefferson et al. An electrical insulating plate composed of layers of mica bonded with an insulating cement, the whole finally hot-pressed and cold-pressed. (This is the original process for making composite mica plate out of mica splittings.)

No. 74,950, Feb. 25, 1902, R. W. Heard and R. A. Synder. Method of building up mica plate upon a drum, shellac being applied to the surface of the drum by rollers and the mica flakes being blown on by an air current.

No. 147,865, May 13, 1913, Canadian Westinghouse Co. Method of making mica plate by distributing mica splittings and dry-powdered binder between a succession of superimposed heated plates and pressing.

No. 148,670, June 17, 1913, Canadian Westinghouse Co. Mica plate building machine, comprising a tower equipped with a horizontal carrier and laying frames, enabling the latter to be moved in and out of position at the base of the tower.

No. 162,058, April 20, 1915, W. F. Cannon. Method of forming mica tubing by building up splittings around a metal rod, with the addition of shellac varnish, binding the whole with flexible metallic ribbon and placing in a metal tube and heating.

No. 193,271, Oct. 14, 1919, Mica Company of Canada. Process of making mica plate by bonding layers of splittings with boracic acid. The acid is sprinkled in the form of a dry powder between each layer and the whole is then heated under pressure until the boracic acid fluxes.

No. 195,694, Jan. 6, 1920, P. J. Bernard. Method of making insulators by threading mica washers, coated with gum and rosin, on a rod, pressing the washers together by means of a nut while subjecting them to a red heat, and finally cutting a spiral groove upon the solid mass.

No. 202,285, July 27, 1920, Arthur D. Little, Inc. Method of making mica plate by bonding splittings with lead borate. The borate is distributed between successive layers of splittings and the whole is heated under pressure to the fusion point of the borate.

No. 203,566, Aug. 31, 1920, Canadian Westinghouse Co. A composite insulation made by disposing a material having high di-electric strength (as mica) between layers of sheet material impregnated with a hardened phenolic condensation product.

No. 249,490, May 12, 1925, E. Haefely. Method of making mica-coated fibrous material by distributing splittings on an endless conveyer belt and pressing onto the splittings a web of fibrous material coated with liquid binder, which picks up the mica.

No. 262,405, July 6, 1926, Chicago Mica Company. Method of making mica plate. The splittings are placed in a hopper at the base of a snowing tower and elevated to a tapered revolving screen at the top of the tower. This screen is of fine mesh for its tapered, feed portion and of coarser mesh for its cylindrical portion. Any grit and dust contained in splittings thus pass the fine mesh and fall to a discharge chute outside the tower, while the flakes fall through the coarser mesh down the tower. Agitator arms set within the tower effect an even distribution of the flakes. Near the base of the tower, and in one wall thereof, are set two superimposed, stationary suction drums, the surfaces of which facing the tower and each other are perforated. Endless screen belts, pervious to air, pass around these drums, the lower belt being longer than the upper and serving as a carrier or laying belt for the mica splittings. As the mica falls down through the tower, the flakes are drawn by suction against the belts and are carried between them so as to form a uniform layer upon the lower belt. By the travel of the latter, they are carried forward along the bed of the plate table, where binder is applied to them by means of a roller mechanism. A section of the plate table is enclosed within a steam-heated drying chamber, furnished with a vent for carrying off the vapour of the drying binder. The finished plate is cut into lengths by a roller knife set at the end of the table.

United States Patents

No. 697,696, April 15, 1902, H. F. Watson and M. A. Snider. Method of laying mica plate. The mica splittings are automatically spread on an endless belt and sprayed with binder. The layer of mica then passes between rollers and is cut into the desired lengths, the thin sheets being afterwards pressed together in steam presses.

No. 764,810 and 764,811, July 12, 1904, C. W. Jefferson. Method of treating mica splittings with an adhesive coating, so as to enable them to be pressed into plate. The splittings are fed to a conveyer belt and dusted with powdered shellac. They then pass over burners, and the shellac is melted and coats the flakes. After cooling and drying, the flakes can be handled like crude splittings, and only need to be pressed together under heat to form plate. In place of dusting with dry shellac, the splittings may be sprayed with a binder containing a volatile solvent and then dried over burners. In this case, they only need to be wetted again with the solvent to enable them to be pressed into plate.

No. 833,401, Oct. 16, 1906, B. G. Levis. Method of building up mica plate. The splittings are placed in a loose heap on a carrier which passes back and forth beneath a funnel closed by a perforated plate and connected with a suction device. When the carrier comes to rest beneath the funnel, a layer of splittings is lifted and adheres to the perforated plate, sealing the apertures. The carrier then moves away, the suction is cut off and the layer of splittings falls onto a tray. This tray then moves out from beneath the funnel and the splittings are simultaneously coated with a layer of shellac by a spray, roller, or other device. The operation is repeated until the required thickness of mica is obtained.

No. 847,910, March 19, 1907, Edward Cooper. In the making of mica plate, the splittings are coated with the liquid binder by placing them in a wire basket which is immersed in a tank of shellac. The former is then lifted and drained and the splittings are removed and arranged on a laying screen. The operation is repeated until the required thickness of mica has been laid, the screen being tilted over a strong light during the operation so as to reveal weak spots and permit uniformity in laying.

No. 890,500, June 9, 1908, Edward Cooper. A machine for folding sheets of mica for insulating covers.

No. 934,057, Sept. 14, 1909, E. L. Elwell. Method of building mica plate, including the mechanical separation of splittings from dust and other foreign material and the arrangement of them in layers upon an inclined, vibrating bed. The splittings slide from the bed onto a carrier which deposits them onto a moving belt, where the binder is applied. (*See also* Canadian Patent No. 121,135, Oct. 12, 1909.)

No. 1,003,368, Sept. 12, 1911, M. Meirowsky. Method of making mica plate by aspirating splittings against a perforated cylinder revolving about a second stationary inner cylinder containing a central, longitudinal air pressure chamber. The mica picked up and held by suction against the surface of the outer cylinder is blown by air, passing from the pressure chamber through a slot, onto the periphery of a drum coated with an adhesive binder.

No. 1,024,529, April 30, 1912, W. H. Sills. Machine for building mica plate. A carrier, coated with an adhesive, is run over a receptacle containing mica splittings, depressed to pick up a layer of mica, then raised and run back to deposit the mica, layer by layer, upon a laying plate.

No. 1,026,986, May 21, 1912, C. W. Jefferson. Method of laying mica plate by showering splittings from a rotating drum down through a tower onto a wire screen. This screen may be supported on a car or frame, which can be run or slid into the tower, and to which an aspirating device can be connected, so as to draw a current of air down through the screen and so cause the falling mica to distribute in an even layer upon the latter.

No. 1,074,576, Sept. 30, 1913, J. R. Sanborn. Machine for building mica plate, comprising a tower, at the top of which is set a hopper for splittings. From the hopper, the flakes fall through an upward current of air, which effects their even distribution upon a plate set at the base of the tower. Below the hopper is a cylindrical sieve, extending completely across the tower and free to roll back and forth. This sieve contains dry, powdered bond, which, in operation, is showered evenly down the tower to fall amongst and between the mica flakes.

No. 1,126,161, Jan. 26, 1915, H. R. Edgecomb. Method of effecting an even distribution of dry, powdered bond in mica plate laying machines of the tower type by means of an endless belt, to which the bond is fed, and from which it is blown by a succession of air jets.

No. 1,133,325, March 30, 1915, W. H. Sills. Machine for making mica plate, comprising a tower through which splittings are showered. Even distribution of the splittings upon the laying plate at the base of the tower is effected by an upward air current and by a series of rods set across the tower so as to obstruct the free fall of the mica.

No. 1,163,434, Dec. 7, 1915, M. Meirowsky. Method of effecting an even distribution of mica splittings upon a laying belt. The splittings are placed in a container with a perforated base and an air inlet at the top. Air is forced up through the mica to loosen the flakes and also drawn in through the upper vent. The air current picks up the mica flakes and carries them along a channel, extending from the top of the container, to an endless screen belt set at right angles to the channel. The flakes adhere by suction to this screen and are carried down to fall upon the laying belt below.

No. 1,196,036, Aug. 29, 1916, W. H. Sills. Improvement in machine for making mica plate described in patent No. 1,133,325, by the provision of an outside receptacle for the bond and of means for delivering an additional layer of adhesive to successive layers of splittings.

No. 1,320,509, Nov. 4, 1919, C. E. Swett. Method of making composite mica bodies by the use of dry, powdered lead borate as a binder, the whole being heated under pressure to the temperature of fusion of the borate.

No. 1,349,351, Aug. 10, 1920, D. Waling. Machine for making mica plate, comprising an endless wire mesh laying belt, the feed end support of which is a stationary perforated drum connected with a suction device. Adjacent to this drum is placed the mica hopper, from which splittings fall and are aspirated in a layer against the belt, which carries them beneath a tank from which drips a stream of binder. A backing of paper or other material may then be fed from a roller placed above the belt and is pressed against the layer of mica by a pressure roller. The whole then passes forward between a series of steam pipes, which supply heat to soften the binder and expel the solvent, finally passing between a pair of rolls which squeeze out the surplus binder and impart a uniform thickness to the sheet.

No. 1,359,685, Nov. 23, 1920, L. T. Frederick. Device for effecting a separation of mica splittings and a uniform distribution of the same in the tower of a mica plate laying machine. In place of an upward air current, with or without baffle rods, a series of truncated, cone-shaped, revolving screens is used. These screens revolve one inside the other and the mesh increases from the innermost to the outer screen. The splittings are fed to the inner screen and the flakes small enough to pass it fall through the entire series, while the oversize discharges into the second screen. The throughs from this in turn fall through the remaining outer screens, the oversize discharging to the next screen, and so on. The larger end of the outermost screen is provided with slats in place of wire.

No. 1,454,274, May 8, 1923, L. T. Frederick. Machine for making mica plate, comprising a tower, from the top of which extends for some distance downward a central vertical pipe or cylinder. This cylinder is open at its lower end and terminates near the base of a second cylinder of larger diameter by which it is surrounded. Within this second cylinder and directly below the smaller one, is set a blower. Mica splittings are fed by a conveyer belt into the top of the smaller cylinder, fall down through it and on striking the upward current of air are carried up between the walls of the two cylinders and fall in an even shower down through the tower onto a laying plate.

No. 1,588,600, June 15, 1926, L. McCarthy. Method of manufacturing mica plate by the use of a special arrangement of wire screens and metal sheets placed between the individual layers of plate going to the presses. The particular arrangement described for a single unit consists of two outer coarse wire screens, two intermediate steel plates, and two inner screens of fine mesh wire cloth, the layer of plate being placed between the two latter. The object of the given arrangement is to prevent sticking of the plate to the enclosing material.

No. 1,589,094, June 15, 1926, L. E. Barringer and C. F. Peterson. Mica plate made with a binder consisting of a compound of glycerine and phthalic anhydride dissolved in acetone.

No. 1,622,795 and 1,622,796, March 29, 1927, L. McCarthy. Machine for laying mica plate. The mica splittings are deposited on a laying belt by means of a travelling carriage, electrically propelled, and carrying a splittings hopper, binder tank, and pressure rolls. The carriage travels back and forth along the whole length of the bed until the required thickness of plate is laid. The belt is then put in motion and carries the plate forward to be cut up into sections by a knife set at the end of the table.

No. 1,631,652, June 7, 1927, R. Sprenger and H. Conradt. Forms of suction plates for holding layers of mica splittings in the manufacture of mica plate.

No. 1,633,622, June 28, 1927, J. Borer. Method of transferring mica splittings to a fibrous web by means of a perforated, rotary, suction drum. The drum is set above a hopper containing the splittings, the base of the hopper being connected with a pressure blower. The drum rotates about a fixed hollow axle which is connected at each end with a suction fan. Within the drum is a segmental suction chamber, formed by radial walls secured to the axle. This chamber thus remains stationary above the mica hopper while the drum rotates. In operation, the splittings are blown up by the air forced through the hopper and are held by suction against the surface of the drum. As the latter rotates, the adhering mica is brought into contact with, and removed by, a fabric coated with a binder.

No. 1,644,631, Oct. 4, 1927, J. Borer. Method of laying mica plate. The splittings are placed in a hopper connected at its base with a pressure blower and having a cover or top formed of a screen. The splittings in the hopper rest on a screen set above the blower opening. Above the screen cover or top is set a funnel connected with a suction fan. When the blower is started, the splittings are carried up the hopper within reach of the suction, which draws and holds them against the under side of the screen cover. When this is completely sealed by mica, the blower air is cut off, a hinged section of the hopper wall is lifted, and a carrier bearing a take-off plate is run in beneath the screen and raised to press against it. The suction is then cut off, and the carrier lowered, taking with it the layer of splittings.

No. 1,645,415, Oct. 11, 1927, J. M. Coffey. Mica plate built up by the use of a binder consisting of a condensation product of phenol and glycerol dissolved in alcohol.

MICA SPLITTING

Canadian Patents

No. 74,949, Feb. 25, 1902, R. W. Heard and R. A. Synder. Method of separating mica laminæ by repeated heating and quenching in water, subsequently passing the sheets between rollers.

No. 75,968, May 20, 1902, W. C. Kent. Method of separating mica laminæ by heating and quenching, substantially as outlined in No. 74,949.

No. 119,055, June 22, 1909, C. A. Guertin. Device for splitting mica by means of knives carried on a revolving, horizontal disk. The mica is fed to the knives from a magazine, and the splittings fall through slits in the disk.

No. 127,128, 1910, F. Lilienthal and G. Lauer. Method of splitting mica by passing the sheets between a series of drums provided with suction orifices and revolving in opposite directions.

No. 278,002, Feb. 21, 1928, L. T. Frederick. Method of splitting mica by means of an initial heating to expand the sheets, followed by passage through a set of beater arms to loosen the laminæ, and finally passing the loosened sheets between pervious belts moving around fixed suction drums. There may be any number of such drums and belts, in series, and the mica may be soaked in water or other fluid before the initial heating.

United States Patents

No. 677,775, July 2, 1901, I. de Kaiser and C. W. Hadfield. Machine for splitting mica by means of a rotating table upon which the blocks of mica are held by suction. Stationary knives split thin films from the bottoms of the blocks as the table rotates. Modifications provide for a stationary table and revolving knife, or for a knife and table moving counter and parallel to each other.

No. 832,494, Oct. 2, 1906, H. C. Michell. Method of splitting mica mechanically by first drying it in a kiln and then passing the sheets between corrugated rolls. The rolls loosen the laminæ, and the final separation is effected by subjecting the sheets to a powerful air blast. (*See also* Canadian patent No. 48,608, April 4, 1895, and No. 77,354, Sept. 9, 1902.)

No. 901,130, 1908, B. Walchner. Method of splitting mica by means of oscillating knives carried on a horizontal table to which a reciprocating motion is imparted. The mica blocks are held by a clamp in line with the axis of the knife. An air blast removes the splittings as they are made.

No. 1,155,298, Sept. 28, 1915, Edward Cooper. Machine for splitting mica, comprising endless fabric belts between which the mica is held and carried forward between a series of rollers. In passing between the rollers, the mica sheets are flexed and loosened by the rubbing action of the belts.

No. 1,185,881, June 6, 1916, Edward Cooper. Mica splitting machine, consisting of an endless belt which carries the mica sheets between a series of ribbed rollers. The rollers are set in pairs, the diameters of which decrease progressively. The bending of the mica by the rolls loosens the layers, separation of which is achieved by finally passing the mica beneath a smooth rubber roller set above the belt drum and revolving at a higher speed than the latter.

No. 1,194,155, Aug. 8, 1916, H. R. Edgecomb. Method of splitting mica by first heating it by passing it through a furnace, from which it drops into a quenching tank. The quenching causes a partial exfoliation of the sheets, which are then carried by an endless belt between a series of staggered rollers. These bend the mica and cause a further loosening of the layers. From the rollers, the mica drops into a tower, equipped with pivoted baffle plates and through which a strong stream of water is directed. The force of the water striking against the edges of the mica sheets effects the splitting. The splittings fall to a conveyer which carries them through a drying furnace. In place of the tower, an endless belt passing over a series of rollers of progressively increasing diameter may be substituted. Above this belt is set a second belt passing around a similar series of rollers, the distance between the belts and two sets of rollers gradually increasing from the feed to the discharge end. As the mica sheets pass forward between the upper and lower belts, streams of liquid are directed against their edges with sufficient force to cause them to exfoliate into thin films. From the belts, the mica falls down through a tower, the drop sufficing to separate the films.

No. 1,263,057, April 16, 1918, J. T. Griffin. Method of producing mica films of any specified thinness by means of a grinding wheel. The mica sheets are held by suction against the upper surface of a horizontal rotatable disk and are carried beneath a rapidly rotating, horizontal grinding wheel. This wheel is adjustable vertically so as to make films of any required gauge. After grinding is complete, and the film moves from beneath the wheel, suction is cut off, the film is removed, and a fresh blank falls into its place from a magazine.

No. 1,383,370, July 5, 1921, G. J. Bancroft. Method of splitting mica by first saturating it with water and then heating it in a pressure cylinder with the addition of more water. Heating is continued until a pre-determined pressure is attained, when the pressure is suddenly released, thus effecting expansion of the mica layers.

No. 1,666,130, April 17, 1928, L. T. Frederick. Machine for splitting mica. An inclined revolving drum, fitted with baffles and open at both ends, is provided with a feed chute at the upper end, through which the mica sheets are introduced. Before being fed to the drum, the sheets undergo a preliminary loosening by being passed between flexing rolls or by some other treatment or device. In front of the lower end, and at a short distance from it, is set a funnel of the same diameter as the drum and connected with a pipe through which a current of air is forced. A damper in the neck of the funnel provides a means of regulating the amount of air issuing from it. Through the side of the funnel passes a second air pipe, which extends within the drum almost to its far or upper end and is so set as just to clear the path of the baffles. This pipe is closed at its forward end by a cap, and a slot extending along its entire length permits a current of air to be directed toward the rising side of the drum. This air blast meets the mica lifted by the baffles and blows apart the layers already loosened by the tumbling action. The light, thin flakes are blown out of the upper end of the drum by the air issuing from the funnel and fall to a collecting hopper. The heavy, compact sheets discharge out of the lower end of the drum and are collected for re-treatment. By regulating the strength of the current of air passing from the funnel through the drum, the thickness of the flakes blown through the drum can be controlled.

No. 288,062, March 19, 1929, Chicago Mica Company. Method of splitting mica and of grading the split flakes. The mica is first heated by passing it on a belt through an oven, from which it falls to a quenching bath. It is then passed through a dryer and elevated to a snowing tower. This tower is equipped with a rotary screen, which serves to separate the expanded mica sheets by tumbling. The splittings fall from the screen through a chute provided with kickers, which serve to still further split the flakes. The chute discharges beneath a suction hood across the base of which passes an endless screen belt. The thinner and lighter mica flakes are aspirated and held against the under side of this screen, which drops them as soon as it passes beyond range of the suction, and they fall to a hopper. The thicker and heavier flakes, that are not lifted by the suction, fall to an elevator and are lifted to a hopper capable of being made to discharge in any one of three different ways: (1) to the belt passing through the heating oven; (2) to a tumbling drum, feeding to a set of crimping or flexing rolls, between which the mica is carried by belts, and from which it discharges to the elevator feeding to the snowing tower; (3) directly back to the snowing tower.

NOTE.—A description of a suggested means of separating mica sheets into thin layers is given in Eng. & Min. Journ., June 8, 1929, p. 919, under the title "A Mica-Splitting Process and Equipment," by H. N. Kirk. The method described consists in first grinding the edges of $\frac{1}{4}$-inch to $\frac{1}{8}$-inch mica sheets to a bevel on an emery wheel, soaking the sheets in water and then placing them in perforated steel containers. These are then placed in a steel chamber into which high-pressure steam is introduced. When a pressure of 600 pounds has been attained in the chamber, a valve is opened, and the sudden drop results in separation of the mica sheets into thin films, due to the expansion of the steam forced between the laminæ.

MISCELLANEOUS USES OF MICA, METHODS OF TREATMENT, ETC.

British Patents

No. 10,949, 1905, M. Meirowsky. A process of softening mica sheets by pressing them between plates in a calcining furnace.

No. 12,570, 1908, A. B. C. Rogers. Process for producing mica powder by grinding scrap which has first been saturated with a liquid of antilubricating character, such as a solution of alum. The alum is removed from the ground product by washing, or dried into it, in order to improve its non-flammable character.

No. 8,780, April 12, 1910, W. McLaughlin and J. Houghton. Method of disintegrating mica by stirring it in a liquid, such as magnesium sulphate solution, water, or weak acid or alkali solutions. The mica is then washed and dried, mixed with a binder, moulded into the desired shape and baked at a temperature of 250°-400°F.

No. 8,753, April 7, 1914, P. W. Owens. A puncture-sealing compound consisting of ground mica and water, with or without resin.

No. 156,542, May 27, 1919, F. A. McCarty. Puncture-sealing compound made of powdered mica and cork dust, mixed with water.

No. 155,318, July 5, 1919, H. C. de Whalley. Method of recovering mica and resin from scrap micanite by autoclaving the waste with a solution of ammonia or other alkali. In patent No. 176,117, Nov. 29, 1920, naphtha is substituted for the alkali solution.

No. 225,386, Dec. 5, 1923, E. S. Rowlandson. Puncture-sealing compound made of powdered mica, cork dust, sawdust, and powdered rubber, mixed with water, with or without the addition of glycerine, spirit tragacanth, etc.

No. 238,778, Jan. 27, 1925, F. W. Robinson. Method of rendering mica sheets translucent by abrading their surfaces with a wire brush.

United States Patents

No. 783,438, Feb. 28, 1905, E. G. Kastenhuber. Machine for cutting irregular shapes out of mica plate.

No. 845,450, Feb. 26, 1907, P. Dobler. Method of treating mica to render it more easily ground. The mica is heated at a high temperature in a rotary kiln. After cooling, it is cut into strips and subjected to steam pressure in a closed chamber. It is claimed that this treatment renders the mica soft and greatly facilitates grinding.

No. 885,934, April 28, 1908, F. J. Machalske. Method of making artificial mica by fusing a charge in an electric furnace. Among the ingredients suggested as the charge are sand, bauxite, magnesia, and caustic potash or soda.

No. 888,197, May 19, 1908, E. G. Shepherd. Machine for knife-trimming mica sheets. The device consists of a vertical revolving disk or plate having a heavy rim to act as a fly wheel. The disk is slotted across its diameter to receive a knife blade bolted into place on a slight slant. The disk revolves within a casing provided with a horizontal slit for insertion of the mica sheets. These are laid on a lip or shelf, forming part of the frame of the machine and level with the slit, and are held flat by the operator's fingers and pushed against the knife plate, being turned to successively trim the rough edges. The disk is also provided with fan vanes which eject the waste through a discharge chute in the casing. (Note.—This machine, as described, or in a modified form, has been used in a number of Canadian mica shops for the production of knife-trimmed mica.)

No. 903,949, Nov. 17, 1908. J. P. Beckman. Method of rendering hard, brittle mica soft and flexible by immersion in molten metal.

No. 1,241,539, Oct. 2, 1917, M. Meirowsky. Method of separating packed or adhering mica splittings by means of a revolving screen of a mesh corresponding to the size of the individual flakes.

No. 1,310,939, July 22, 1919, G. J. Bancroft. Method of separating and recovering scrap mica from a rock consisting of feldspar and mica. The run-of-mine rock is ground wet and the product passed through hydraulic classifiers. The coarse and fine products are then tabled on separate Wilfley-type tables, making clean mica and feldspar products. These are then settled and dried.

No. 1,338,393, April 27, 1920, C. J. Patton. The manufacture of a wide variety of articles ranging from boot heels to horse collars, out of sheet or ground mica bonded with rubber, glue, etc.

No. 1,476,102, Dec. 4, 1923, G. W. Pickard and J. Barth. Method of optically testing thin mica films intended for condensers or other articles. By the method described, the thickness of a film and also the presence in it of cracks, holes, thick and thin spots, crystallization imperfections, inclusions and other defects, may be detected. A film is laid on a glass plate set in the path of a beam of upwardly-directed polarized light, the film is observed through a chute or hood of special construction, and its thickness is gauged by the nature of the observed interference colours. A scale giving the various colours characteristic of certain definite thicknesses of mica is used by the operator.

No. 1,595,088, Aug. 10, 1926, F. A. Gudger. Method of drying mica and cleaning it of admixed grit. The grit is removed during the passage of the material over an inclined conveyer belt, being automatically shaken off the belt. The clean mica is dried by passing it through a series of cylinders by means of screw conveyers.

No. 1,695,383, Dec. 18, 1928, L. McCarthy. Method of separating packed and adhering mica splittings and of grading the same according to size and quality. The splittings are placed in a rotary screen drum having openings wide enough to pass the largest flakes. The tumbling in the drum effects the separation of the flakes, which fall to a hopper feeding into a large pipe, through which a current of air is forced. The mica is carried by the air into a vertical, cylindrical chamber or tank whose upper section and top are formed of wire screen of a mesh finer than that of the drum. The pipe enters this tank at its base and projects centrally up within it for a short distance. Above its opening is set a conical baffle. The base of the tank terminates in a funnel leading to a chute through which the large mica flakes fall to a bin. The tank itself is enclosed in a chamber, through the wall of which passes an air pipe connected with a suction fan; this pipe terminates within the chamber in a large funnel, whose mouth is set parallel and adjacent to the upper or screen portion of the tank. In operation, the larger mica flakes blown into the tank, and unable to pass its screen wall, fall out through the opening in its base; the smaller flakes pass through the wall and deposit within the enclosing chamber; while the dust and fine flake mica are drawn out through the suction funnel.

APPENDIX II

MICA SHOPS, MICA GRINDING PLANTS, AND MICA MANUFACTURING PLANTS IN CANADA

MICA SHOPS

The sheet mica produced in Canada is either prepared for market by the mine operator, or is sold in the rough state to a mica dealer. Most of the larger operators are at the same time dealers, and maintain their own trimming and splitting establishments—termed mica "shops"—for the handling of their mine output; they may also buy up in the rough the production of smaller mines. The principal mica shops in Canada are listed below:

Mica Insulator Company,[1] (Head Office, 200 Varick Street, New York). Shops at Victoriaville, St. Agapit, Plessisville, Manseau, and Daveluyville, Que.

Loughborough Mining Company, (Head Office, Sydenham, Ont.: subsidiary of the General Electric Company). Shops at Sorel and St. Raymond, Que.

E. Wallingford, Perkins, Que.

Blackburn Bros., 303 Maisonneuve Street, Hull, Que.

H. T. Flynn, 33 Montcalm Street, Hull, Que.

R. F. McGlashan, 190 Montcalm Street, Hull, Que.

W. C. Cross, 209 Bridge Street, Hull, Que.

Mica Company of Canada, Lois Street, Hull, Que.

J. B. Gauthier, Buckingham, Que.

A. G. Martin, 234 Besserer Street, Ottawa, Ont.

S. O. Fillion, 97 Duke Street, Ottawa, Ont.

Capital Mica Company, 538 MacLaren Street, Ottawa, Ont.

Kent Bros., 114 Gore Street, Kingston, Ont.

Most of the mica handled in the shops of the Mica Company of Canada, Mica Insulator Company, and Loughborough Mining Company, is utilized in the companies' own mica factories. The other names are those of dealers, who either own their own mines or buy up the production of smaller operators, selling trimmed sheet, punched shapes, splittings, and scrap mica to the trade.

MICA GRINDING PLANTS

Few grinding plants have been operated in Canada, owing to the limited domestic consumption of ground mica and the heavy duty (20 per cent ad valorem) on the ground product entering the United States.

The first mill was installed about twenty years ago at Papineauville, Que., by Messrs. O'Brien and Fowler, who later transferred their operations to Ottawa. This plant was dismantled after running for a few years.

[1] This company reports in 1928 that its mica shops in Canada are to be closed down permanently

In 1920, the Mineral Products Company, 246 Montcalm Street, Hull, Que., erected a small mill at Hull, and have run intermittently, producing chiefly roofing mica. Grinding is performed by a KEK hammer mill, with air-lift to screens.

A small mill was built in 1925 at Bancroft, Ont., by the Orser-McKenzie Mica Milling Company (now the Bancroft Mica Company). The mill has been in intermittent operation, grinding scrap mica produced in the district, and making chiefly a roofing grade. The mica is ground in a ball mill, discharging to silk bolters, making 20-, 60-, and 140-mesh products.

A little mica for roofing, artificial stone and stucco purposes has also been produced by Mr. S. Orser, in a small mill at Verona, Ont. The material ground is a coarse biotite rock, occurring on lot 9 of concession X, township of Portland. The plant is a small one and is equipped with jaw crusher, rolls, and screens, making three products, viz., —4 +10 mesh, —10 +16 mesh, and —16 mesh. It is reported that the plant was taken over in 1928 by the Bio-Mica Company, Ltd., 324 North Fifth Avenue, Montreal.

No wet-grinding mica mills have ever been operated in Canada.

MICA MANUFACTURING PLANTS

The only plant in Canada manufacturing mica board, tubes, etc., is that of the Mica Company of Canada, Lois Street, Hull, Que., which has been in operation since 1912. This company also has a factory at Massena, N.Y.

The plant, which employs a maximum of 50 hands, manufactures a full line of mica products, including commutator, moulding and flexible plate, tubes, mica paper and cloth, built-up washers, segments, rings, etc. The laying of the plate is done by hand.

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