CANADA

DEPARTMENT OF MINES

HON. P. E. BLONDIN, MINISTER; R. G. McCONNELL, DEPUTY MINISTER

MINES BRANCH

EUGENE HAANEL, PH.D., DIRECTOR

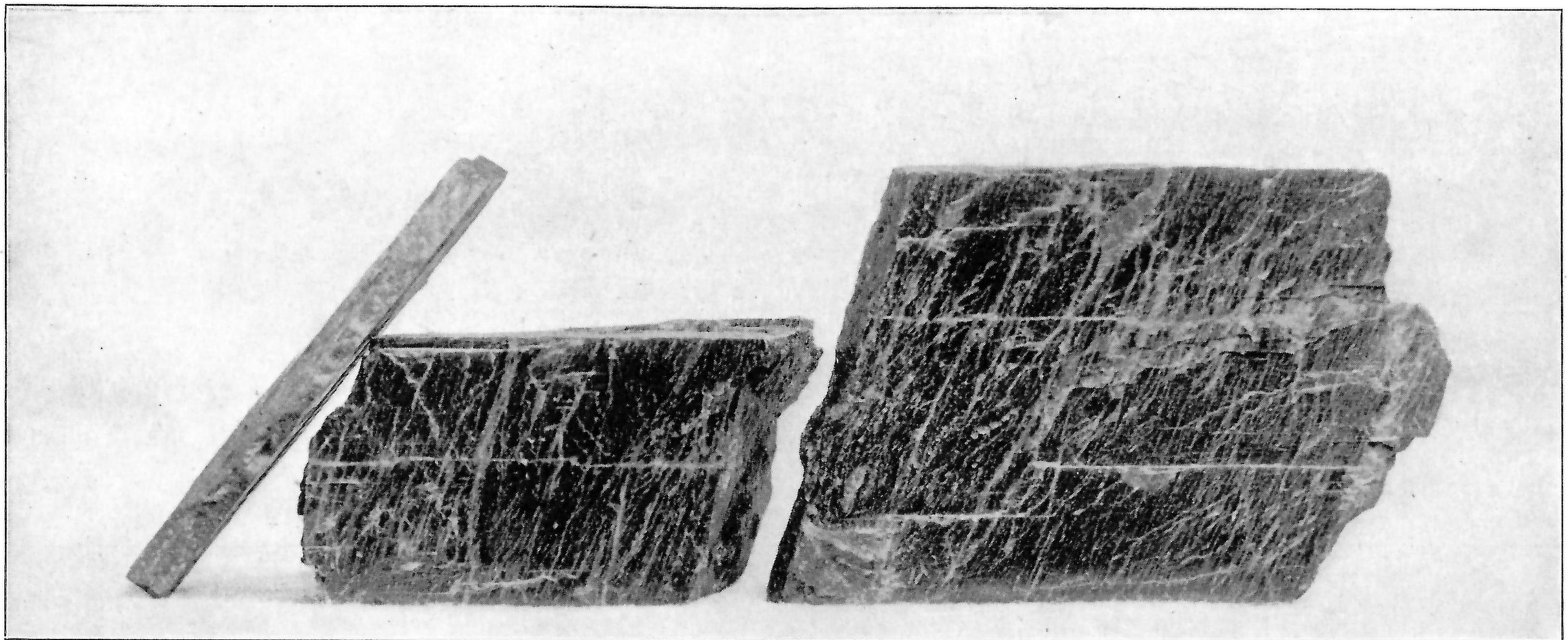
Feldspar in Canada

BY

Hugh S. de Schmid, M.E.

OTTAWA
GOVERNMENT PRINTING BUREAU
1916

No. 401



Cleavage pieces of microcline feldspar of characteristic reddish-brown colour, from quarry of the Kingston Feldspar and Mining Company, Bedford township, Ont.

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LETTER OF TRANSMITTAL

Dr. Eugene Haanel,
Director Mines Branch,
Department of Mines,
Ottawa.

Sir,—

I beg to submit, herewith, my report on the feldspar industry in Canada, together with details relating to the occurrence of economic deposits of the mineral in various parts of the world, and notes on the treatment of feldspar for use in the ceramic and other industries.

I have the honour to be,
Sir,
Your obedient servant,
(*Signed*) **Hugh S. de Schmid.**

Ottawa, February 23, 1916.

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FELDSPAR IN CANADA.

INTRODUCTORY.

Canada possesses practically unlimited feldspar resources, pegmatite dikes being found over an immense area: from Labrador in the east, through the Provinces of Quebec and Ontario, and northward through northeastern Manitoba into the Northwest Territories. Mica-pegmatites are known, also, in the Rocky mountains, throughout a belt stretching from Tête Jaune Cache, on the Grand Trunk Pacific railway, southward to Revelstoke. Practically, the whole of Quebec province north of the St. Lawrence, and the major portion of Ontario, consist of crystalline rocks of a granitic or gneissic type, in which feldspar dikes and stringers are of frequent occurrence.

By far the greater number of these spar bodies, however, are too small to be of any economic importance, and the majority are situated too far from existing railways to be worth exploiting. At the present time, crude feldspar for the ceramic industry (which consumes the greater part of the spar quarried) is worth only in the neighbourhood of $5 per ton laid down at United States potteries, and consequently deposits situated more than a couple of miles from a railway cannot be worked profitably. Even where favourably located close to a rail point, the cost of freight to the New Jersey or Ohio potteries is sufficient to render development of all but the adjacent Ontario deposits a doubtful undertaking. It is to a growing domestic consumption, therefore, that any future development of the Canadian feldspar mining industry must look. The present annual consumption of feldspar for all purposes in Canada, as reported by consumers, is not more than 3,000 tons, of which total less than 400 tons appear on the returns as domestic mineral. As, however, there are in Canada no mills for grinding spar for pottery and other purposes, it is possible that a certain amount of imported mineral is Canadian spar that has been shipped to the United States, there ground, and re-exported. The greater part of the spar quarried in Canada, however, is consigned to American potters, who use the mineral in their own works, so that the quantity of re-imported spar is probably not large.

Recently, two attempts have been made to establish spar grinding plants in Ontario, but up to date neither has proved a success. With a present domestic market of about 3,000 tons, a properly equipped mill centrally situated, and deriving its crude mineral from one of the larger and better grade deposits, should prove a successful undertaking.

As regards the possibility of extracting the potash content of feldspar, the most that can be said at this time, is that several processes have been evolved which are reported to have given satisfactory laboratory results. It still remains questionable, however, whether any of the methods proposed can successfully be employed on a commercial scale at a time of normal prices for potash salts.

In Part I of this report is given a review of the Canadian feldspar mining industry, together with detailed descriptions of the various quarries and occurrences of feldspar in the Dominion. Part II includes chapters on the mineralogical character of the feldspars, occurrence of the mineral in foreign countries, uses and treatment of feldspar, etc.

PART I.

CHAPTER I.

THE CANADIAN FELDSPAR MINING INDUSTRY.

The development of Canadian feldspar deposits dates from about the year 1890, there being a recorded output of 700 tons in that year. With the exception of 1894, there has been a recorded yearly production ever since—although active development did not commence until 1901. Since the latter year the annual output has shown a more or less steady increase, a tonnage of 18,060 tons, in 1914, being the highest recorded.

In the earlier years, most of the spar raised was obtained from the province of Quebec: the chief deposits being situated in Templeton and Hull townships, within a few miles of the city of Ottawa. In 1900, however, development work was commenced on several large spar bodies in the neighbourhood of Bedford and Verona, Ontario, near the line of the Kingston and Pembroke railway; and these deposits, being situated considerably nearer to the American potteries (to which practically the whole of the Canadian production is consigned), soon caused the Quebec quarries to be closed down. In recent years, only one mica-feldspar quarry has been operated in Quebec province: the Villeneuve property in Ottawa county being worked for a few weeks each year for high-grade white microcline (dental spar). The present rail freight cost of Templeton and Hull feldspar to eastern United States points is in the neighbourhood of $4 per ton while the selling price is only $5–$5.50 per ton delivered, so that there is little inducement to work these quarries.

Attention has been drawn from time to time since 1885 to a large body of feldspar on the Gulf of St. Lawrence, at Manikuagan bay. A small part of the spar body has been stripped; but no mining has been attempted, although the deposit, being situated on tide-water, is admirably located for quarrying.

Practically, the whole of the present Canadian production is the output of two or three quarries in the Verona district, Ont., worked by the Kingston Feldspar and Mining Co., the principal deposit being that on lot 1, concession II, of the township of Bedford (see p. 12).

The spar bodies of the Verona district yield a high grade of mineral, the dikes consisting essentially of feldspar and quartz, with practically no mica and but little in the shape of accessory iron-bearing minerals such as tourmaline, hornblende, pyrites, garnet, etc. The quartz is usually confined to zones in the dike mass, and in the larger bodies the quartz ledges or bosses can often be left standing until the surrounding spar has been extracted, and may then be quarried separately for shipment to smelters. A certain amount of quartz is frequently present also in graphic-granitic intergrowth with the feldspar, but such intergrown mineral is seldom present in sufficient quantity to necessitate much hand sorting. In the matter of purity and suitability for ceramic purposes the run-of-mine spar of the Verona quarries is probably unrivalled, quite a large proportion of the output of the Kingston Feldspar and Mining Company's main quarry needing no sorting at all.

It is a matter of regret that no mill for grinding feldspar has as yet been erected in Canada, domestic potters, glazers and enamellers having to import the ground mineral from the United States. The most serious attempt so far made to install a grinding plant is that of Dominion Feldspar, Limited, who recently erected a small mill near Parham, Ont. This plant, however, is not equipped with the necessary machines for producing a grade of spar suitable for ceramic and enamelling purposes; a Maxecon ring-roll mill being employed for grinding. The output to date has consisted principally of poultry grit and artificial stone grades. The present consumption of ground spar in eastern Canada—about 3,000 tons annually—should warrant the erection of a mill to grind domestic mineral.

In the event of a satisfactory process being evolved for the production of potash from feldspar, on a commercial scale, there are a number of spar deposits in Canada which, though yielding a grade of mineral unsuitable for ceramic purposes, or, through being situated too far away from a railway to be worked for export pottery spar, yet contain large quantities of spar suitable for domestic potash extraction. Several of such spar bodies are situated close to undeveloped waterpowers, from which power might be drawn for electric furnaces.

In the following table are shown the annual production and exports of feldspar from 1890 to 1914:—

TABLE I.

Tonnage and Value of Canadian Feldspar Production and Exports from 1890 to 1914.

Calendar year	Production		Exports	
	Tons	Value	Tons	Value
1890	700	3,500	......	......
1891	685	3,425	......	......
1892	175	525	......	......
1893	575	4,525	50	500
1894	nil.	nil.	nil.	nil.
1895	......	*2,545	......	2,545
1896	972	*2,583	972	2,583
1897	1,400	3,290	3,078	5,637
1898	2,500	6,250	1,542	4,396
1899	3,000	6,000	1,757	5,126
1900	318	1,112	379	1,116
1901	5,350	10,700	4,367	10,973
1902	7,560	15,152	7,374	13,708
1903	13,928	18,966	13,760	23,319
1904	11,083	22,166	13,960	29,263
1905	11,700	23,400	9,161	27,660
1906	16,948	40,890	18,183	60,312
1907	12,584	29,819	12,068	37,932
1908	7,877	21,099	9,524	34,045
1909	12,783	40,383	10,834	35,234
1910	15,809	47,667	15,601	47,962
1911	17,723	51,939	16,150	56,085
1912	13,733	30,916	12,779	44,114
1913	16,790	60,795	15,966	62,767
1914	18,790	70,824	18,072	74,100

* Exports.

The output of the Ontario and Quebec quarries respectively, as given in the Annual Reports of the Ontario and Quebec Mines Bureaus, are shown separately on pages 11 and 30.

FELDSPAR GRINDING PLANTS.

Mill of Dominion Feldspar, Ltd., at Parham, Ont.

A small two storey mill was erected on the line of the Kingston and Pembroke railway, near Parham, Ont., in 1911, by the Suroff Feldspar Mining and Milling Co., who proposed to grind the spar from a deposit on Bobs lake, in the township of Bedford. The name of the above company has since been changed to Dominion Feldspar, Limited.

This mill is not equipped with the proper machinery for grinding feldspar for pottery or enamel purposes, and the class of goods turned out has been chiefly of the poultry and roofing grit grades. The crude, lump spar, is handpicked on the ground floor, and is fed to a jaw crusher, from which it falls to an elevator boot, and is raised to the top floor. Here the mineral passes over two Newaygo screens, set to 80 mesh. The oversize is fed by a spiral conveyer to a Maxecon, 3-roll mill, the product being then again elevated to the screens, and the oversize returned to the mill. The plant is run by a 125-H.P. Corliss engine. The capacity is about 3 tons per hour, of 80-100 mesh product. The plant has been run only intermittently since its erection.

The spar from the Company's deposit is not of a particularly high grade, there being much quartz present. In addition, the transportation of rock to mill involves a barge haul of several miles from the mine to Fish creek, where it is loaded onto wagons, and hauled another two miles to the mill.

Mill of Standard Feldspar and Silica Mining Co., at Gordon Bay, Ont.

A commencement was made in 1912 at erecting a spar-grinding plant on lot 5, concession VIII, township of Conger, Parry Sound district. One 100-H. P. horizontal boiler, a rotary crusher and a pebble mill were placed on the property, and a small camp was erected. Nothing further appears to have been done, however, and no spar has been ground.

The plant was designed to treat spar from a series of outcrops on the above lot (see p. 23). The mineral, however, is much mixed with quartz and black mica, and is hardly suitable for ceramic purposes.

The property lies beside the Parry Sound-Toronto tracks on the Canadian Pacific railway.

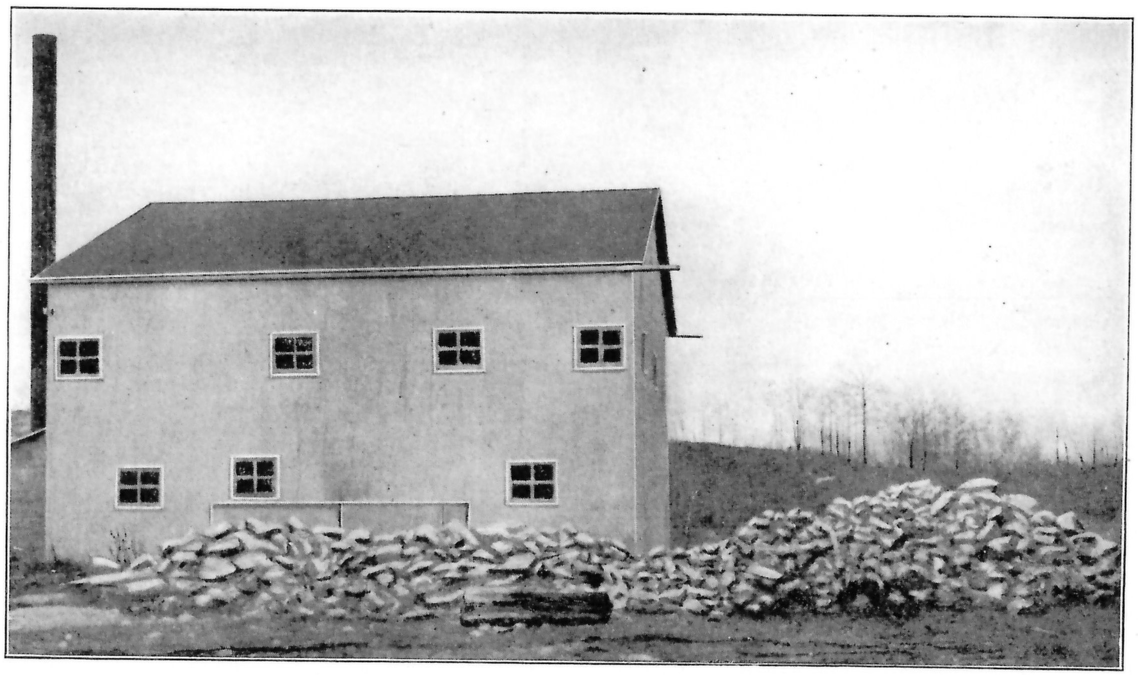
CONSUMING CENTRES.

The following are the present chief consuming centres in Canada for feldspar, the annual consumption of the various grades used being also given:—

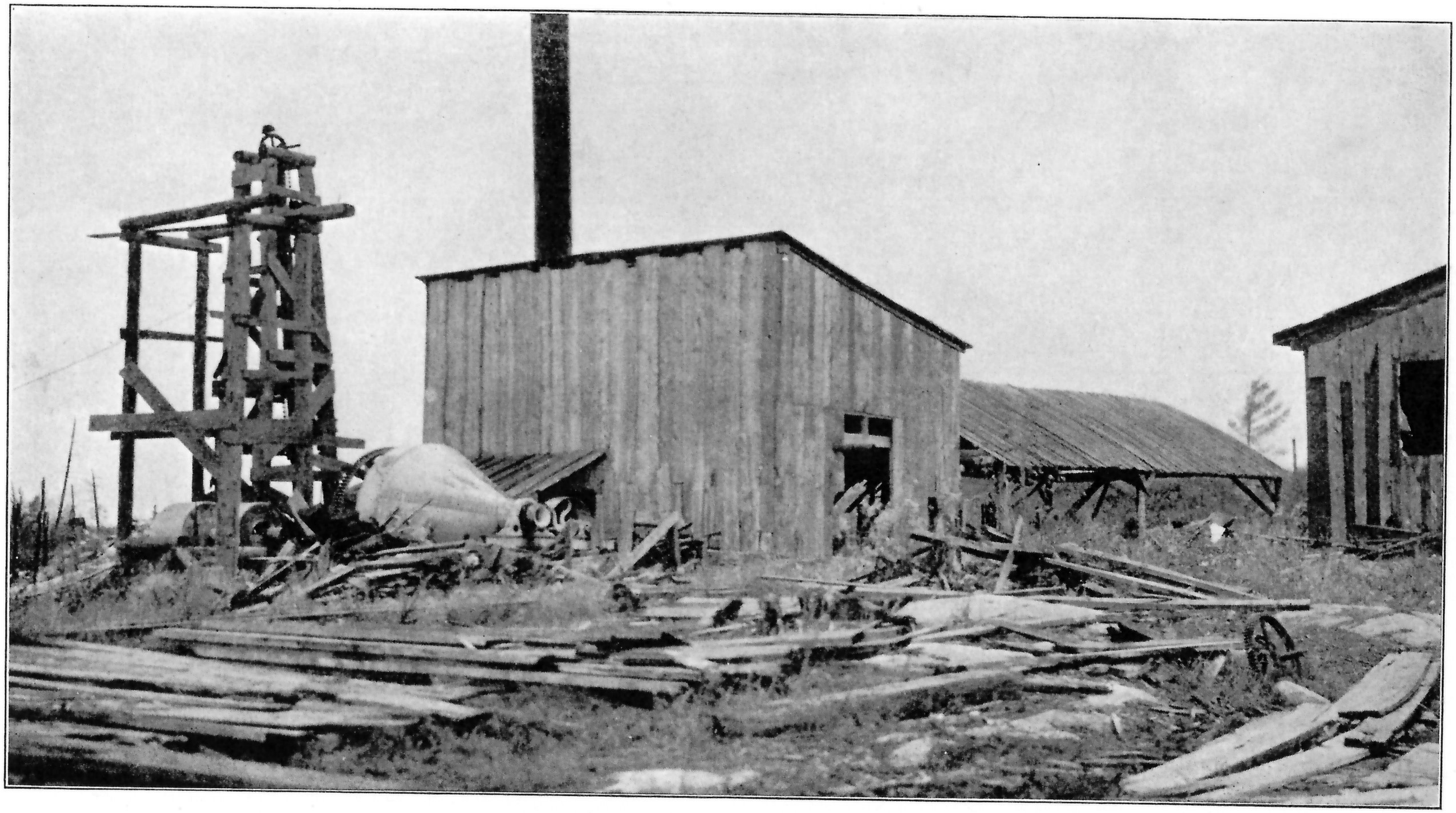
Province	Works at	Grades of feldspar		
		Pottery and enamel ware	Abrasive wheels	Roofing and artificial stone
		tons	tons	tons
Quebec................	St. John's.....			
"	Montreal.....	1,150	......	......
Ontario...............	Toronto......			
"	Port Hope....			
"	London.......	730	40	590
"	Brantford.....			
"	Hamilton.....			
Nova Scotia...........	Amherst......	90	......	......
Total.................		1,970	40	590

In map Fig. 1 is shown the position of the principal feldspar deposits in Canada and the United States, in relation to the consuming centres in the two countries.

Plate II.



Mill of Dominion Feldspar, Ltd., Parham, Ont.



Trial grinding plant of Standard Feldspar and Silica Mining Company, Gordon Bay, Ont.

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CHAPTER II.

THE CANADIAN FELDSPAR DEPOSITS.

The geologic features of the Canadian feldspar bodies are described in detail on the following pages, under the headings of the different quarries, hence it is hardly necessary to more than state briefly the main features observed. The mode of occurrence and general nature of granite-pegmatite bodies are very similar the world over, and the Canadian dikes call for little in the way of special description.

Age.

The age of the Canadian pegmatites is Pre-Cambrian, there being no recorded instance of dikes intruding the Palæozoic sediments. It is, however, probable that the intrusions were not all strictly contemporaneous, but extended throughout the cooling period of the granite-gneiss that forms the basal series in eastern Canada. This is evidenced by the somewhat conspicuous diversity of composition and structure exhibited by the dikes.

There is no evidence to show that the pegmatites are connected with distinct granitic intrusions into the gneisses which are now found enclosing them, and it seems probable that they represent effluxes of attenuated magmatic material from the same source as the enclosing granite-gneisses: that is, that during the period of consolidation of the batholithic granite that is now represented by the granite-gneisses of the Laurentian system, a more or less continuous process of effusion of residual, acidic magma took place along the cracks and fissures formed during cooling. The pegmatites and feldspar stringers may thus be considered to have originated by a sort of cementation process, and their material to consist of the still hot viscous magma that welled up along shrinking and dislocation channels in the cooling, upper portions of the batholite.

Types of Deposits.

The greater part of the feldspar quarried in Canada has not been derived from pegmatites of the ordinary "giant-granite" type; such pegmatites may, indeed, be said to be relatively uncommon, compared with the aplitic dikes that are so widely distributed throughout the granite-gneiss area of Ontario and Quebec. Most of the mica-pegmatites so far exploited for their mica content are situated at too great a distance from a railway to permit of their being worked for spar.

The economic feldspar bodies may, then, be divided into two quite distinct types, the normal mica-pegmatites, or "giant-granites," and the aplites, the latter being the most important on account of their comparative freedom from minerals deleterious to the quality of the feldspar. In addition to these two types, there is a third class of spar body, which, though not hitherto exploited, might possibly be drawn on for the mineral. This is the irregular stringers of purple-brown microcline-quartz-sphene rock which are frequently found throughout the mica-apatite region, both in Ontario and Quebec provinces. These stringers seldom attain workable size, however, and for immediate, practical purposes, this class of rock may, probably, be left out of consideration. The frequent presence of appreciable amounts of sphene in this rock, also, would probably preclude its employment for ceramic purposes, the quartz content, in addition, generally being considerable.

The aplite dikes of the Kingston district, Ontario, constitute the chief source of supply of Canadian feldspar at the present time. These dikes, or belts, yield a microcline ranging in colour from brick-red to pinkish-white, the predominant shade being a buff. The spar is mixed with quartz, which either forms ledges or irregular bosses and stringers throughout the dike-mass, or, along the contacts with the country rock more especially, occurs in graphic-granitic intergrowth with the spar. Iron pyrites may occur, but is seldom present in appreciable amount, and is generally confined to segregated masses in the quartz. Tourmaline is seldom present in quantity, and garnet is completely absent. Hornblende may be present, but is almost always confined to the immediate contact of the dike with the country rock. Biotite is absent in the spar bodies of the Kingston district, but effectually spoils the quality of the spar at the quarries in the Parry Sound region, where it occurs throughout the dikes, on seams and crevices.

These spar bodies are, with one exception, narrow, a width of 50 feet being the maximum. At the Richardson quarry, however, the dike worked is 150 feet wide, and this width persists to 100 feet, which is the present depth of the pit.

The country rock throughout the Ontario and Quebec spar-bearing areas is of essentially similar character—a reddish biotite-granite gneiss—which, near the dike contacts, commonly assumes a darker colour and a more compact texture, due to recrystallization.

Analyses of Canadian Feldspars.

The following analyses of representative samples of feldspar from various Canadian deposits are given separately under the respective headings of the particular quarries, but are tabulated for comparative purposes. All the analyses were conducted by N. L. Turner, of the Mines Branch, Department of Mines, in 1914:—

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
SiO_2	65·07	64·54	64·42	64·78	64·74	64·60
Al_2O_3	18·20	18·81	18·26	18·05	18·11	18·23
Fe_2O_3	0·08	0·08	0·05	0·46	0·53	0·60
FeO	0·06	0·06	0·03	0·03	0·09	0·03
MgO	0·02	0·02	0·01	0·02	0·02	0·02
CaO	0·72	0·57	0·18	0·40	0·20	0·30
Na_2O	2·83	2·68	3·07	2·72	2·72	2·82
K_2O	13·46	13·67	14·16	13·80	13·80	13·60
H_2O	0·10	0·10	0·10	0·12	0·10	0·08
TiO_2	trace	trace	trace	trace	trace	trace
MnO	trace	trace	trace	trace	trace	trace
SrO	....	....	....	....	....	....
BaO	trace	trace	trace	0·01	trace	0·02
CO_2	nil	nil	nil	nil	nil	nil
	100·54	100·53	100·28	100·39	100·31	100·33

No. 1. O'Brien mine, lot 21, range VI, West Portland township, Ottawa county, Que.
No. 2. Villeneuve mine, lot 31, range I, Villeneuve township, Ottawa county, Que., (microcline).
No. 3. Leduc mine, E ½ lot 25, range VII, Wakefield township, Ottawa county, Que., (amazonite).
No. 4. Canadian Feldspar Co.'s mine, Manikuagan bay, Saguenay county, Que.
No. 5. Leduc mine, E ½ lot 25, range VII, Wakefield township, Ottawa county, Que., (microcline).
No. 6. Pearson mine, lot 13, range XII, Buckingham township, Ottawa county, Que.

	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13
SiO_2	64·90	65·65	63·40	64·50	64·32	64·44	65·42
Al_2O_3	18·49	21·65	21·66	18·75	17·78	17·63	18·54
Fe_2O_3	0·60	0·46	0·63	0·60	0·91	0·74	0·23
FeO	0·03	0·03	0·07	0·03	0·06	0·03	0·01
MgO	0·18	0·18	0·02	0·03	0·02	0·02	0·24
CaO	1·73	1·20	3·85	0·50	0·36	0·40	0·48
Na_2O	3·02	9·87	9·41	3·57	3·23	3·31	2·91
K_2O	10·44	1·08	1·09	12·18	13·37	13·39	12·58
H_2O	0·08	0·08	0·10	0·12	0·12	0·12	0·12
TiO_2	trace	trace	trace	trace	trace	trace	trace
MnO	trace	trace	trace	trace	trace	trace	trace
SrO	0·03	....	0·09	....	....	....	....
BaO	0·29	trace	trace	0·01	0·03	0·02	....
CO_2	0·65	nil	nil	nil	nil	nil	0·01
	100·43	100·20	100·32	100·29	100·20	100·10	100·54

No. 7. Silver Queen or Smith mine, E ½ of lot 13, concession V, North Burgess township, Lanark county, Ont.
No. 8. Villeneuve mine, lot 31, range I, Villeneuve township, Ottawa county, Que., (albite, var. peristerite).
No. 9. Lac Pied des Monts mine, Lac Pied des Monts, Saguenay county, Que., (albite).
No. 10. Lac Pied des Monts mine, Lac Pied des Monts, Saguenay county, Que., (microcline).
No. 11. Gamey mine, lot 5, concession XIII, Portland township, Frontenac county, Ont.
No. 12. Richardson mine, lot 1, concession II, Bedford township, Frontenac county, Ont.
No. 13. Range VII, lot 10, Bouchette township, Ottawa county, Que.

In the following pages are described the various spar bodies which have been worked at various times in the provinces of Ontario and Quebec.

PROVINCE OF ONTARIO.

With one or two notable exceptions, the feldspar dikes hitherto discovered in the Kingston district of Eastern Ontario are of relatively small size. That this should be so is to be expected from the nature of such bodies, which probably represent expressions of residual acid magma that has been squeezed into cracks or fissures in the enclosing gneissic rock. They may be described, in other words, as the cement filling of fissures, rather than as true pegmatite dikes intruded into the country rock. Such fissures are seldom of great width, or continuous longitudinal extent, and, consequently, the feldspar deposits, for the most part, are of small size. Although consisting principally of microcline feldspar, the dikes often carry various accessory minerals, such as tourmaline, pyrites, chloritic or micaceous mineral substance—all of which may be found throughout the entire width of the spar bodies—and hornblende, which latter mineral is usually confined to the more or less immediate contact of the dikes with the enclosing gneiss. All these minerals are common accessory constituents of the feldspar dikes, and are present in varying amount, sometimes existing (especially in the smaller deposits) in such quantity as to render the spar worthless. Black mica, or biotite, is another mineral which occurs in certain of the deposits, and was noticed more particularly in the dikes of the Parry Sound district. In the latter region, also, allanite—often in large crystals—is a common mineral species in certain of the deposits. The remaining mineral, found often in large amounts in the dikes, is quartz. This occurs both in graphic-granitic intergrowth with the spar, and in the form of benches, splashes, or stringers in the mass of the dike body; in the large deposits, a boss or sheet of quartz is often found occupying the central portion of the dike. When occurring in large aggregations, so that it can be easily extracted in a clean state and free from admixture with spar, the quartz is saved as a by-product and shipped to smelting works. The majority of spar mines ship greater or lesser amounts of quartz, the usual destination being Welland, Ont.

Although impaired in some instances by the presence of the deleterious minerals noted above, the quality of the feldspar found in the dikes of the Kingston area is, on the whole, high, and the mineral can often be secured in a very clean and pure state, requiring little cobbing or handpicking. Up to the present, practically the entire production has been marketed in the United States, the shipments comprising only the best and purest mineral adapted to pottery purposes. All spar of inferior grade is discarded and goes to the waste dumps, there being no plant in Canada for handling such material and grinding it for roofing purposes, poultry grit, etc.

The following table shows the annual production of feldspar in Ontario since 1900—the year of the commencement of the mining industry:—

TABLE II.

Production of Feldspar in the Province of Ontario, since the commencement of mining.[1]

Year	Amount	Value	Employees	Wages
	tons	$		$
1900	4,000	5,000	25	3,900
1901	5,100	6,375	25	6,750
1902	8,776	12,875	66	10,250
1903	15,296	20,046	51	14,089
1904	10,983	21,966	34	16,300
1905	12,234	29,968	52	19,200
1906	20,773	43,849	89	40,807
1907	12,328	30,375	71	23,359
1908	7,875	20,300	35	15,631
1909	11,001	36,204	53	14,858
1910	16,374	47,518	107	32,901
1911	17,697	51,610	76	26,580
1912	13,633	28,916	60	21,257
1913	18,615	67,142	78	33,317
1914	18,062	55,686	......	......

[1] Figures based upon reports issued by the Ontario Bureau of Mines. The quantities and values given here, and in Table III, do not compare with the totals shown in Table I these latter figures being calculated upon an entirely different basis.

Carleton County.

TOWNSHIP OF HUNTLEY.

Concession II, lot 21. A small deposit of grey-brown spar exists on this lot, and was worked in a small way some fifteen years ago. The mining rights are held by Charles Humphreys, of Carp. The material consists of grey perthite in large crystals, and mixed with quartz. Where quarried, the dike widens out into a small boss 30 feet across, which narrows within a distance of 30 feet from the pits to a small stringer of insignificant width. Seams of quartz traverse the spar body and would probably necessitate handpicking of the greater part of the output. No other accessory minerals were noticed, and the feldspar, what there is of it, is of good quality.

Probably only a small tonnage could be obtained at this spot, surface showings indicating only a few hundred tons within a reasonable depth.

The deposit lies one mile distant from Carp station, on the Grand Trunk railway, Parry Sound line, and close to the main road.

The spar taken from this deposit is understood to have been shipped to a pottery works in Ottawa.

Frontenac County.

TOWNSHIP OF BEDFORD.

Concession II, lot 1. Richardson quarry; known also as the Hoppins or Desert Lake property. This quarry, which is the largest producer of feldspar in Canada, lies seven miles by road from Bedford station on the Kingston and Pembroke section of the Canadian Pacific railway, and near the western arm of Desert lake. The owners and operators are Messrs. Richardson and Sons, of Kingston, Ont., who mine under the name of the Kingston Feldspar and Mining Company.

The quarry has been in constant operation since 1901, when the initial development of the property was commenced by Messrs. Richardson and Smith, of Kingston, under lease from the owner, Mr. A. Hoppins. During the first three months of mining over 4,000 tons of spar were shipped to Trenton, N. J., and the annual output since has averaged some 10,000 tons.

The average number of men employed is 45, the number varying according to the amount of spar required by the contracts.

There is a large camp, including boarding house, sleeping quarters, office, etc. The equipment includes two boilers—one 40 H.P., and one 25 H.P.—two 2-inch cable hoists strung across the pit, and a number of derricks and steam drills. A No. 10 Cameron pump is installed in an 18-foot sump at the southwest end of the pit, and is found sufficient to keep the water down. The hoist house and other buildings are located on the northwest of the quarry. This side falls perpendicularly to the bottom of the pit, while the opposite bank shelves more gently for a considerable portion of its depth.[1]

The mineral is raised from the pit in buckets or hoist trays of 2-tons capacity, by means of cable hoists, and is dumped into small cars holding 4 tons, which run on an inclined tramway to Thirteen Island lake, some quarter mile distant. Here the cars are run on board scows, which are ferried across the lake by a small tug. On the farther side, the cars are run off the scows and across a narrow neck of land to Thirty Island lake where they are again loaded onto scows and taken across to the landing at Glendower. Here the mineral is put on board flat cars and taken by rail on a spur line to Bedford station on the Kingston branch of the Canadian Pacific railway, whence it proceeds to Kingston. From here it is shipped across Lake Ontario to Oswego or Sodus point, and proceeds by rail to the pottery centres in New Jersey, Ohio, or New York.

All the mineral produced is shipped in the crude state, and is at present consigned principally to Messrs. Worth, at Charlotte, N.Y.

[1] Since the above was written, a new inclined skipway has been erected at the northeast end of the quarry, and the arrangement of the cable hoists changed. A 60-h.p. boiler, also, has been installed.—(H. S. de S.)

PLATE IV.

Quarry of Kingston Feldspar and Mining Company, Bedford township, Ont.

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[1]Analy

A considerable amount of quartz is met with in the quarry, and a quantity is shipped to the Electro-Metals works at Welland, Ontario, to be used in the manufacture of ferro-silicon. The last large shipment of quartz was made in 1909, when 6,000 tons were produced.

The feldspar is microcline of a red or brownish colour, cleaves readily in two directions, and comes from the mine usually in more or less rhombic fragments or masses. With the exception of a large boss of quartz carrying magnetite and pyrite in small quantities, which occurs in the centre of the dike mass, and of isolated hornblende crystals found principally scattered through the spar adjacent to the contacts of the dike with the country gneiss, few impurities are present in the deposit. The run-of-mine is, consequently, taken out in a remarkably clean state, and requires little if any handpicking. Three analyses of feldspar from this property are appended, and the figures may be taken as representing the average composition of the mineral from any of the red feldspar belts of this district, the deposits being all more or less identical in character and composition.

Analyses of Feldspars.

	A	B	C	D
Silica	66·23	65·40	65·87	64·7
Alumina	18·77	18·80	19·10	18·4
Potash	12·09	13·90	12·24	16·9
Soda	3·11	1·95	2·56	....
Lime	0·31	nil	0·20	....
Water	nil	nil	0·64	..
	100·51	100·05	100·61	100·0

A. Analysis by J. B. Cochrane, Royal Military College, Kingston.
B. Analysis by Heinrich Ries, Ph.D., of Cornell University.
C. Analysis by George Steiger, United States Geological Survey.
D. Theoretical composition of pure orthoclase.

NOTE:—The following analysis of a picked sample of dark red feldspar from this quarry was made after the above was written, and is given as being more complete than the preceding ones, especially as regards the iron content:—[1]

SiO_2	64·44%
Al_2O_3	17·63
Fe_2O_3	0·74
FeO	0·03
MgO	0·02
CaO	0·40
Na_2O	3·31
K_2O	13·39
H_2O	0·12
BaO	0·02
	100·10

[1]Analysis by N. L. Turner, Mines Branch, Department of Mines, 1914.

The above analysis would indicate almost the highest percentage of iron usually considered permissible by potters in the best grades of feldspar.

The workings originally consisted of two pits, opened on either side of the central quartz boss. These two openings were later run into one another, and the present workings consist of one large open pit or quarry. This excavation measures 450 feet in length, is 150 feet wide, and 105 feet deep, at its deepest or southwest end. The boss or pillar of quartz occupies the central portion of the opening, the spar being taken out on all sides of it by means of open cutting and drifts.

The deposit consists of a belt 150 feet in width, and shows well defined contacts with the enclosing black biotite-gneiss. The spar body is capped on the northwest side of the pit by a heavy roof of gneiss, 12 to 20 feet thick. The strike of the belt is NE-SW., and the dip NW. The enclosing gneiss appears to have suffered a certain degree of alteration by the intrusion, being darker in colour along the contact than the prevailing country rock, and containing much secondary biotite, in small scales.

Small zones of a brownish-green soda feldspar sometimes occur in the mass of the microcline, and appear to be developed especially in those parts of the dike adjacent to the contact with the gneiss, and in association with hornblende crystals. These latter are frequently of a bluish colour, being partly altered to a powdery or clayey substance—a change due, probably, to decomposition of the iron sulphide which usually is present either in the crystals themselves or in the spar immediately surrounding them.

The price offered at the United States potteries for the feldspar produced at this and other quarries in the district is about $5.50 per ton, f.o.b. mills, for the crude mineral.

The output of the quarry when worked at its full capacity averages about 100 tons per diem.[1]

Concession III, lot 3, Jenkins or Harris mine. This property was opened in 1902 by Mr. Charles Jenkins, of Petrolia, Ont., who is the present owner. The quarry lies about 5 miles east of Bedford station, and about one mile northeast of the Richardson mine. An average of half a dozen men were employed by Mr. Jenkins for 3 years, and about 1,500 tons of spar were shipped to Trenton, N. J., and East Liverpool, Ohio. The quarry has been closed down since 1905.

The workings comprise two open pits. One of these is situated alongside the road leading north from the Richardson property, and measures 80 × 40 feet, and 15 feet in depth. This opening exhibits a pinkish spar much mixed with quartz, and containing local inclusions of magnetite. The strike of the dike is N. 70°E, and the dip, approximately, vertical. The second pit measures 130 × 45 feet, and is 27 feet deep. This opening

[1] Geol. Surv. Can., XIV, Ann. Rep., 1901, p. 183 A. Ont. Bur. Min., X, p. 26; XI, pp. 39, 88, 295; XII, p. 136; XIII, p. 90; XIV, p. 81; XV, pp. 40, 99; XVI, p. 85; XVII, p. 89; XVIII, p. 137; XIX, p. 127; XX, pp. 43, 107.

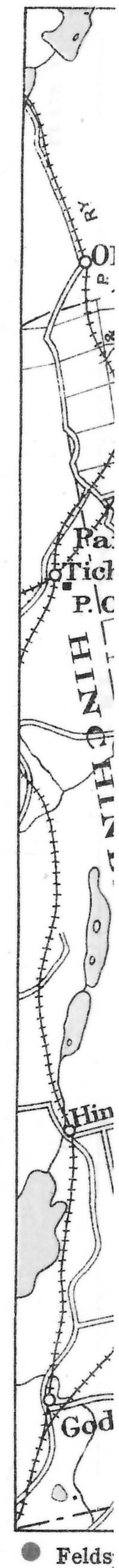
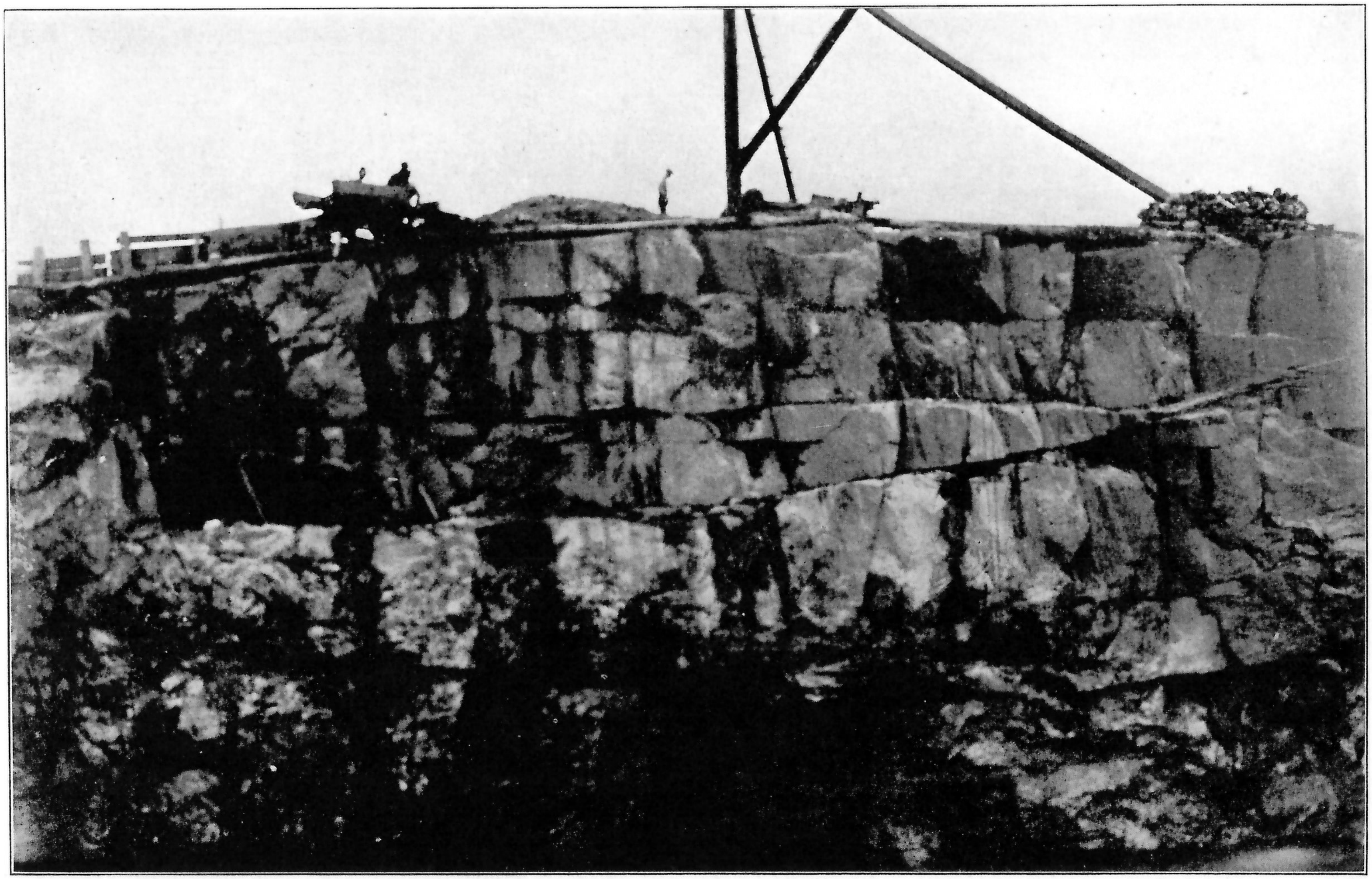


PLATE V.



Granite-gneiss capping over feldspar dike at quarry of Kingston Feldspar and Mining Company, Bedford township, Ont.

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lies a few hundred feet back from the road, and south of the smaller pit. The deposit is similar to the first named, except that rather less quartz is present.

There are no buildings or machinery on the property.

Ont. Bur. Min., XII, 138; XIII, 90; XIV, 82; XV, 101.

Concession III, lot 32. Owned by Mr. J. M. Stoness, of Perth Road, who has had three men engaged in prospecting the property for a couple of months. A few small surface pits have been opened, all of which display a similar type of rock. The deposit is of the usual pink, microcline class, having a direction of N. 60°E, and possessing a graphic-granitic character and structure. The country rock is a dark coloured gneiss or schist, and a considerable amount of biotite mica is present in the dike, on and adjacent to the northwest contact with the enclosing rock. The same mineral is frequently met with on joints and seams in the mass of the dike, and constitutes a deleterious constituent necessitating careful cobbing of the feldspar before the latter can be utilized for pottery purposes.

The width and extent of the spar body have not been ascertained, but the mineral has been found over a considerable area. It occurs in the form of more or less parallel ridges or "hogsbacks," which rise some 50 feet above the level of the intervening swamp land, the width of the largest ridge being about 100 feet and its length 500 feet. These ridges seem to constitute a series of parallel dikes of feldspar, and are separated by narrow belts of dark schist.

The new main line of the Canadian Pacific railway passes directly over part of the deposit.

Concession IV, lot 5. A deposit of feldspar is reported to have been worked during 1904 by Mr. A. Chisholm. Work was discontinued after a few weeks, and about 300 tons of spar are reported to have been taken out.

Ont. Bur. Min., XIV, p. 83.

Concession V, lot 28. Owned by Dominion Feldspars, Limited, of Toronto, (originally the Suroff Feldspar Mining and Milling Company), who have opened up a deposit of pink-white feldspar on the west side of Green bay, Bobs lake.

The amount of work so far done is small, and only a few men have been employed for a couple of months.

The deposit lies directly on the shore of the lake, and the mineral is loaded into scows, which are towed by a small gasoline boat down the lake to Fish creek. There, the spar is loaded onto wagons, and hauled a distance of 2 miles to Drafton siding, on the Kingston and Pembroke line of the Canadian Pacific railway. A mill has been erected by the Company at this point, and it is proposed to turn out different grades of ground spar.

The mineral body consists of a spar belt or dike having an almost due north and south direction, and dipping some 50° west. The enclosing rock is a black mica-schist, possessing a similar strike, but dipping 45° to the east. The dike mass is composed of pinkish-white microcline, containing large zones and stringers of quartz distributed through it; graphic-granitic intergrowth of spar and quartz is common along the contacts. A grey or yellowish, micaceous mineral—possibly gilbertite—occurs in some quantity on seams and joints in the dike.

Only one opening has been made on the property, this being a small open pit 50 × 30 feet, and 15 feet deep, sunk on the shore of the lake, the spar and quartz being run in barrows to the scows. A camp for 10 men has been erected, and a small 30 H.P. horizontal boiler supplies steam for one steam drill.

Although said to be of considerable extent, this spar body does not yield a very high grade of mineral, there being too much quartz intimately mixed with the spar to allow of a clean product being obtained without considerable handpicking. The road haul from the lake landing to the mill is an additional item, and costs about 60c per ton.

An analysis of clean, picked spar, from this deposit, as supplied by the manager, showed:—

Silica	64·0
Alumina	21·0
Potash	13·8
Soda	1·8
	100·6

TOWNSHIP OF LOUGHBOROUGH.

Concession XII, lots 1 and 2. Known as the Freeman quarry, and situated directly south of Fourteen Island lake and about 9 miles by road from Verona station. The distance by winter road from the latter place, however, does not much exceed 4 miles. Part of the workings lie on lot 1 of the XIIIth concession in the adjoining township of Portland.

The property was worked in 1902 and 1903 by the Pennsylvania Feldspar Company, of Toughkenamon, Pa., who employed a dozen men and installed a steam plant, comprising hoist and drills. No further work has been performed since 1903.

Most of the work done consisted of surface stripping; a couple of shallow pits, also, were sunk at the foot of a small ridge of pink spar mixed intimately with quartz. Several hundred tons of the mineral extracted are still lying at the pits, and the stock piles exhibit a fairly clean grade of spar. A considerable amount of black biotite mica occurs through the dike mass, and the presence of this mineral necessitates careful cobbing of the run-of-mine.

The buildings are still in good repair, and much of the machinery used still remains on the property.

Ont. Bur. Min., XII, 138.

Concession XII, lot 5. Reynolds or Fourteen Island lake quarry. Situated on the east side of Mud lake. The deposit is owned and operated by the Kingston Feldspar and Mining Company, of Kingston, Ont. Work has been carried on intermittently during the last ten years, but the greatest development of the spar body took place during 1913 and 1914. It is reported that about 8,000 tons of spar have been taken from the deposit up to date.

There is only one opening—an open cut about 200 feet long, and 35–40 feet wide. This follows a NE-SW spar dike, carrying both pink and white microcline, in which occur large masses of quartz. The pit has reached a depth of 25 feet at the southwest end, while at the northeast end it has been sunk to 50 feet, this latter opening being about 50 feet square.

There is a small camp on the property, and hoisting is done by means of a steam derrick driven by a small portable boiler. The average force of men employed in the past few years has been 25. Shipping is carried on in winter over the lake to Verona station. The quarry is reached by a mine road of 1½ miles from the Sydenham-Bedford road.

TOWNSHIP OF OSO.

Concession V, lot 10. Messrs. Mills and Cunningham, of Kingston, carried out stripping operations here in 1905, and uncovered a body of spar. No further development of the property appears to have been undertaken.

Ont. Bur. Min., XIV, p. 83.

TOWNSHIP OF PORTLAND.

Concession X, lot 1. Walker quarry, situated one mile north of Holleford village, and about 5 miles from Verona, the nearest shipping point. The only work conducted on this property was carried out in 1902 by the Pennsylvania Feldspar Company, of Toughkenamon, Pa. A pit has been opened close to the main, north concession road, and measures about 50 feet across, and 10 feet deep. A little surface stripping has also been done in the vicinity of this opening. The pit discloses a red, lustrous spar, possessing a high degree of cleavage, and permeated by stringers and zones of quartz. The deposit appears to possess a northeasterly trend, and has been uncovered for a width of about 50 feet.

Ont. Bur. Min., XII, p. 138.

Concession XI, lot 16 E½. Card quarry. Owned by the Kingston Feldspar and Mining Company (Messrs. Richardson and Sons), of Kingston, Ont., who purchased the property in 1909.

Work was commenced here in 1905 by the Kingston Mining and Development Company, who employed 20 men, and extracted a quantity of spar by surface stripping along the deposit. The output was shipped to East Liverpool, Ohio. This quarry was again operated in 1910 by the present owners, with a force of 25 men, and a steam plant, including a 50

H.P. boiler, was installed. A cable hoist, also, was erected, and the old workings were deepened. Work was again abandoned towards the latter part of the following year and has not since been resumed. All the machinery, etc., still remains on the property, and a small camp exists.

The quarry lies 2½ miles west of Verona station on the Kingston and Pembroke section of the Canadian Pacific railway, the output being hauled by teams to that point.

There is only one opening, this being an open pit 400 feet long, 40 feet wide, and about 35 feet deep. About 100 feet of stripping has also been carried out at the north end of the pit, making a total length of 500 feet worked. The spar dike has a direction almost due north and south, and dips vertically, its width being the same as that of the pit, namely 40 feet. The walls are well defined, and consist of dark coloured gneiss, which becomes lighter in colour as the distance from the dike increases. This is a common feature of the gneiss enclosing the spar dikes in this district: the intrusions, having apparently been attended by the formation in the country rock of considerable amounts of secondary biotite, and sometimes, also, of hornblende. The occurrence of large crystals of the latter mineral in the dike mass itself, is often a conspicuous characteristic, though at this particular point little of this mineral is in evidence. Tourmaline, however, in large crystal aggregates, is a common accessory mineral, and large blocks were observed on the dumps.

The feldspar is the usual type of pink microcline, and forms the main constituent of the dike, quartz stringers and splashes occurring throughout its mass.

Plate VI shows a view of the pit and hoist house.

Ont. Bur. Min., XV, p. 102; XIX, p. 130; XX, p. 43.

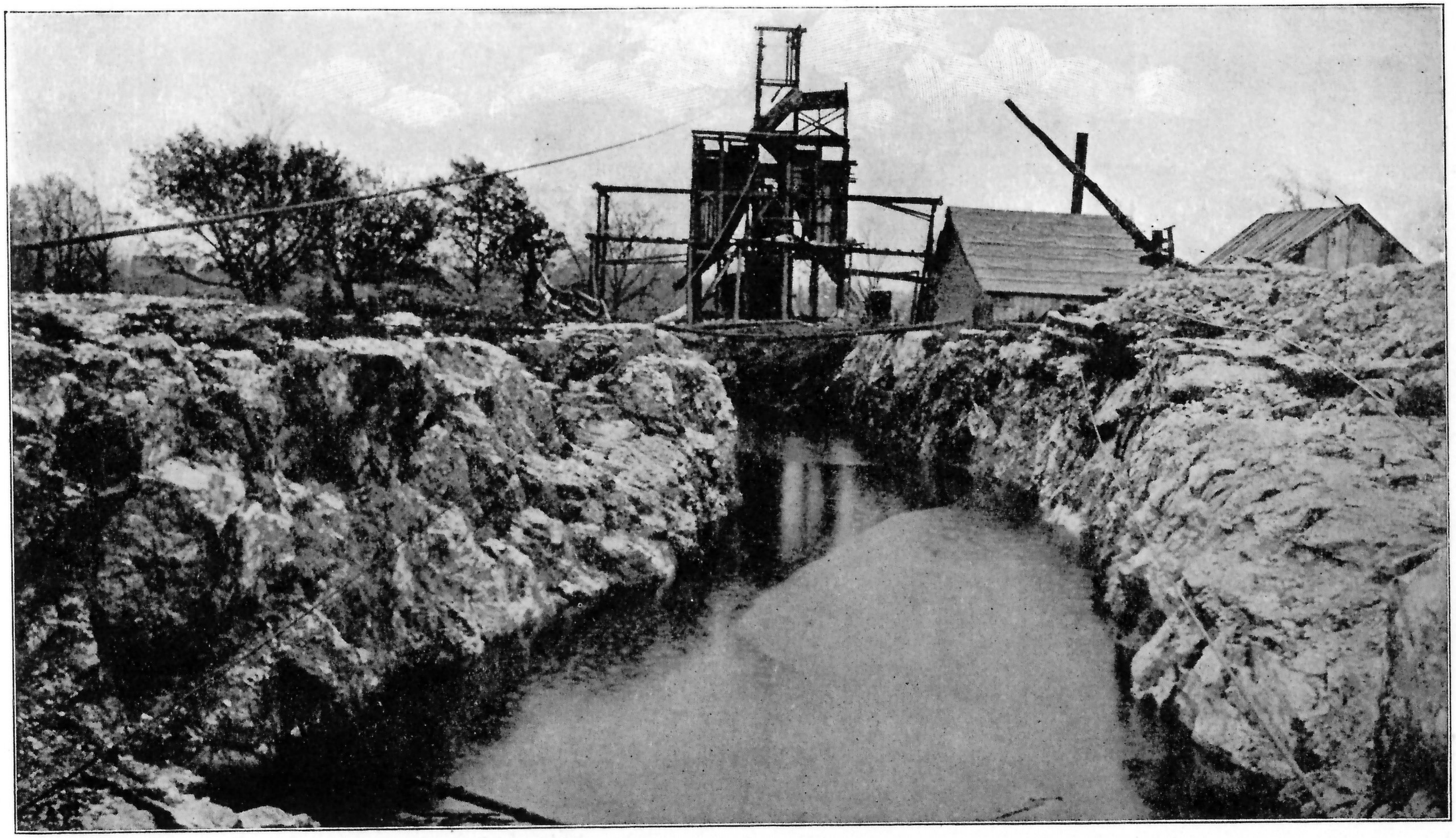
Concession XI, lot 16 W½. Work was commenced on this property in May, 1915, the operators being the Canada Feldspar Corporation, Limited, of Toronto, who have worked continuously to date (November, 1915,) with a force of 15 to 20 men. The property adjoins the Card quarry to the east. The spar body possesses the same general direction as that at the latter quarry (north and south), and consists of similar material—grey to pink microcline.

One pit has been opened, and is 70 feet square, by 35 feet deep. About 3,000 tons of spar have been shipped from this opening, chiefly to Trenton and East Liverpool.

A steam plant has been installed, and operates drills and a derrick.

The distance from Verona—the nearest rail point—is 2½ miles, the spar being hauled by teams taking about 3 tons to a load.

Concession XI, lot 19. Bellrock quarry. Owned by W. Brooks, of Bellrock. This is a small deposit of spar which was worked for a few months in 1907, by the Pennsylvania Feldspar Company, of Toughkenamon, Pa. About 600 tons of spar are reported to have been shipped. No further work has been done there.



Card quarry, Portland township, Ont.: showing open-cut and cable hoist.

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There are two small shallow pits on the property, which lies 3 miles west of Verona, the nearest rail point. The dike mass appears to consist of rather mixed mineral, splashes of quartz and thin books of dark mica occurring in a matrix of light-coloured spar.

Concession XII, lots 3 and 4. Hofman quarry. This property adjoins the Gamey quarry, to the east, the Hartington-Bedford road separating the two sets of workings. The chief opening is situated on lot 4. This is an open pit 35 × 15 feet, and some 25 feet deep. The feldspar is of a similar grade to that occurring at the Gamey quarry, but is rather lighter in colour, and exhibits often a mottled, brownish-white appearance. An extremely conspicuous accessory mineral in the dike is pyrites, which occurs in large masses of several pounds weight, and appears to be uniformly distributed through the spar body. Quartz, also, is present in large quantities, and is intimately mixed with the spar. Judging from the extent of the waste dump, there would appear to be a very large proportion of impure and commercially worthless mineral in the deposit. This pit is equipped with a small derrick and boiler house.

Small openings have been made, also, at several spots on lot 3, and small feldspar dikes seem to be extensively developed through this area. At one place a large surface pocket or cavity was struck, the opening being 20 feet in depth and of irregular chimney-like form. The walls of the cavity are formed of very large microcline feldspar crystals, measuring as much as 2 feet in diameter, but having usually only the terminal faces developed. These feldspar individuals are coated with crystallized quartz, and the latter mineral occurs, also, as the filling of the small seams and fissures in the rock.

The quarry was worked some years ago by the McDonald Feldspar Company, of Toronto, and in 1911 the Kingston Feldspar and Mining Company carried out some work—mostly of a prospecting character.

Concession XII, lots 5 and 6. Known as the Gamey or Bauder quarry, and situated 3 miles northeast of Verona, the nearest shipping point. The owners are the McDonald Feldspar Company, of Toronto. In 1902 this property was leased by the Pennsylvania Feldspar Company, of Toughkenamon, Pa., who had a dozen men employed for about a year. In 1906 the Company renewed operations with a force of 15 men, and continued work during the succeeding year. In 1909 the deposit was acquired by the present owners, who continued work during 1910, since when the property has been idle. This Company employed an average of 30 men, and shipped some 6,000 tons of spar to East Liverpool, Ohio. Some shipments of quartz were also made to Welland, Ontario.

The quarry produces a reddish spar, the dike body being traversed by stringers and veins of white quartz. Hornblende crystals are developed in the dike near its contact with the enclosing gneiss, and what are, apparently, included fragments of the country rock, are to be seen at the east end of the pit. The average grade of the run-of-mine is high, and the property has yielded a large quantity of excellent spar.

There is only one pit—an opening 300 feet long, and averaging 20 feet in width, and about 60 feet in depth. This open cut has been excavated upon a NE-SW spar dike, which here traverses a small knoll, the pit forming a narrow, open trench or drift, running back from the north face of the hill.

The buildings and equipment comprise a boarding house, boiler house, two steam derricks, and a steam pump and drills; the buildings, etc., being in good repair.

A picked sample of greenish-grey spar from this quarry yielded:—[1]

SiO_2	64·32
Al_2O_3	17·78
Fe_2O_3	0·91
FeO	0·06
MgO	0·02
CaO	0·36
Na_2O	3·23
K_2O	13·37
H_2O	0·12
BaO	0·03
	100·20

Ont. Bur. Min., XII, p. 137; XV, p. 102; XVI, p. 86; XVII, p. 90; XX, p. 110.

Concession XII, lot 11. Owned by the G. and M. Feldspar Mining Company, of Arnprior, Ont., and worked for three months during 1911 with a dozen men. The property lies about 3½ miles west of Verona—the nearest shipping point—and one-half mile off the road leading to this place. The distance to Verona by winter road across Mud lake is about 2½ miles. A steam plant was installed, comprising a 45 H.P. boiler, hoist, and two drills, all of which have since been removed. A few hundred tons of mixed spar and quartz were taken out, but no mineral has been shipped.

The only opening is a small pit opened in the southeast face of a small knoll. This pit is 15 feet deep and measures 35 × 25 feet. The feldspar is much mixed with quartz, the two minerals occurring in about equal amount. The quality of the mineral is impaired also by the presence of soft, decomposed, yellowish mica, which is met with throughout the dike, and would necessitate the discarding of a considerable amount of the run-of-mine.[2]

Concession XIII, lot 15. First Lake quarry. A small amount of spar was taken off this property in 1913 by the Canadian Feldspar Corporation, Limited, of Toronto.

[1] Analysis by N. L. Turner, Mines Branch, Department of Mines, 1914.

[2] This property was worked again during the latter part of 1914 by Mr. Austin, of Toronto, and a small tonnage shipped.

Lanark County.

TOWNSHIP OF NORTH BURGESS.

Concession V, lot 13 E½. Silver Queen mine, owned by Mr. Edward Smith, of Perth, Ont. This property has been worked for mica and phosphate since 1905, the two minerals occurring together on a lead having a direction of N. 30°E. A couple of years ago it was found that a belt of feldspathic rock paralleled the above lead, at a distance of 500 feet to the southeast, and operations have been conducted during the past two years to develop the deposit. Only surface stripping has, as yet, been carried out, a small portable boiler and one steam drill being employed; the deepest pit is down 10 feet. The owner reports a shipment of 1,000 tons of feldspar in 1912, the entire amount being consigned to the Eureka Flint and Spar Company, at Trenton, N. J. Should this deposit prove extensive, and be found to yield a sufficiently high grade of spar, shipment can be readily made to the United States potteries via the Rideau lakes; the mine lies only about one mile distant from Hogg bay on Big Rideau lake, and barges can thus be brought to within a short distance of the workings. The water freight charges from Hogg bay to Sodus point, via Kingston and Lake Ontario, amount to $1.12 per ton, and the rail freight from Sodus point to Trenton, N.J. is $1.80 per ton, making $2.92 in all.

This particular spar deposit is, in many respects, quite unlike any other feldspar body that has come to the writer's notice either in Quebec or Ontario. All the other deposits belong essentially to one or other of two distinct types—mica-bearing pegmatites, found principally in the province of Quebec, and carrying both microcline and albite feldspar, and muscovite, or the reddish, aplite dikes so extensively developed in Bedford and Portland townships, in Ontario, as well as, on a small scale, throughout the entire area of Pre-Cambrian rocks in Eastern Canada. The spar body at this spot, however, is unlike either of these types. The chief constituent of the spar body is microcline of a cloudy, bluish-white colour. This mineral does not occur in massive form, but exists as an aggregate of holocrystalline individuals, which sometimes attain a length of 4 inches, but more usually measure less than 2 × 1 inches. Smoky quartz, in small stringers and patches, occurs disseminated through the feldspar, but is present in quite subsidiary amount, and does not form more than probably 8–10 per cent of the mass. Other minerals present in the spar belt, some of which constitute undesirable impurities, are sphene, or titanite, in small, lustrous and well shaped crystals, embedded usually in the microcline; pyrite and pyrrhotite, in scattered crystals of small size; apatite, in slender prisms of a bright blue colour; well formed crystals of diopside, having prismatic habit and measuring as much as 5 inches in length, by 2 inches across; green tourmaline; a silvery-white mica, probably muscovite, in small leaves, and calcite. The last named mineral exists in noteworthy amount all through the dike mass, and occurs as small masses, apparently as the filling of vuggs or cavities in the spar. The feldspar surrounding such vuggs usually exhibits well developed crystal faces, which penetrate into the calcite filling. Near the surface, this filling has often been dissolved out by surface waters, and the cavity walls then display well formed microcline crystals, having rough and pitted faces, upon which lie small titanite individuals. The calcite is of two principal shades, yellow, and blue, and these two colours merge into one another, so that one cavity filling often displays both extremes of shade, as well as all gradations between the two. The diopside usually occurs in stout prisms wholly embedded in such calcite filling, but occasionally, a crystal also has its lower extremity based upon the enclosing feldspar. These crystals exhibit well defined basal cleavage.

The tourmaline occurs always in narrow three-sided prisms, either penetrating feldspar, or lying upon the terminal faces of feldspar crystals lining vuggs. The apatite prisms occur always entirely in and penetrating calcite. The blue shades of the latter mineral display beautiful nuances, and some vuggs contain a filling of a deep, sky-blue colour.

The belt of rock between the feldspar body and the parallel mica and phosphate lead, consists principally of coarse-grained, crystalline limestone, possessing a similar yellow or bluish colour, and carrying small crystals of pyrite, pyrrhotite, diopside, phlogopite, and apatite scattered through it.

A marked peculiarity, possessed alike by this limestone belt and the adjacent feldspar body, is, that both are fœtid to a high degree. The offensive odour of sulphuretted hydrogen is appreciable at some distance from any newly worked exposure of the rock, and a block of either limestone or feldspar, when struck with a hammer, liberates the gas.

We have, evidently, here an intrusion of pegmatitic material similar to the grey aplitic dikes so common in the granite-gneisses of the Quebec mica-apatite region; only, in this case, the intruded rock is a crystalline limestone, and the intrusion has probably been attended by a considerable degree of contact metamorphic action. Assuming that the formation of the spar body followed along aqua-igneous lines, the deposition of the minerals in the ascending solution (feldspar, sphene, tourmaline, quartz, etc.) probably synchronized with a corresponding solution of the invaded limestone, which in part re-crystallized in cavities in the spar body, imprisoning some of the sulphuretted hydrogen that either accompanied the intrusion, or was released from the limestone itself. The apatite and diopside are obviously contact metamorphic minerals, and a variety of other species of similar origin would probably be found if the deposit was opened up.

The potash content of the feldspar is not very high —10·44 per cent— and a small amount of barium is present. The following analysis of the spar has been made by N. L. Turner, of the Mines Branch (1914):—

SiO_2	64·90
Al_2O_3	18·49
Fe_2O_3	0·60
FeO	0·03
MgO	0·18
CaO	1·73
Na_2O	3·02
K_2O	10·44
H_2O	0·08
SrO	0·03
BaO	0·29
CO_2	0·65
	100·43

Judging from the variety of accessory minerals present in the spar body, the titanite and pyrites alone being in sufficient amount to constitute serious impurities, the feldspar is hardly likely to be of much use for pottery or enamelling purposes, without being subjected to very careful sorting.

Ont. Bur. Min., XV–XX.
Dept. Mines Can., Min. Br., Mon. Mica, 1912, p. 107.

Parry Sound District.

TOWNSHIP OF CONGER.

Concession VIII, lot 5. Owned by the Standard Feldspar and Silica Mining Company, of Gordon bay, Ontario. This property is located close to the track of the Toronto-Parry Sound line of the Canadian Pacific railway. A few pits were opened on this lot a number of years ago, but no details regarding operations are available. The present owners have done little work, having confined their operations to surface stripping, and testing the spar body uncovered.

The main outcrop of feldspar consists of a boss, or low ridge, of pegmatitic, pink granite, some 250 feet in length, and from 12 to 15 feet wide. This ridge stands up conspicuously to a height of about 10 feet above the enclosing gneiss country, and is formed of pink microcline feldspar and white quartz, the latter mineral often forming graphic-granitic intergrowths with the spar, and sometimes, also, occurring in small veins and stringers through the dike mass.

The quality of the feldspar in almost all the exposures examined is seriously impaired by the presence of large flakes or leaves of black biotite mica. This mineral occurs in plates, up to 18 inches across, upon seams and joints in the dike, and is especially abundant upon the contacts of the dike with the country rock. The quantity of biotite present in the spar body must necessarily entail a considerable amount of cobbing before the mineral can be utilized for pottery purposes. Large pieces of clean and pure feldspar are relatively rare, the dike possessing, usually, a coarse granitic structure, and the spar is intimately mixed with quartz.

A small camp has been erected near the railway, and a commencement made with the erection of a grinding mill (see p. 6). This plant comprises a 100 H.P. horizontal boiler, a rotary crusher, and a pebble mill. The crusher is designed to grind the rough spar to $\frac{1}{4}''$ mesh, the screened mineral then passing to the pebble mill, which brings it to 120 mesh. Only trial parcels of mineral had been put through the mill up to the time of the writer's visit in 1912, and all work on the property ceased shortly after.

Should the feldspar improve in quality in depth, the deposit is admirably situated as regards shipping facilities, a spur line of a few hundred feet only being necessary to connect the workings with the railway.

Concession IX, lot 4. A deposit of spar was worked on the above lot during the year 1910 by the Ojaipee Silica-Feldspar Company, of Toronto, a concern incorporated in September 1910, with a capital of $40,000. About six months' work was done, and a production of 100 tons of feldspar and 1,500 tons of quartz was reported. The former mineral was shipped to East Liverpool, Ohio, and the quartz to Electro-Metals, Limited, at Welland, Ontario.

The workings—which lie alongside the Toronto–Parry Sound line of the Canadian Northern railway—comprise one main pit 50 × 12 feet, by 25 feet deep, and a few small surface openings. A small steam plant has been installed, and a camp and short tramway erected, but the buildings, etc., are now in a tumble-down condition.

The spar body has a direction almost due east and west, and averages 12 feet in width. The dike consists of large masses of white or yellowish quartz, separated by zones of pink microcline feldspar, the former mineral predominating—as is shown by the statement of shipment above. As a rule the feldspar occurs in large crystals, up to 2 feet in length, embedded in a matrix of quartz. Much of the rock on either side of the dike proper has the character and composition of graphic-granite.

Large plates (up to 2 feet across) of black biotite mica are frequently met with throughout the dike, the mineral being usually in thin leaves; it is very much crushed, possesses no lustre, and is economically valueless. This mica occurs principally on joint planes and seams in the spar body, and is apparently of later origin than this. Very large tabular, allanite crystals occur plentifully in the dike, the individuals frequently attaining a length of 12 inches; the average width of the crystals, however, does not much exceed half an inch.

The pit is situated near a small lake, and water infiltration is understood to have caused trouble. The mine lies 3 miles west of Port Cockburn, to which place a good road exists, and 2 miles south of Blackstone station. A spur line of some two hundred feet has been run to the pit from the Canadian Northern tracks.

It is understood that the Company has now been dissolved.

Miscellaneous Locations.

Feldspar, chiefly microcline and albite in intimate association, but sometimes a fairly pure microcline, is the chief constituent of numerous mica-bearing, pegmatite dikes found throughout the area of the Archæan rocks in the provinces of Ontario and Quebec. These dikes are of widespread occurrence, and have, in some cases, (more especially in the Parry Sound district, and in Frontenac and Hastings counties, Ontario,) been worked in a small way for their mica content. The presence of deleterious, accessory minerals in the feldspar bodies, and the remote locations of many of the deposits, are, however, likely to prevent any development of the dikes for their spar content. The following are the more important locations where mica-bearing pegmatites have been discovered and, in certain instances, worked; operations have, with few exceptions, been confined to the surface; and little mining upon deposits of this class has taken place within recent years, the greatest activity having been shown during the late eighties and early nineties.

Addington County.

TOWNSHIP OF EFFINGHAM.

Concessions V, and VI, lots 1. A mica-bearing pegmatite body was worked in this township, in 1912, by Messrs. Smith and Lacey, of Sydenham. A fair quantity of clear, white mica is reported to have been secured. The property is now owned by the Loughborough Mining Company, Limited, who also own lots 5, 6, and 7, in concession VI.

Carleton County.

TOWNSHIP OF MARCH.

In the neighbourhood of Ottawa, on lots 6 of concessions II and III of the township of March, and about one mile south of South March station on the Grand Trunk railway, a deposit of feldspar is recorded by E. D. Ingall.[1] The mineral is said to be of both microcline and albite varieties, and is mixed with quartz. The dike is partly covered by arable land, and no development of the deposit appears to have taken place.

Frontenac County.

TOWNSHIP OF CLARENDON.

Concession II, lot 24. Mica has been mined in a desultory fashion on this lot, the work done being performed previous to 1900. No details of results, or of the grade of feldspar encountered, are available.

[1] Geol. Surv. Can., X Ann. Rep., 1897, p. 220 S.

TOWNSHIP OF MILLER.

Concession XI, lots 4 and 5. A small amount of stripping has been done, revealing mica crystals up to 18 inches.

TOWNSHIP OF PALMERSTON.

Concession II, lot 24. A narrow (4 to 7 feet) dike of pegmatite has been stripped for 450 feet, and worked to a depth of 10 feet. Muscovite crystals up to 18 inches across are reported to have been taken from this deposit in 1881. The narrowness of the body would hardly permit of the deposit being worked for feldspar.

Hastings County.

TOWNSHIP OF MONTEAGLE.

A few shipments of feldspar to England are reported to have been made in 1898 from Bird's creek, a price of $8 per ton being realized. The exact location is not given in the report on the deposit, but it would appear to be in either the third or fourth concession.

TOWNSHIP OF HUNGERFORD.

Concession XII, lot 29. Mica-bearing pegmatite was worked here in a small way in 1888 by D. Stewart. The vein is reported to average 15 feet wide.

Lanark County.

TOWNSHIP OF BATHURST.

Concession IX, lot 9. The opalescent variety of albite feldspar, called peristerite, has been recorded from this locality, as far back as 1850, and is mentioned in various reports of the Geological Survey. The amount of work done upon the deposit would appear to be small. An analysis of the spar, which occurs as a constituent of a coarse-grained granite, made in 1863, by Dr. Sterry Hunt, yielded:—[1]

Ont. Bur. Min., IX, p. 206.

SiO_2	66·80
Al_2O_3	21·80
K_2O	0·58
Na_2O	7·00
CaO	2·52
MgO, Fe_2O_3	0·50
Ignition	0·60
Total	99·80

[1] Geol. Surv. Can., Rep. Prog., 1863, p. 477; also p. 833; Ann. Rep., 1887–88, p. 75 S.

TOWNSHIP OF NORTH BURGESS.

Concession VI, lot 3. This locality was one of the first, if not the first at which the lamellated intergrowth of microcline and albite feldspars, to which the name "perthite" was given by Dr. Thompson, was particularly noticed. The mineral received its name from the town of Perth, which is situated at a little distance from the deposit. The feldspar is reddish in colour, and is barred with lighter and darker bands of flesh-red and reddish-brown shade. These bands exhibit, in certain lights, golden reflection in much the same manner as aventurine. The feldspar forms, with quartz, coarse granitic or pegmatitic belts, which have since been met with at various places in the township. While constituting a handsome ornamental stone, the mineral hardly occurs in sufficient quantity at any point to warrant mining, for pottery or similar purposes. The cleavage surfaces, also, are usually small, and slabs large enough for polishing for ornamental purposes are rare.

An analysis of perthite from the above locality yielded:—

Silica	66·44
Alumina	18·35
Potash	6·37
Soda	5·56
Peroxide of iron	1·00
Lime	0·67
Magnesia	0·24
Volatile	0·40
Total	99·03

Geol. Surv. Can., Rep. Prog., 1863, pp. 474, 833.
Ont. Bur. Min., IX, p. 206.

Parry Sound District.

A number of muscovite-bearing, pegmatite dikes have been opened up in this district at various times, chiefly during the late eighties and early nineties. While certain of the deposits have yielded small quantities of mica, no attempt has ever been made to turn the feldspar of the dikes to account. The most important of such pegmatite bodies are given below, the deposits constituting a possible source of feldspar.

TOWNSHIP OF FERGUSON.

Concession I, lot 11. Several test openings, made about 1894, disclosed mica-bearing pegmatite over a small area. No mining has ever been conducted.

Ont. Bur Min., V p. 280.

Concession II, lot 18. Harris mine. This deposit was opened up in 1894, and a few men have been employed upon it at intervals during subsequent years. The operator was Henry Harris. A few tons of mica were taken out from an opening 30 × 7 feet, by 25 feet deep. The dike would appear to be narrow, averaging not more than a few feet.
Ont. Bur. Min., V, p. 279.

TOWNSHIP OF BURPEE.

Mica-bearing pegmatites have been located and worked in a small way in this township, at various points, but little information is available regarding the exact localities and the work done.

TOWNSHIP OF CHRISTIE.

A muscovite deposit, which is said to have attained a width of 16 feet, and to have been traced over a length of 1,000 feet, was opened up in 1897 by the Virginia Mining Company, of Toronto: the location being 4 miles from Edgington station, on the Ottawa and Parry Sound railway. No details of the work done are available, nor is the exact location of the mine given.
Ont. Bur. Min., VII, p. 98.

TOWNSHIP OF MCDOUGALL.

Concession X, lot 12. This lot was worked with half a dozen men during 1895, a deposit 12 feet wide being uncovered and worked to a depth of 15 feet. The mica proved to be too stained to be readily marketable.
Ont. Bur. Min., V, p. 280.

Concession XII, lot 8. Oak ridge mine. Situated 1½ miles east of Waubamik, this deposit was located and stripped to a certain extent in 1895 by Mr. F. P. Leushner. A length of over 500 feet was exposed, and the dike averages 7 feet in width.
Ont. Bur. Min. V, p. 279.

Nipissing District.

In the Nipissing district, mica-bearing pegmatites have been located at several points. In the township of Calvin, a small amount of mica was taken off lot 9 in concession I by Mr. McKay, in 1895, and on lot 16 in concessions II and III, a similar deposit was worked in the same year by F. B. Hayes, of Ottawa. The variety of spar forming the dikes is not stated in the Report.[1]

Perthite and amazonite have also been found in the Nipissing district, the specimens coming from lots 6 and 7, on concessions A and B of the township of Cameron. Further details regarding the occurrence of these varieties are not reported.

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[1] Ont. Bur. Min., III, p. 196.

Block 24. A mica deposit was opened up in this region, in 1895, by the Spanish River Nickel Mining Company. The pegmatite forms large ridges, and is said to be traceable for a distance of many miles.[1]

Rainy River District.

W. H. Collins[2] records a large pegmatite body just south of Gull lake. Feldspar individuals up to 18 inches in length were observed, and sheets of muscovite six inches across were obtained. No attempt at development of the deposit has ever been made.

Lake of the Woods Region.

Pegmatite dikes of considerable extent are reported by A. C. Lawson[3] as occurring around the southern part of the lake, and on the south side of Falcon island two locations are recorded to have been worked for mica in 1885. At one of these, a pit 40 × 8 feet, and 8 feet deep, was opened, and exhibited orthoclase individuals of large size, mixed with quartz and muscovite crystals.

PROVINCE OF QUEBEC.

Owing to their distance from the United States market, which takes nearly all the feldspar produced in Canada, the operators of Quebec feldspar deposits have been unable, since the opening up of the Ontario quarries, to compete with the latter, hence, practically, no spar has been quarried in the Province during the past 15 years. The white microcline from the old Villeneuve mica mine, is, however, still in demand for dental purposes, and a small tonnage is shipped each year to American manufacturers of artificial teeth. This mineral is chiefly obtained by picking over the old waste dumps.

If a grinding plant were to be erected within reasonable distance of the old Quebec quarries (the principal ones are situated in the neighbourhood of Ottawa, in the townships of Hull and Templeton) the deposits might be re-opened and the ground spar shipped to Montreal and St. Johns (Que.) potters as well as to consuming centres in Ontario. The run-of-mine spar is not, perhaps, of quite such high grade as the Ontario mineral, and requires a certain amount of handpicking; the deposits also are hardly as large as those in the Verona district, Ont. Nevertheless, with ground pottery-spar, imported from the United States, selling at Ontario and Quebec points at from $12 to $14 per ton, and with a domestic consumption of about 2,500 tons, it is a matter of regret that no attempt has been made to supplant the imported product by Canadian spar ground in this country.

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[1]Ont. Bur. Min., VI, p. 278.
[2]Geol. Surv. Can., I, Ann. Rep., 1885, p. 150 CC.
[3]Geol. Surv. Can., I, Ann. Rep. 1885, p. 150 CC.

The following table shows the annual production of feldspar from Quebec quarries from 1889 to date:—

TABLE III.

Production of Feldspar in the Province of Quebec, 1889-1914.[1]

Year	Tons	$
1889	250	1,750
1890	.....	.....
1891	.....	.....
1892–1893	1,000	.....
1893–1894	550	.....
1894–1895	250	.....
1896	1,018	2,545
1897	1,250	4,000
1898	2,000	5,000
1899	3,000	7,500
1900	147	441
1901	420	1,271
1902	52	172
1903	20	37
1904–1910	No production	
1911	30	600
1912	110	2,200
1913	74	1,554
1914	98	2,156

Ottawa County.

TOWNSHIP OF BOUCHETTE.

Range VII, lot 10. An outcrop of spar occurs on this lot, the mining rights being owned by J. Lacroix, of Blue Sea. A small amount of stripping was carried out by Mr. Coté, of Ottawa, in 1910, but no mineral has ever been shipped. The feldspar body is a dike having an average width of 35 feet, and is exposed for a distance of about 500 feet. The strike is approximately E. and W., and at the easterly end of the outcrop the dike mass forms the face of a low ridge for a distance of about 100 feet, while towards the west it is wholly enclosed in the granite-gneiss country rock (see Plate VII). The dip of the spar body is to the north, or into the ridge, the angle of dip being about 60°.

Much of the material of the dike consists of a medium to coarse graphic-granite, the quartz having a smoky tinge and the feldspar being of a greenish or grey shade. Zones of more or less pure spar occur throughout the dike, and it probably would be possible to secure a small tonnage of such material; the major part of the output, however, would consist of a graphic-granite with from 10 to 20 per cent of quartz. Accessory minerals in the

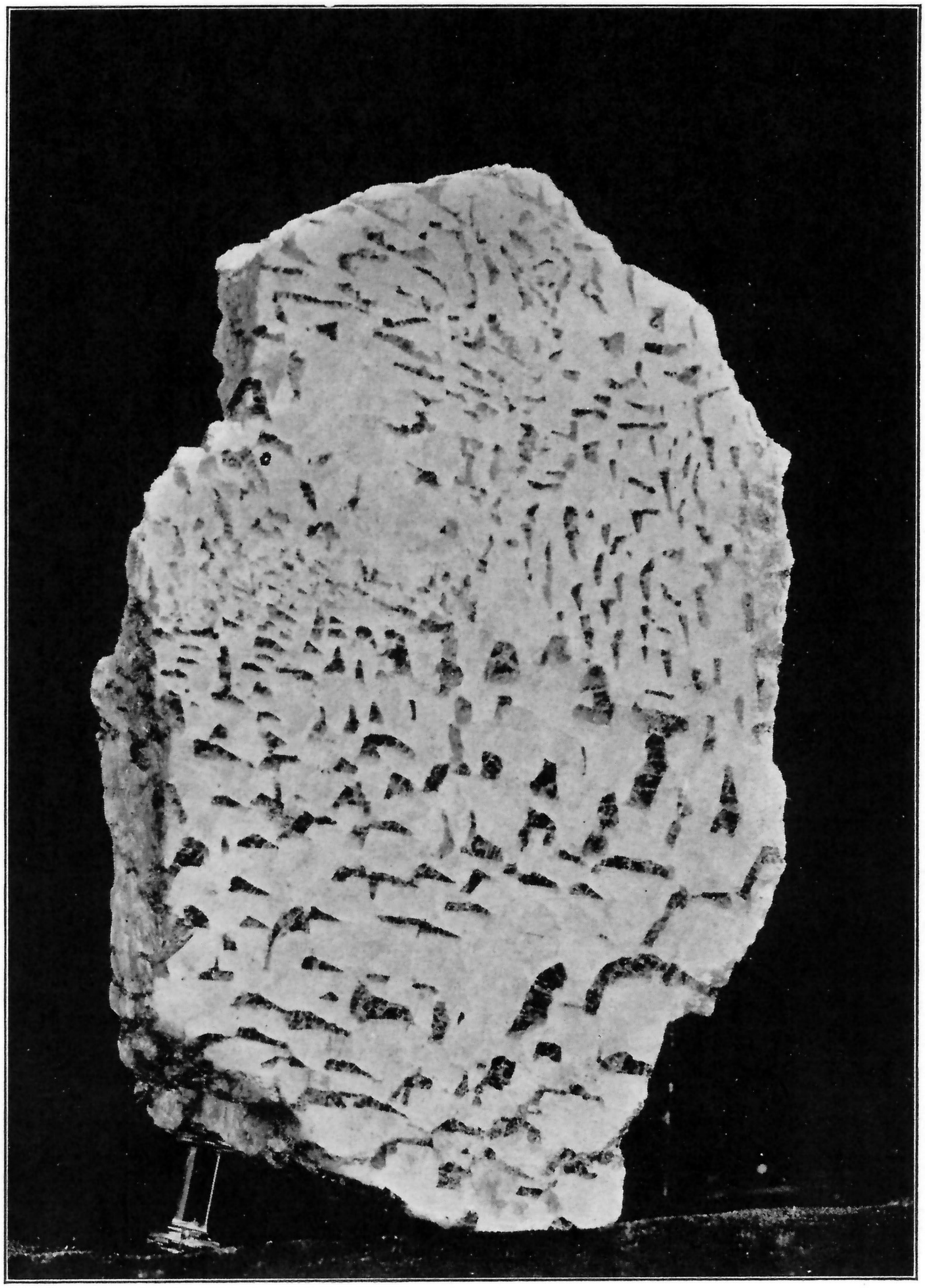
[1] Figures from Annual Reports of the Quebec Bureau of Mines.

PLATE VII.

PLATE VII.

Feldspar dike, range VII, lot 10, Bouchette township, Que.

[redacted]



Graphic-granite, from range VII, lot 10, Bouchette township, Que.

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shape of thin books of biotite mica and black tourmaline occur scattered in small amount throughout the spar.

The distance from the railway is 1½ miles, and the property lies close to the main road. By winter road across Blue Sea lake, the distance to rail is about one mile. The rail haul to Ottawa is 65 miles.

The deposit could be worked open cut to a depth of about 45 feet from the highest point of outcrop, the quantity of mineral in sight to this depth being about 40,000 tons.

Two analyses of picked samples of spar from this deposit are appended. No. 1 was made by M. F. Connor, and No. 2 by N. L. Turner, of the Mines Branch, Department of Mines.

	No. 1	No. 2
SiO_2	64·40	65·42
Al_2O_3	18·50	18·54
Fe_2O_3	trace	0·24
CaO	0·10	0·48
MgO	0·10	0·24
Na_2O	3·86	2·91
K_2O	12·38	12·58
H_2O etc.	0·65	0·13
	99·99	100·54

TOWNSHIP OF BUCKINGHAM.

Range XII, lot 14 E. ½. Was worked about 1900 by W. A. Allan, of Ottawa, who carried out some prospecting for mica. In 1912 a few weeks' work was done by M. J. O'Brien, who had four men engaged in prospecting and stripping. Two small pits, each about 10 feet deep, were opened on the southwest end of the ridge traversed by the pegmatite dike, but the mica proved to be of no better quality than that on the adjoining Pearson property, and work was abandoned. The mine lies about 9 miles north of Buckingham, the nearest shipping point, and the expense of hauling prevents the profitable mining of the feldspar or quartz.

Range XII, lot 14 W. ½. Pearson quarry. Last worked in 1895, by G. Corcoran, of Pittsburgh, who is the present owner. The property was originally opened up by Charles E. Pearson, of Buckingham, and has been worked for both feldspar amd mica. A production of 250 tons of spar is reported during the period of Mr. Corcoran's operations.

There are two openings on the property, both close together and excavated on the same exposure of pegmatite. The larger of the pits measures 75 × 20 feet, and is 40 feet deep.

The width of pegmatite body is over 150 feet, and the dike extends over several lots. The feldspar is a pink-grey orthoclase, and occurs in large crystals, which form benches or ledges in the quartz. Little of a graphic-granitic structure is displayed, and the spar and quartz can both be mined in a relatively pure and clean condition. The dike carries rather more mica (muscovite) at this spot than on the adjoining lots. The mica crystals, however, in addition to being much iron stained, are wedge-shaped, that is they are thicker on one side than on the other, and so are of little value commercially. The country rock is a rusty gneiss, and is much shattered and penetrated by small stringers from the main dike mass. Little impurity, in the shape of accessory minerals, such as tourmaline or garnet, was noticed, the feldspar being obtainable in large, clean pieces.

The mine lies about 9 miles from Buckingham, and is reached by a mine road of about half a mile, connecting with the main north road from Buckingham.

A picked sample of spar from this quarry yielded:—[1]

SiO_2	64·60
Al_2O_3	18·23
Fe_2O_3	0·60
FeO	0·03
MgO	0·05
CaO	0·30
Na_2O	2·82
K_2O	13·60
H_2O	0·08
BaO	0·02
	100·33

Que. Bur. Min., 1895, p. 61.
Geol. Surv. Can., X, Ann. Rep., 1897, p. 220 S.
Dept. Min. Can., Min. Br., Mon. Mica, 1912, p. 199.

Range XII, lot 15 E. ½. A small amount of work for feldspar was done on this lot during the winter of 1910 by C. Pellneau, of Buckingham. The ridge traversed by the pegmatite body falls abruptly at this point, and the face of the cliff has been stripped, and a few loads of spar taken out.

TOWNSHIP OF HULL.

Range IX, lot 13. Owned by C. W. Chamberlin, of Old Chelsea, and situated about 2 miles from Chelsea station on the Gatineau Valley line of the Canadian Pacific railway. The only work done on this property was performed by Messrs. Taylor, Arnoldi, and Bowie, of Ottawa, who mined for 3 months in 1898 with 8 men. No machinery was used, and about 8 carloads of spar were shipped to the Ohio potteries.

The spar body has an east and west direction, and is rather narrow. It has been worked by one pit 60 feet long, 20 feet wide and 10 feet deep, this opening being located on the north side of a small knoll about half a

[1] Analysis by N. L. Turner, Mines Branch, Department of Mines, 1914.

mile from Old Chelsea. The feldspar is a light brown or greyish microcline, and much of it is very clean; a large proportion of the dike mass being free from quartz or any other admixed mineral. The run-of-mine, however, consists of an intimate mixture of feldspar and quartz, the rock having a granitic texture. Spar outcrops are met with at several points on the hill, and appear to be apophyses from the dike mass lower down.

This lot and lot number 15 exhibit a remarkable variety of mineral species, an area of a few acres containing deposits of apatite, phlogopite mica, feldspar, rensselaerite, serpentine, marble, barytes, and fire clay, while graphite and a band of red jasper exist on lot 15 of range X.

Range X, lot 5. A belt of pink microcline feldspar traverses this property, and was worked in 1896 by J. H. Taylor, of Ottawa. A small tonnage of spar was taken out and shipped to the United States. The quarry lies east of the Gatineau river, and 5 miles from the nearest shipping point—this being Gatineau station, on the Canadian Pacific north shore line.

The workings comprise one large pit measuring 50 × 50 feet and 25 feet deep, also a number of small surface openings. The feldspar is of the usual pink variety, and is traversed by small stringers of quartz. This latter mineral is not present in benches or ledges, as is so often the case in deposits of this type, but is intimately mixed with the spar. The dike mass has, in fact, the composition and texture of an aplite with local zones of relatively pure feldspar. The mineral is thus not of very good quality, and requires careful cobbing. With the exception of small groups of radiating tourmaline crystals, no deleterious foreign minerals were noticed in the spar body.

The main pit lies on a small knoll or boss of feldspar, the country rock being a reddish gneiss with white crystalline limestone bands. Massive red phosphate, barytes, and amber mica occur on this and adjoining properties, which have been worked at various times.

Range XIV, lots 13a and 14a. A feldspar dike traverses these lots in a northeast-southwest direction, and is well exposed on the south side of the ridge bordering on Hall's lake. A little prospecting has been carried out at one point, the pit exposing a greyish or greenish spar mixed with a little quartz. The spar body, as usual in the dikes in this district, would appear to consist of zones of varying purity, quartz being present locally in sufficient amount to bring the rock into the graphic-granite class. A little black tourmaline, in bunches of acicular crystals, also occurs, but this mineral does not appear to be present in sufficient amount to detract from the quality of the spar. At the spot where the prospect pit has been opened the width of the dike is about 150 feet. The outcrop can be readily followed for a distance of several hundred yards along its strike, the exposure occurring along the southerly slope of the ridge, which has a similar northeast-southwest direction and rises about 100 feet above the lake. The dip of the dike, if any, is not apparent at the surface, but is probably northwest, or into the ridge. The width of the dike appears to diminish to the northeast.

The deposit is conveniently situated for shipping, being situated 2½ miles by winter road from Kirk's Ferry station on the Gatineau branch of the Canadian Pacific railway; it is on the Cameron property, and the mining rights are held by P. M. Coté, of Ottawa. An analysis of the pure, picked spar yielded:—[1]

SiO_2	65·10
Al_2O_3	19·01
Na_2O	3·18
K_2O	12·50
	99·79

TOWNSHIP OF PORTLAND EAST.

Range VI, lot 7. On the summit of a ridge 500 feet high, near Pike lake, a pegmatite dike some 30 feet wide is exposed. The dike is composed of white microcline and albite feldspars and quartz, and carries a somewhat stained and smoky muscovite mica. The crystals of the latter mineral are not large, in as far as has yet been ascertained, the maximum diameter of the sheets being about six inches. The dike has a strike of N. 20°E.

Very little development of the deposit has, as yet, taken place, and that solely for the mica it contains. The deepest pit is down ten feet, and has been opened on the crest of the hill. This work was done in 1909 by Messrs. Watts and Payette, who, however, ceased operations after a few weeks. The deposit is at present owned partly by M. J. O'Brien, and partly by W. Watts.

The occurrence is somewhat similar to that at the Villeneuve mine, though spessartite garnet is, perhaps, more abundant at the latter locality. The country gneiss is much tourmalinized along the contact with the dike, which follows a somewhat twisty course. The presence of small vuggs or druses in the dike mass is of interest, these vuggs being lined with crystals of biotite and purple fluorite. This is the only Canadian occurrence observed by the writer, outside the Saguenay region of muscovite and biotite in close association in a pegmatite.

The remote location of this property, together with the presence in the dike of garnet, mica, and other impurities, renders it unlikely that the feldspar can ever be profitably worked.

Range IX, lots 31, 32. Messrs. O'Brien and Fowler opened up a small body of white microcline (dental spar) here in 1914, and have shipped about 200 tons to the United States.

The feldspar is very similar to that at the Villeneuve quarry, a short distance to the north, but the deposit differs from that at the latter place,

[1] Analysis by M. F. Connor, Mines Branch.

in that hardly any mica, tourmaline, garnet, etc., are present. Albite, also, is present in only subsidiary amount.

The microcline occurs in intergrown crystalline masses, and well developed crystal faces are often shown by the individuals.

The dike is only 20 feet wide at the point of attack, and the pit here is about 20 feet square and 20 feet deep. The dike strikes nearly north and south, and the length of outcrop is only some 50 feet, the spar body being crossed by a 40-foot diabase dike having an east and west direction; this dike apparently faults the spar body, as what appears to be the latter's continuation on the farther side is met with a short distance to the west of the pit.

A number of pits have also been opened up by the same operators for amber mica on these same lots, and a considerable quantity of mineral has been secured, including a high proportion of large size sheets. Very little phosphate is present with the mica.

The distance from the village of La Salette is 3 miles, and from Buckingham, the nearest rail point, 22 miles. The spar is hauled in winter from the quarry to Buckingham.

TOWNSHIP OF PORTLAND WEST.

Range V, lot 15. A small mica-bearing pegmatite dike traverses the north half of this lot, and is probably the southerly continuation of the larger deposit on range VI, lot 21. The mica crystals are small, and much quartz is present in the dike. The feldspar is hardly pure enough to be profitably worked, and the body is not more than 25 feet wide. No work has ever been carried out on this outcrop, which is located on the farm of Nicolas Orange, of Holland Mills. An asbestos deposit on the same property was worked by W. A. Allan, of Ottawa, in 1892.

Range VI, lots 21 and 22. This property was taken up in 1911 by M. J. O'Brien, and a few months' work for mica was carried out during the winter of 1911-12. Beyond a little prospecting, no previous development of the property had taken place. The work done consisted of sinking a pit 35 feet deep and measuring 30 × 20 feet, the dike being stripped also for a further distance of 30 feet. No machinery was employed—a derrick being used for hoisting. A small camp was built, comprising bunk house, culling shed, stable, etc. About half a dozen men were employed.

The pegmatite body at this spot is identical in character with that at the Villeneuve mine, the rock mass consisting of large crystals of white albite and pink microcline feldspar with quartz and crystals of mucovite. The dike is 20 feet wide, and has a strike of N. 15°W., dipping 80° to the east. The country rock is a dark gneiss, which is permeated with small stringers from the main dike body. A little black tourmaline occurs penetrating the feldspar, and spessartite garnet is present in some quantity, the gneiss walls also being considerably garnetized. Uraninite, or pitch blende, was noticed in some appreciable amount, the mineral occurring in small buttons up to ½″ in diameter. These buttons usually are surrounded by a yellow or bright orange zone of gummite, which is an alteration product of the pitch blende, and which makes the presence of this mineral in the ground mass of quartz or spar very conspicuous. The mica is of good quality, although the crystals are inclined to be small. The spar is clean, and, though sometimes rendered impure by the presence of small amounts of garnet, mica, or tourmaline, can be readily cobbed in large pieces. The microcline found here and at the Villeneuve mine is in demand for the manufacture of artificial teeth.

A noticeable feature of the country gneiss in the neighbourhood of this deposit is the presence of irregularly shaped masses of pyroxene and amphibole, these fragments usually being surrounded by a narrow band of light red garnet.

The quarry is situated on a high hill near Harper lake, lies about 7 miles west of the Lièvre river, and is approached from the main highway by a steep bush road of 1½ miles. About 200 tons of dental spar were shipped from this property in 1913-14.

An analysis of a picked sample of microcline from this quarry yielded:—[1]

SiO_2	65·07
Al_2O_3	18·20
Fe_2O_3	0·08
FeO	0·06
MgO	0·02
CaO	0·72
Na_2O	2·83
K_2O	13·46
H_2O	0·10
	100·54

TOWNSHIP OF TEMPLETON.

Range II, lot 14. Opened in 1896 by J. H. Taylor, of Ottawa, who continued work for two years, and shipped some 2,000 tons of spar to East Liverpool, Ohio. A force of 15 men was employed, and steam drills and hoists were used. The mineral had to be hand cobbed, and an output of about 5 tons per diem was maintained. The mine lay idle subsequently until 1908, in which year the Electric Reduction Company, of Buckingham, worked for a short while. The mine is at present owned by this Company.

The workings consist of one pit 25 feet deep, 75 feet long, and 45 feet wide, with about 75 × 50 square feet of surface stripping on the east side. This pit has been opened on a low ridge situated about half a mile from the station of East Templeton, on the Canadian Pacific north shore line.

[1] Analysis by N. L. Turner, Mines Branch, Department of Mines, 1914.

Stripped surface of feldspar dike, range II, lot 14, Templeton township, Que.

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United States.

The deposit consists of a dike having an almost due north and south direction, and intruded into rusty gneiss. The spar body is by no means of uniform width, and does not form a well defined contact with the gneiss. The intrusion has much shattered the enclosing rock, and the spar forms a central boss, from which irregular stringers and apophyses run off into the gneiss. The width of the dike at the south end of the property is only 3 feet, while at the north end it fingers into several narrow stringers, the widest of which does not exceed 15 feet. The total length of spar body visible at the surface is 400 feet.

The dike mass consists of a mixture of pink orthoclase feldspar and quartz, the two minerals being often in coarse intergrowth, with individuals of spar up to 1 foot in length. Feldspar forms the main mass of the deposit, and the quartz occurs in veinlets and splashes through it.

Accessory minerals are somewhat frequent and include black hornblende, in crystals up to 24 inches in length and 12 inches wide; schörl, in small aggregates of needle-shaped crystals, usually penetrating quartz; a whitish-yellow mica (probably muscovite) in small flakes; magnetite, in small crystals or buttons; a dark red, almost black, garnet; purple fluorite, and a little biotite mica. By far the most common of these minerals is hornblende, which occurs locally in considerable amount, and is often associated with magnetite and biotite. The latter mineral is practically confined to the neighbourhood of the hornblende, often forming thin layers through the crystals, and also enclosing them. A considerable degree of local differentiation would thus appear to have taken place in the dike.

Plate IX shows surface stripping south of the main pit.[1]

Geol. Surv. Can., X Ann. Rep., 1897, p. 2208.
Que. Bur. Min., 1896, p. 102.

Range VIII, lot 26 N.½. Known as the Langill or Allan quarry, and owned by W. A. Allan, of Ottawa. The deposit was worked first by J. H. Taylor, of Ottawa, in 1898, in which year 25 men were employed on the property for 3 months, and 2,000 tons of spar were shipped. In the succeeding year W. A. Allan took over the property, and extracted about 3,000 tons. Work was continued during 1900 and 1901, a shipment of 410 tons being reported in the latter year. The property has lain idle since that time.

The only excavation is an open quarry in the face of a precipitous ridge. The opening is 75 feet across and 75 feet high, the total height of the hill being about 150 feet. The entire face of this hill is composed of red microcline feldspar mixed with small pockets and splashes of white quartz. The main body of the ridge, in fact, which is some 500 feet across, is formed by a feldspar dike having a direction of northeast-southwest and dipping 55° N.W. The contact of this dike with the country rock—a dark granite-

[1] This quarry has been worked during the winter of 1915–16 by the Eureka Flint and Spar Company, of Trenton, N.J., who have employed a force of some 25 men and shipped several hundred tons of spar to the United States.

gneiss—is to be seen on the north side of the quarry, where the gneiss forms the face of the hill for a height of 25 feet from the level ground at the base. There is no overburden whatever, the feldspar forming the surface both on the top and on the side of the hill.

The quartz is white and vitreous, and occurs in small amount either disseminated through the mass of the spar or forming graphic intergrowths with the latter. In the latter case, the graphic structure is frequently so scarce that the two minerals can be cobbed clean from one another in pieces up to 2 inches across. The average quartz content of the spar body would be about 10–15 per cent. With the exception of a little dark biotite mica and some black tourmaline no undesirable accessory minerals were noticed.

The side of the hill has been quarried back to a depth of 40 feet. The rock is much jointed and can be easily taken down. The greater portion of the spar is of the same reddish colour as that possessed by the mineral from the Ontario deposits, with local zones of a dark brown shade. No vuggs or druses occur in the dike mass, which is of uniform composition and texture throughout.

The property lies 7 miles from Gatineau station on the Canadian Pacific north shore line.

With the exception of a small quantity shipped to Buckingham, the entire output of this quarry was sent to the United States potteries.

Range VIII, lots 27 N. ½ and 28 N. ½; Range IX, lot 27 S. ½. These lots were prospected by W. A. Allan, of Ottawa, about 1908. Only surface stripping was carried out, and good showings of spar are said to have been located.

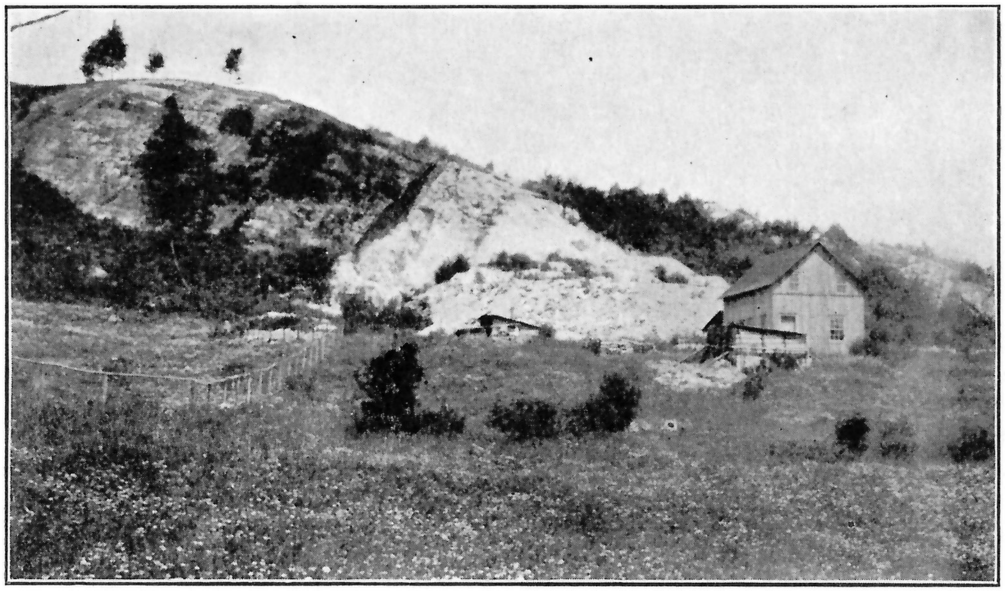
TOWNSHIP OF VILLENEUVE.

Range I, lot 31. Villeneuve mine. Situated 20 miles north of Buckingham, the nearest shipping point, and 3 miles east of the Lièvre river. The deposit which has here been exploited represents one of the largest mica-bearing pegmatite bodies which has so far been worked in Canada.

The mine was opened in 1884 by W. A. Allan, of Ottawa, and was worked for mica. A year later it was taken over by the British and Canadian Mica and Mining Company, who worked steadily from 1885 to 1888, and produced about 35,000 pounds of cut, marketable sheet mica. This mica was disposed of almost entirely in Canada, the larger sizes bringing as high as $14.50 per pound. A shipment of feldspar was made by the Company in 1888, 250 tons being sent to England, and about 150 tons to the United States. A price of $7 to $9 per ton was obtained for this shipment.

The mine, which was well equipped with modern machinery and employed a staff of about twenty-five men, passed, in 1888, into the hands of S. P. Franchot, who worked intermittently for mica from 1890 to 1898. In 1908, the property was purchased by O'Brien and Fowler, who continued to work for mica until December, 1909, with an average of ten men. Since that date the mine has been idle.

PLATE X.



Villeneuve mica and feldspar quarry, Villeneuve township, Que.

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The property was formerly equipped with an extensive plant, but the boiler house containing compressor, etc., was destroyed by fire some seven years ago. The present buildings consist of a large mica culling shed, a boarding house, smithy, and waste sheds.

No direct mining for feldspar alone has ever been carried out, the mineral shipped having been secured while mining for mica.

The Villeneuve mine is situated upon one of a series of white pegmatite dikes which have been intruded along the bedding of a reddish-grey, fine-grained gneiss. The dikes strike northeast and southwest, and dip some 80° to the northeast. They are of varying widths, the one in question being the widest and measuring about 150 feet across.

The country gneiss is highly garnetiferous, and is tourmalinized adjacent to the contact. The workings are situated on the southwest side of a low hill (see Plate X), and consist of an open drift carried some 100 feet into the hill and having a height of 60 feet at its inner end. From the bottom of the open cut additional drifts have been cut into the hill, and a shaft 12 × 12 feet sunk to a depth of 50 feet. The mica occurs principally along and adjacent to the western contact, and it is here that the most extensive work has been carried out. The dike mass consists of an intimate association of white feldspar (microcline and albite) and grey quartz, in which muscovite crystals occur embedded.

Black tourmaline (schörl) is abundant throughout the rock mass in large, well formed needles, which occur in radial aggregates and sometimes possess a length of several feet and a thickness of a couple of inches. Plate XI shows such tourmaline crystals traversing a mass of feldspar.

The occurrence of spessartite, a member of the garnet family with manganese content, and of a reddish-brown colour, is of interest. The mineral occurs, generally in local aggregates, but sometimes also as scattered individuals, throughout the mass of the dike. The crystals do not, as a rule, possess definite outlines, being usually distorted and with rounded faces. Exceptions to this mode of occurrence are, however, those garnets not infrequently found included in the muscovite crystals themselves. These, though sometimes rather flattened, are usually well developed examples of the common dodecahedron type.

Other minerals which, though not common, sometimes are found in the dike, are: grey-green apatite, (usually massive); zircon, in medium-sized individuals; purple fluorite; beryl; the rarer minerals monazite, pitch blende, and the alteration product of the last named, gummite. All these minerals are to be considered more in the nature of curiosities than economic products, and are not present in any quantity.

The mica, which was formerly much in demand for stoves, etc., is a greenish muscovite and occurs often in large crystals. One crystal found weighed 281 pounds and measured 30″ by 22″, yielding $500 worth of merchantable mica. The individuals seldom possess regular crystal outline, being usually of rather indefinite form, though distortion due to crushing is rare. The sheets split readily, but are not very resilient, having a hard, brittle feel, when bent. In addition, the quality of the sheets is often much impaired by the presence between the laminae of numerous flattened garnet crystals, which are so thin as to be little more than stains. Dendritic films of specularite and göthite are also common, and often render the sheets almost opaque. These inclusions render the sheets unsuitable for electrical purposes, since they improve the conductivity of the mica, while for stove and lamp purposes stained sheets are equally unsuitable.

The feldspar found at this mine is of two varieties, microcline or potash-soda feldspar, and albite or soda-feldspar. Both are generally white, though the greenish variety of microcline known as "amazon stone" is sometimes met with. Peristerite, the name given to a variety of albite showing high iridescence, is common, and beautiful examples of this mineral, which rivals labradorite in its variety of colour play, have been found here.

The feldspar has, on account of its colour and purity, been recognized both in England and the United States as remarkably fit for the manufacture of fine chinaware, both the microcline and albite being suitable for this purpose. The potash spar, however, which is white in colour and obtainable in large, clean pieces, finds its chief use in the manufacture of artificial teeth. For this purpose it has to be very carefully cobbed, in order to avoid the admixture of the albite variety. A quantity of this so called "dental spar" has been shipped to Philadelphia, and brings as much as $20 per ton, while for pottery use its value would not be more than about $5 per ton.

The mass of the dike is composed of the above mentioned varieties of feldspar—often in perthitic intergrowth—and were the deposit located nearer to a shipping point the large quantity of spar here available would be valuable. As it is, the haul of 20 miles to the railway renders the extraction of the pottery grade of feldspar impracticable, while the market for the dental spar is too limited to permit of operations for this variety alone being undertaken.

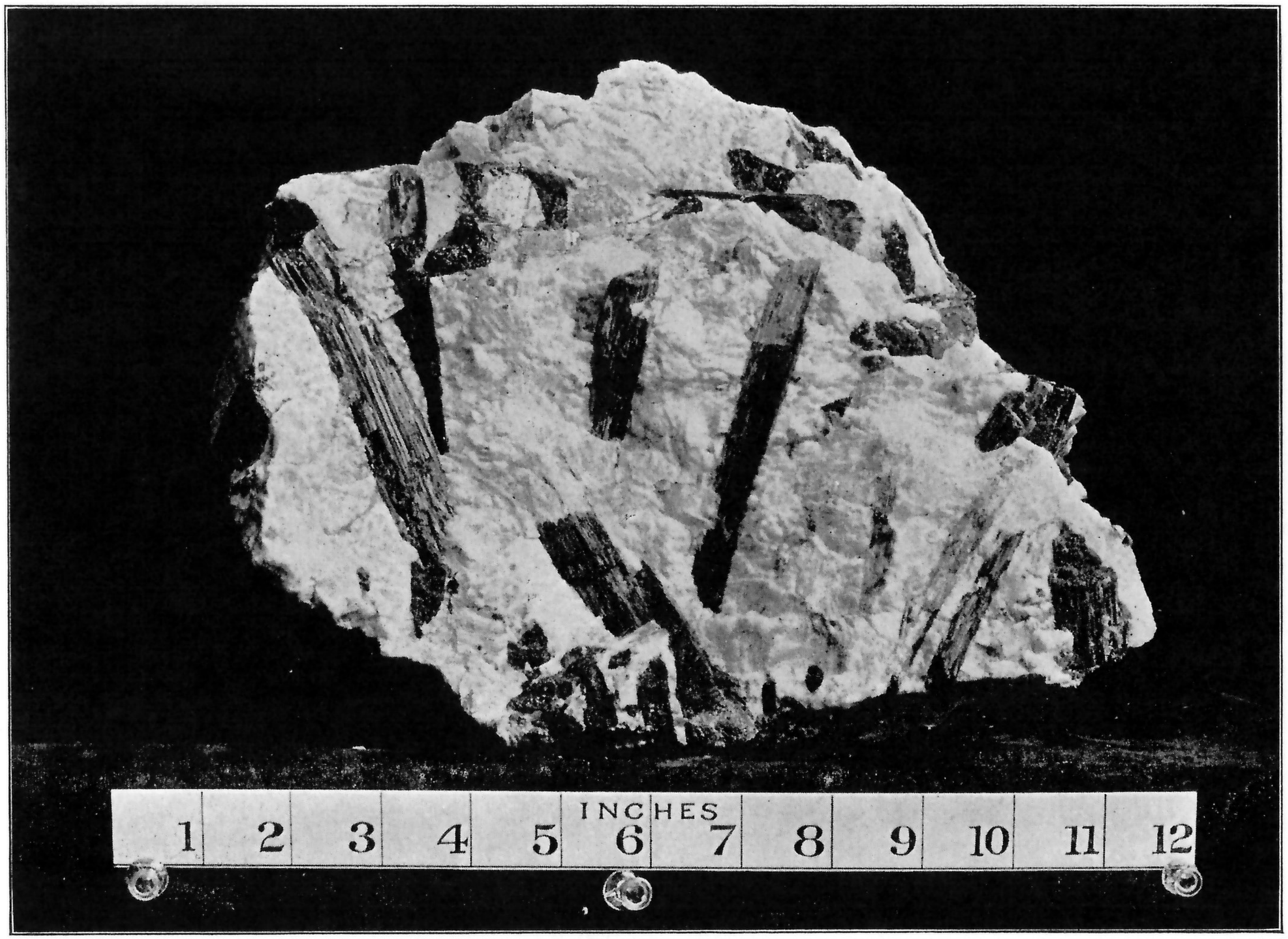
A sample of uraninite, or pitch blende, from this mine, has been analyzed by the United States Geological Survey, and was found to contain:—

Oxide of uranium......................	37·70%
Oxide of yttrium.......................	2·57%
Oxides of cerium and thorium...........	6·81%

A specimen of gummite obtained by the writer was found to slightly excite the scintilliscope, showing the presence of small quantities of radium. A noticeable feature of the occurrence of the pitch blende and gummite is that both minerals are, in the majority of instances, found closely associated with the tourmaline crystals. In fact, the majority of the latter exhibit small pittings and circular depressions containing powdery grey or yellow gummite.

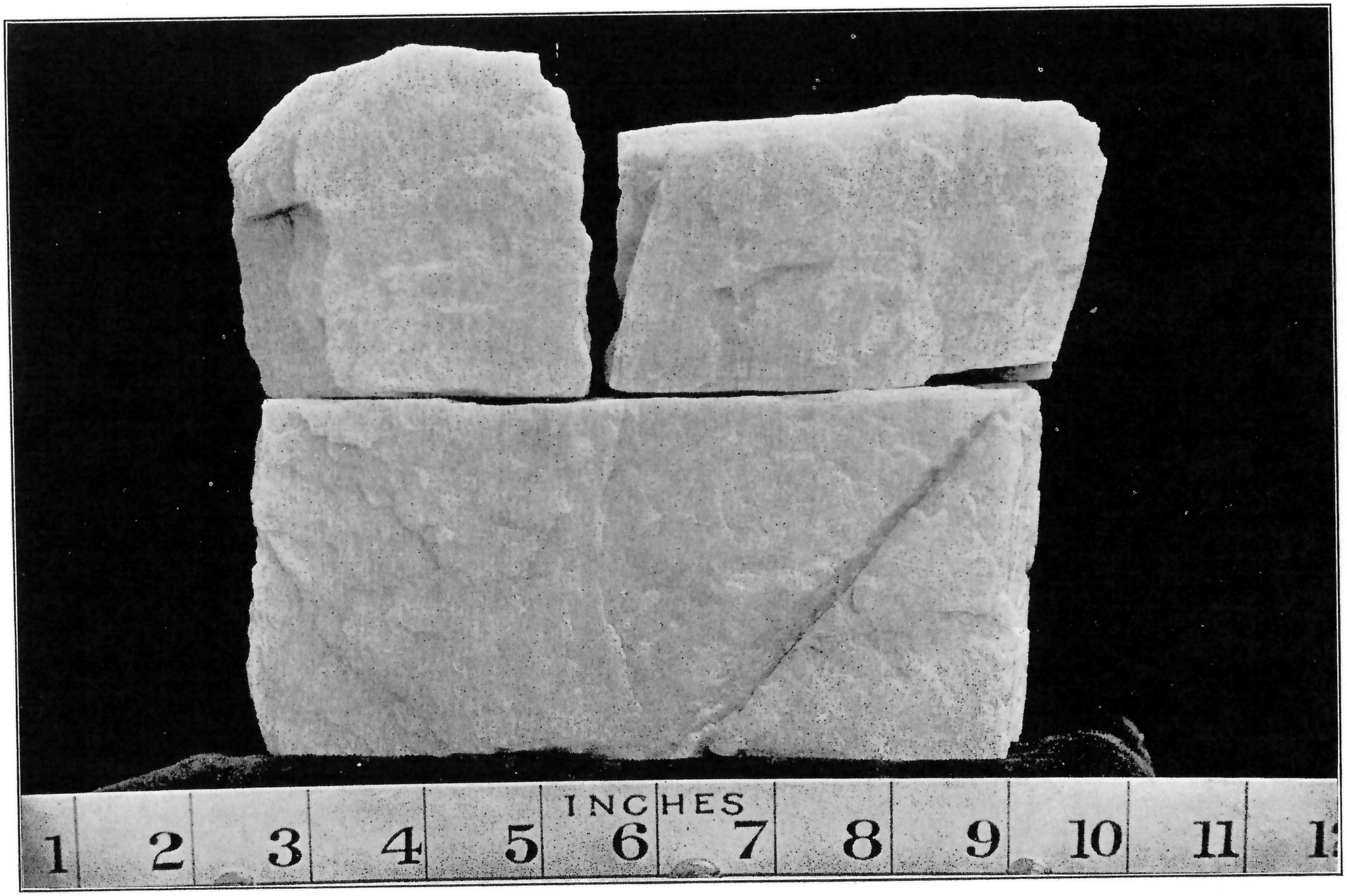
Cerite is reported to occur, and a brown, compact mineral having a matt appearance and resembling monazite was found. The occurrence of

PLATE XI.



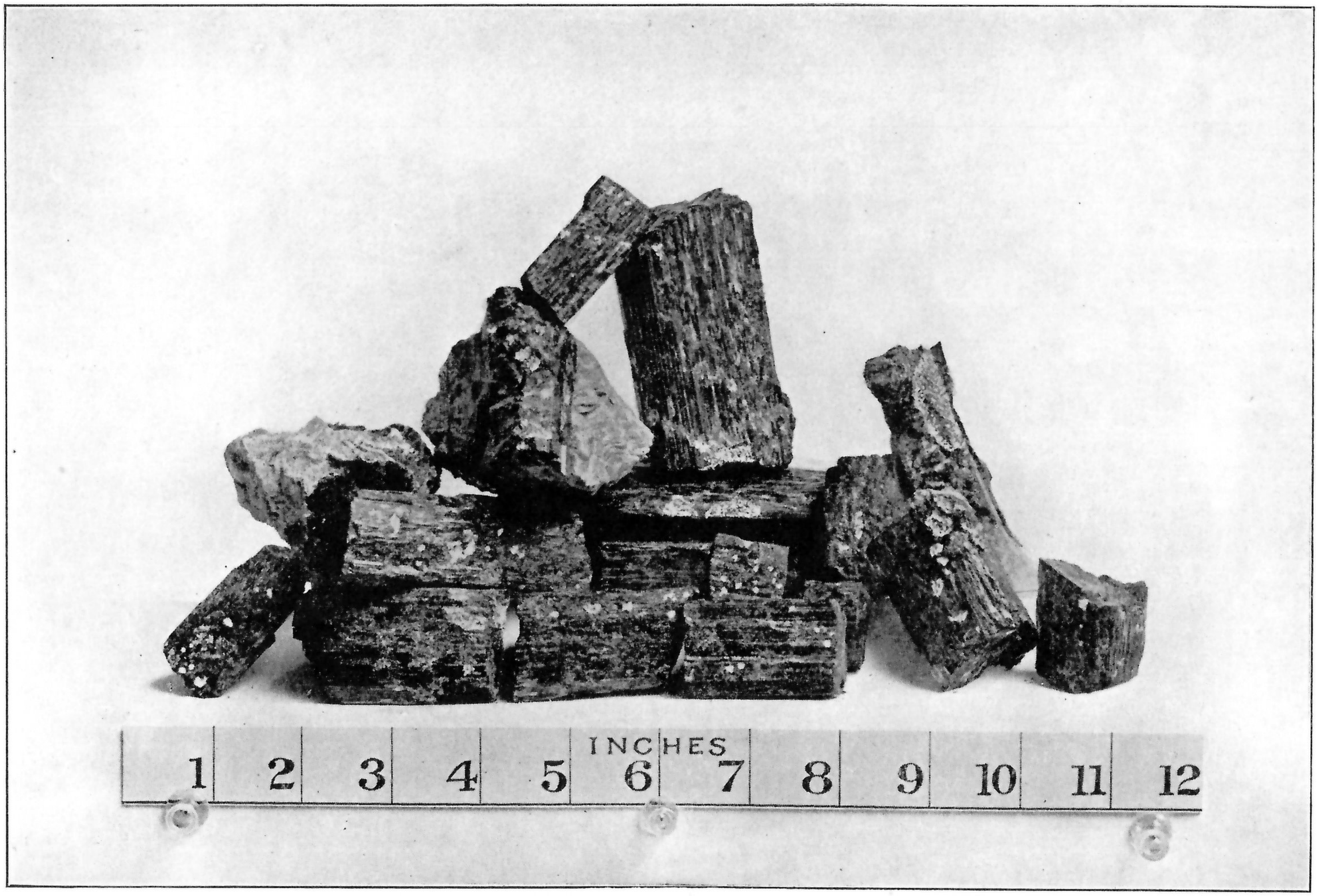
Mass of microcline and albite penetrated by tourmaline crystals, Villeneuve quarry, Que.

PLATE XII.



White microcline feldspar (dental spar) from the Villeneuve quarry, Que.

Plate XIII.



Gummite on tourmaline, Villeneuve quarry, Que. The gummite is in powdery form and shows as light coloured specks on the tourmaline.

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such minerals containing rare earths is interesting, but, as remarked above, is so seldom found that no possibility exists of their being economically exploited.

Some of the massive quartz from this mine is remarkably clear and free from flaws. When cut en cabachon, it displays a well defined six-rayed star, and is of value as a gem stone—so called 'quartz asteria' or 'star-quartz.'

Plate XIV shows a narrow dike of trap rock, probably diabase, which traverses the pegmatite near its southeast contact with the gneiss. The dike is only a few inches wide.

A peculiar variation from the ordinary crystalline habit of the microcline feldspar is exhibited by a mass in the east wall of the quarry. This consists of a very fine-grained, white material, resembling somewhat a fine sandstone and mottled with reddish spots: it occurs as a small zone in the normal spar, and under the lens is seen to consist of a mass of needles of microcline mixed with very small crystals of normal habit. On analysis this material yielded:—[1]

SiO_2	66·36
Al_2O_3	19·86
Fe_2O_3	0·63
FeO	0·05
CaO	1·20
MgO	0·03
Na_2O	0·50
K_2O	11 31
H_2O	0·12
BaO	0·01
SrO	0·03
	100·10

A specimen of rose-coloured muscovite from this mine is mentioned by G. C. Hoffman in 1887, and similar specimens were found, also, by the writer, the mineral occurring in small leaves embedded in microcline.

The finding of a large mass of monazite is also recorded, and an analysis of a portion of this mineral will be found in the American Journal of Science, 3rd Ser., Vol. 38, 1889, page 203. A mass of uraninite of over one pound in weight, partly altered to gummite, is said to have been found in the mine in 1885.

Another noticeable feature of this deposit is the entire absence of vuggs in the dike mass. In the upper portions of pegmatite bodies, cavities, lined often with crystals of feldspar, quartz, and other minerals, are a characterisitic occurrence. The absence of such cavities in the majority of Canadian pegmatites is noteworthy, and is to be ascribed, probably, to intense erosion of the original upper portions of the dikes.

[1] Analysis by N. L. Turner, Mines Branch, Department of Mines.

Two analyses, the one (A) of albite and the other (B) of microcline, conducted on selected samples of spar from this quarry, are appended:—[1]

	A	B
SiO_2	65·65	64·54
Al_2O_3	21·65	18·81
Fe_2O_3	0·46	0·08
FeO	0·03	0·06
MgO	0·18	0·02
CaO	1·20	0·57
Na_2O	9·87	2·68
K_2O	1·08	13·67
H_2O	0·08	0·10
	100·20	100·53

Geol. Surv. Can., II Ann. Rep., 1886, p. 11 T, III Ann. Rep., 1887, p. 58 T; IV Ann. Rep., 1888-89, p. 158 K; X Ann. Rep., 1897, p. 220 S; XII Ann. Rep., 1889, p. 112 J and p. 24 R.

Mines and Minerals of the Province of Quebec, 1889–90, p. 134.

Que. Bur. Min., 1888, p. 90; 1889, p. 96; 1892, p. 87; 1893, p. 105; 1894, p. 94; 1905, p. 40.

TOWNSHIP OF WAKEFIELD.

Range VII, lot 25 E. ½. Known as the Leduc quarry. This property is unique as being the only lepidolite—or lithia-mica-bearing pegmatite so far discovered in Canada. The deposit was mined for mica as far back as 1885, by L. H. Shirley, the mica being mistaken for muscovite. About a ton is reported to have been taken from one small surface pit, the plates being as much as 20 inches across.

The property is at present owned by M. J. O'Brien, who worked in 1908, the mineral sought being the green and pink tourmaline which occurs here somewhat plentifully. It was thought that the better specimens of the crystals might yield material fit for gems, but the expectation was not realized and work was abandoned after a short while. A quantity of feldspar and quartz was secured at the same time, but has not been shipped.

The deposit consists of a pegmatite dike about 40 feet in width, composed essentially of white and smoky quartz, cream-coloured microcline feldspar in which large crystals of green amazon stone sometimes occur embedded, and grey lepidolite. Green, black and pink tourmaline, in large terminated prisms as well as in aggregates of crystals, are found penetrating the quartz and feldspar matrix, and a few red garnets also occur. Perfect crystals of tourmaline are rare, and the proportion of clear and valuable specimens to cloudy and fractured mineral is small.

The mica has little commercial value, being hard and brittle, and only of importance as a source of the element lithium, of which it contains some 5·50 per cent. The sheets are too readily fusible to allow of their being used for stoves or as insulating material; besides which they are usually cloudy and split very badly. The mineral occurs in aggregates of plates

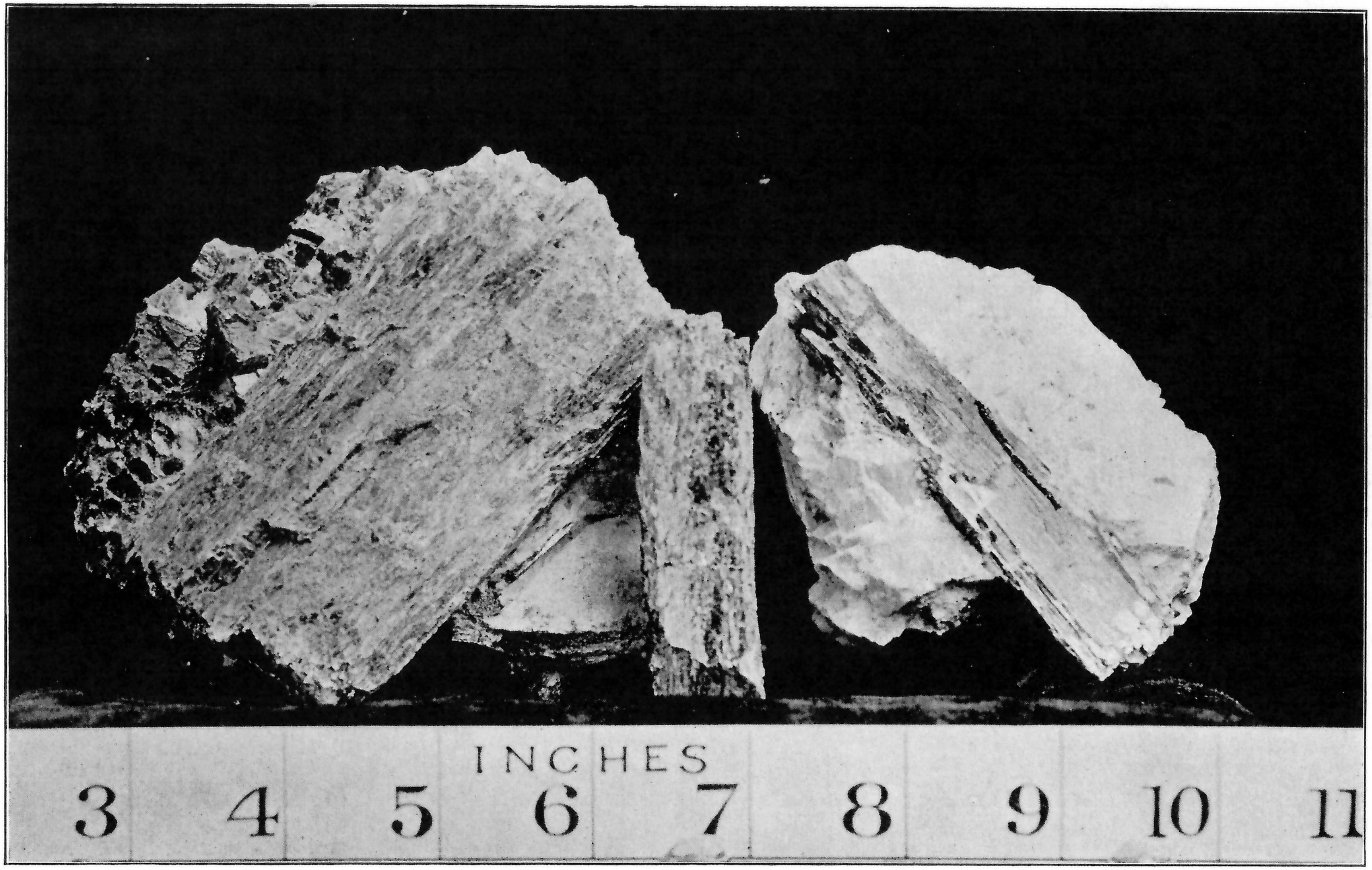
[1] Analyses by N. L. Turner, Mines Branch, Department of Mines, 1914.

PLATE XIV.

Narrow diabase dike cutting feldspar,
Villeneuve quarry, Que.

PLATE XV.

PLATE XV.



Tourmaline altered to muscovite, Villeneuve mine, Que.

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rather than in the form of crystals, the resultant form having the appearance of a flat pyramid. The interior of such an aggregate is usually formed of quartz or feldspar.

The feldspar is of fair quality, and pieces of large size can be mined in a clean and pure condition. The variety is microcline, or potash spar, with a little albite intermixed. Crystals of green microcline, or amazon stone, sometimes occur in a matrix of cream-coloured mineral, the individuals attaining a length of 18 inches.

The dike has a northeast-southwest direction and crops out on the southwest slope of a lofty ridge situated about 5 miles from St. Pierre de Wakefield. Only one opening has been made, this being an open cut 75 feet long, 20 feet deep, and 12 feet wide. No machinery has ever been used.

The following is an analysis of the mica which occurs at this mine, and was made by R. A. A. Johnston, of the Geological Survey:—

SiO_2	47·89
Al_2O_3	21·16
Fe_2O_3	2·52
MnO	4·19
K_2O	10·73
Li_2O	5·44
Na_2O	1·34
MgO	0·36
H_2O	1·90
F	7·41
Total	102·94

Specific gravity = 2·86

Small quantities of uraninite, gummite, fluorite, and spodumene are also recorded from this mine.

Analyses of the amazonite (A), and of the cream-coloured microcline (B), that occur at this quarry follow:—[1]

	A	B
SiO	64·42	64·74
Al_2O_3	18·26	18·11
Fe_2O_3	0·05	0·53
FeO	0·03	0·09
MgO	0·01	0·02
CaO	0·18	0·20
Na_2O	3·07	2·72
K_2O	14·16	13·80
H_2O	0·10	0·10
	100·28	100·31

Geol. Surv. Can., X Ann. Rep., 1897, p. 220 S; XII Ann. Rep., 1899, p. 11 R[1]; XVI Ann. Rep., 1904 p. 229 A.

Mines and Minerals of the Province of Quebec, 1889–90, p. 135.

Que. Bur. Min., 1892, p. 86.

Dept. Min. Can., Min. Br., Mon. Mica, 1912, p. 199.

[1] Analyses by N. L. Turner, Mines Branch, Department of Mines, 1914.

Pontiac County.

TOWNSHIP OF WALTHAM.

Range II, lot 30. A small deposit of feldspar occurs on this lot. The discovery is of recent date, and stripping operations only have been so far conducted. The owners of the deposit are Messrs. C. B. de Loye and A. D. Libby, of Waltham. The distance from rail is 2½ miles.

A partial analysis[1] of a sample of spar from this deposit showed:—

K_2O	12·20
Na_2O	2·89

The spar is a grey-brown microcline, often exhibiting considerable iridescence. The deposit does not appear to be extensive and does not possess dike form, the spar being apparently small segregated bodies from the granite-gneiss which forms the country rock here.

Berthier County.

TOWNSHIP OF DE MAISONNEUVE.

Range II, lots 1 and 2. Known as the Maisonneuve mine and owned by the Canadian General Mining Company, of Paris, who purchased the property in 1904. The location of this mine is too remote to permit of the extraction of feldspar at the present time, but the deposit may be mentioned as constituting a possible supply of the mineral.

Attention was first drawn to the locality in 1880, on account of the discovery there of the rare earth mineral samarskite. The deposit in which this mineral occurs is a mica-bearing pegmatite, and operations have been conducted at various times to extract the mica—the last work having been performed in 1906 by the above named Company. A steam plant was installed and a small camp erected, besides which preparations were commenced for utilizing the water power of the du Milieu river. Operations were suspended, however, at the end of 1906, though the machinery, etc., still remains at the mine.

The mine lies near Mica lake, and is some 40 miles distant from the nearest shipping point—Ste Emélie station on the Canadian Northern Quebec railway.

The pegmatite body is about 45 feet in width, and carries considerable quantities of mica. One main opening has been made on the deposit, and stripping has been carried out for a length of 300 feet. The dike mass consists of quartz and pink orthoclase feldspar, the two minerals occurring

[1] Analysis by N. L. Turner, Mines Branch, Department of Mines.

intimately associated, and are not capable of being cleanly cobbed without considerable labour. The mica crystals range up to 3 × 7 inches.

Mention has already been made of the occurrence here of the mineral samarskite, a black, lustrous species consisting principally of the oxides of uranium, niobium, yttrium, and the cerium group of heavy metals. An analysis of the samarskite found on the property yielded the following:—

Nb_2O_5	55·41
SnO_2	0·10
VO_3	10·75
Ce_2O_3	4·78
Y_2O_3	14·34
FeO	4·83
MnO	0·51
CaO	5·38
H_2O	2·21
MgO, Na_2O, K_2O	0·73
Total	99·04

Specific gravity = 4·95

Tourmaline, beryl, and garnet also occur in some quantity in the dike.

Here, as at other similar deposits in Canada, the occurrence of samarskite and other rare earth minerals is far too limited to permit of their being saved even as by-products in the mining of mica or feldspar.

Geol. Surv. Can., Rep. Prog., 1880–82, p. 1H[1]; IV Ann. Rep., 1888–89, p. 56 T.
Mines and Minerals of the Province of Quebec, 1889–90, p. 135.
Que. Bur. Min., 1892, p. 89; 1905, pp. 12, 40; 1906, p. 42.
Dept. Min. Can., Min. Br., Mon. Mica, 1912, p. 200.

Charlevoix County.

TOWNSHIP OF LACOSTE.

Block A. This property, known as the Pied des Monts mine, and situated near the lake of that name, apparently has its location wrongly given as in the township of de Sales in many of the reports upon the mine. The workings lie both on the northeast side of the lake and of the creek issuing from it, the former being the most important. At this point an approximately horizontal pegmatite body crops out on the southwest side of a steep hill rising abruptly from the lake. The apparent dip of the dike is 10° N.E., and it is overlain by black, hornblende-mica-schist. The thickness of the body could not be ascertained, nor is the underlying rock exposed at the workings; the latter, however, is probably similar to the schist above.

The workings comprise two short adits driven into the pegmatite body, and respectively 15 and 20 feet long by 8 feet high and wide. A small amount of open work quarrying of the face has also been done.

The camp consists of a large boarding house, sheds and stable, and is in a fair state of repair.

The dike mass consists of pink orthoclase feldspar and darkish quartz, in intimate association, with crystals of both muscovite and biotite mica scattered through it. The feldspar and quartz do not occur in individual large masses, but exist in more or less equal amount, and the dike mass has a medium-grained pegmatitic character. A very coarse graphic-granite structure is developed locally, the quartz figures being as much as $\frac{3}{4}''$ across. In addition to pink orthoclase, white albite feldspar also occurs. This variety is found usually in the form of large crystals, scattered through the orthoclase and quartz matrix. The mica crystals attain a maximum size of 10 × 10 inches across their basal planes. The feldspar hardly occurs in sufficiently large or pure masses to be worked, but a considerable quantity could be obtained in a clean condition with a small amount of hand cobbing as a by-product of mica mining.

As already remarked, both biotite and muscovite mica are met with in this dike, and the two varieties are not infrequently found in intergrowth with one another. In the latter case, sheets of biotite either occur enclosed between muscovite, or else a mica crystal consists partially of the one variety and partially of the other, in which case a species of twinning may result.

All the work done has so far been confined to the immediate neighbourhood of the hanging wall. This has been considerably garnetized, and the pegmatite itself adjoining the contact contains quantities of a hyacinth-red garnet. This mineral generally occurs in aggregates, associated with groups of small biotite flakes.

The dike mass proper contains few accessory minerals, but two noteworthy species are cleveite and anthraxolite. The first named is essentially uraninite, but containing about 10 per cent of the oxides of the yttrium group, and occurs here in small lustrous crystals possessing dodecahedral habit. The amount of this mineral present in the dike is small, but anthraxolite is far more common and occurs in small buttons or rounded fragments in both the feldspar and quartz. The mineral is brittle and possesses a matt, coal-like appearance. It is chiefly remarkable for the amount of uranium oxide it contains, the substance on analysis yielding the following:—

Volatile matter	40·18
Carbon	52·60
Ash	7·22
Total	100·00

The ash has been found to contain over 35 per cent of uranium oxide, and is perceptibly radio-active.

However, although the occurrence of the two minerals mentioned is of mineralogical interest, there can be no possibility of them becoming of economic value, owing to the small amount in which they occur.

This mine was first worked for mica in 1893, and was acquired the next year by the Canadian Mica Company, who worked a few years. In 1905 the property was bought by the Canadian General Mining Company, of Paris, who acquired the Maisonneuve mine, also, at the same time, and who still own both properties. No work has been carried on here since 1908.

As already noted, the main workings are located on the mountain side, near the lake and 600 feet above it. The elevation above the St. Lawrence river is 1,460 feet. Other pits exist, also, along the creek which empties out of the lake. This stream flows between steep walls, and it is in the north wall that the openings have been made. The pegmatite body is exposed along the creek for a considerable distance, and two pits have been sunk on the hanging contact of the dike with the country rock. The largest opening measures 10 × 8 feet and is 40 feet deep, being an open, vertical pit. The other excavation is an open cut 10 × 10 feet and 25 feet deep, and lies a few hundred feet nearer the lake. The location of these pits is about one mile southeast of the old workings on the lake. The dike is similar in character at both spots, pink feldspar and quartz in medium pegmatitic intergrowth forming the mass of the vein and carrying muscovite and biotite crystals, garnets (on the immediate contact), and anthraxolite.

A small camp exists near these workings, and an electric plant was installed in 1908, power being obtained from the Murray river 13 miles away. The installation comprises a dynamo, motor, and compressor, all of which are in fair condition.

The distance to Murray Bay, about 18 miles, and the consequent heavy cost of transportation, amounting to $8 per ton, renders even mining for mica an expensive undertaking; to attempt to haul the feldspar that distance would, of course, be out of the question at the present time.

About 15 tons of mica were produced by the present owners, this amount including all grades and scrap for grinding. No attempt to save the feldspar has ever been made.

Two analyses[1] of picked samples of spar from this deposit are appended; A represents selected albite, and B microcline:—

[1] Analyses by N. L. Turner, Mines Branch, Department of Mines, 1914.

	A	B
SiO_2	63·40	64·50
Al_2O_3	21·66	18·75
Fe_2O_3	0·63	0·60
FeO	0·07	0·03
MgO	0·02	0·03
CaO	3·85	0·50
Na_2O	9·41	3·57
K_2O	1·09	12·18
H_2O	0·10	0·12
SrO	0·09	.....
BaO	....	0·01
	100·32	100·29

Que. Bur. Min., 1893, p. 106; 1894, p. 99; 1895, p. 60; 1898, p. 42; 1903, p. 65; 1905, pp. 12, 41; 1906, p. 42.
Jour. Can. Min. Inst., Vol. VII, p. 245.
Dept. Min. Can., Min. Br., Mon. Mica, 1912, p. 201.

Saguenay County.

TOWNSHIP OF BERGERONNES.

Block G.—McGie mine. This property, which was worked between 1891 and 1894 for mica and yielded a considerable quantity of the mineral, lies 12 miles from Escoumains and near Cassette brook. The deposit is far too remote to be worked for its feldspar, but may be mentioned as constituting a deposit of the mineral. The pegmatite body is reported to possess a width of from 25 to 70 feet, and to extend for over 500 yards.

The character of the terrain in this neighbourhood is mountainous, large barren ridges and hills being the predominating feature. These ridges consist principally of reddish or dark mica-schist, and have been extensively squeezed and intruded by pegmatite stringers, some of which, as the above location, carry mica in economic quantities.

The property is owned by G. B. Hall, of Quebec.

Geol. Surv. Can., X Ann. Rep., 1897.
Que. Bur. Min., 1892, p. 89; 1893, p. 105; 1894, p. 98.

TOWNSHIP OF LITTLE BERGERONNES.

Block H.—Beaver lake mine. This property has been worked in a small way for mica in the past, the last operations having been conducted in 1894. The mine lies 18 miles north of Tadousac at the mouth of the Saguenay river, and 15 miles from Escoumains. The location is very inaccessible, and the old mine roads are now almost impassable. A small camp originally existed on the property, but all the buildings have disappeared. No machinery was ever employed.

The workings are unimportant, and comprise a number of shallow prospect openings scattered along a high ridge of white pegmatite. The rock is composed of quartz, white feldspar and small flakes and crystals of light brown coloured muscovite; while biotite occurs also in smaller amount.

Crystals of muscovite were observed entirely enclosing perfectly formed biotite individuals, and vice versa. The mica individuals seldom exceed 6 inches across. A little black tourmaline, green apatite, and dark red garnet occur as accessory constituents of the dike. Quartz is the principal constituent of the pegmatite body, feldspar occurring in minor amount. Even were the property more accessible, it is doubtful whether feldspar could be obtained in sufficiently large amount or pure state to render its extraction worth while.

Que. Bur. Min., 1892, p. 89; 1893, p. 105; 1894, p. 98; 1898, p. 42.

TOWNSHIP OF TADOUSAC.

Mica-bearing pegmatite dikes have been located at several points in this and adjoining townships, and have in some cases been worked in a small way for their mica. One such deposit exists on range III of Tadousac, and was worked by Messrs. Caron and Demeules in 1892. The lot number could not be ascertained. The remote location of most of these deposits is a hindrance to their ever becoming sources of supply for feldspar. Were the mineral brought out to the water at either Tadousac or Escoumains, however, it could be shipped with little expense to Montreal or United States ports.

LOWER ST. LAWRENCE.

A deposit of feldspar that has received frequent mention in Geological Survey and Bureau of Mines reports, etc., is that situated near Piashti bay, on the north shore of the gulf of St. Lawrence, in longitude 62° 40′, and north of the central portion of the island of Anticosti. This location is variously referred to under one or more of the following names, with or without the physiographical designation of river, bay, etc. The correct location of the deposit is upon Manikuagan peninsula, east side of Quetachu bay, at the mouth of the Watshishu river. The locality can be reached by schooner from either Eskimo point or Natashkwan—both these places being ports of call for the north shore mail boats—Piashti bay lying about midway between the two, and some 35 miles from either. The distance below Quebec is about 325 miles.

The property is at present owned by the Canadian Feldspar Company, of Montreal, who acquired the deposit a few years ago. Beyond shipping a small trial consignment of about 30 tons to the potteries at Trenton, N. J., and also to England, the owners have carried out no work. The property was leased in 1912 to a syndicate, who, however, did little beyond prospecting work, three men being employed for a couple of months in surface stripping. Several hundred tons of spar were lying at the quarry when the property was visited,[1] but none had been shipped. A quantity estimated at about 200 tons is reported to have been taken out as far back as 1899,

[1] In 1912.

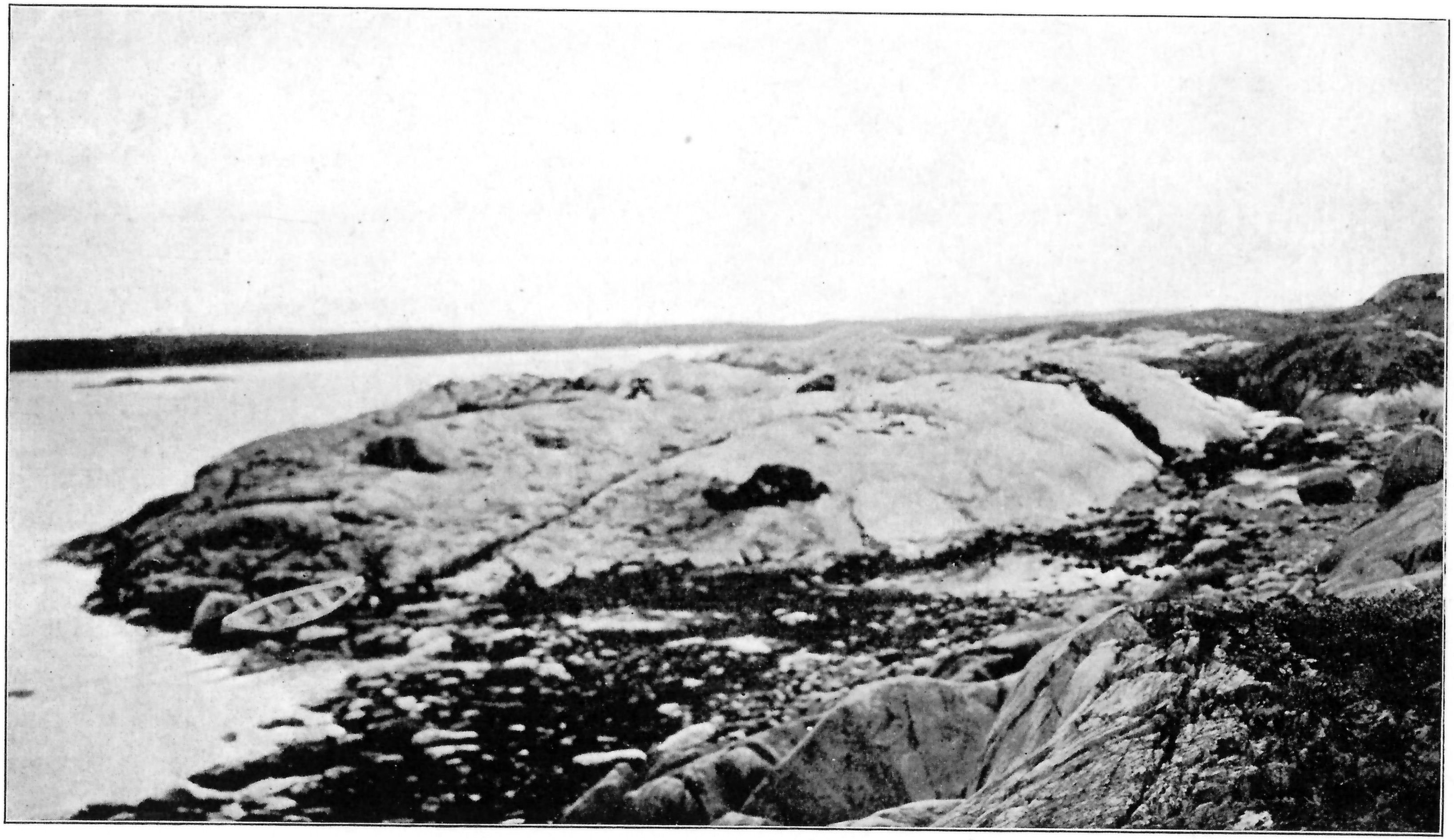
but no record of shipment is obtainable; the mineral at present lying on the property probably includes this output. No machinery has ever been employed, though the present owners purposed installing a boiler and steam drills, part of the equipment being ready to ship in the latter part of 1912. The entire work so far performed consists solely of stripping off the thin overburden of moss and soil which covers a great part of the deposit, and of blasting out the purer spar exposed on the surface.

The deposit consists of a pegmatite body composed of microcline feldspar and quartz. The feldspar is of a light cream colour, and occurs locally as large individual crystals scattered through a matrix of more or less coarse-grained graphic-granite; the usual mode of occurrence, however, is in small individuals, graphically intergrown with quartz. The large individuals frequently yield plates or slabs of pure spar up to 18 inches in length. The proportion of feldspar to quartz in the dike is sufficiently large, were it not for the presence of injurious accessory minerals in the dike mass, to permit of a large amount of the mineral body being shipped crude with a minimum of hand cobbing, the percentage of quartz in several zones in the dike averaging under 10 per cent. The amount of quartz present in the graphic-granitic zones would average around 25 per cent; while probably 10 per cent of the run-of-mine would represent clean spar. Whether these conditions would persist in depth can only be determined by actual development; the pegmatite body, however, is of sufficient width to warrant the assumption of approximate homogeneity throughout its mass to a considerable depth.

The accessory minerals referred to above and which detract from the value of the feldspar for pottery purposes, are biotite mica, black tourmaline, and garnets. The last two, however, occur in such small quantity as to be of little importance. The mica is more abundant, and occurs in the form of thin leaves as much as 6 inches across but seldom exceeding $\frac{1}{4}$ inch in thickness. Yet another deleterious constituent of the dike is a soft, greenish-grey clay, which is to be noticed in small vuggs or cavities throughout the dike mass; this is, apparently, a decomposition product of some other mineral—perhaps garnet. The cobbing of this substance from the feldspar must entail considerable labour; as, though the proportion present in the dike is relatively small, a very small amount of such foreign mineral in pottery spar is sufficient to materially detract from its value. Rose quartz occurs in certain portions of the dike, but is not of a very deep or fine colour. No rare earth minerals were observed. Molybdenite occurs in small splashes along the eastern contact of the pegmatite with the country rock; the mineral is not present in economic quantity, although attempts have been made to mine it.

The spar body forms part of a tongue of land running out in a westerly direction from the eastern side of Quetachu bay. This tongue is some 250 yards wide, and consists on its northern, or inland side, of pegmatite, and on its southern side of black hornblende-mica-schist. This latter rock

PLATE XVI.



Spar body at Manikuagan bay, lower St. Lawrence, Que.

PLATE XVII.

PLATE XVII.

Stripped surface of spar body, Manikuagan bay, lower St. Lawrence, Que.

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forms the country rock in this region, and, at this particular point has a strike of northwest and southeast (see Plate XVI). This dark schist has been very extensively shattered and intruded by a granite batholite, with the result that there is considerably more granitic rock to be seen in the region than schist. Dikes of the former rock have cut the earlier formation in all directions, the visible schist now representing isolated blocks and zones enclosed in granite. A considerable degree of differentiation would appear to have taken place in the granitic magma; for, while the greater portion of the area displays more or less normal granitic structure, local zones exhibit a decidedly pegmatitic development, with a considerable preponderance of feldspar over quartz.

The spar belt on this property has a width of about 200 feet, and has been stripped over an area of 100 × 900 feet. The dike probably extends for a considerable distance shorewards. The average height of the peninsula above high water level is 30 feet, and, as deep water extends right up to the deposit, loading of the mineral into barges should present no difficulties. Good anchorage exists, the inlet being narrow and well protected from storms. Freight rates to Trenton, N. J., have been estimated at about $2 per ton.

An analysis of picked spar—that is, of mineral unmixed with quartz, etc.—from this property yielded:—

Silica	64·60
Alumina	19·24
Potash	11·75
Soda	3·41
Ferric oxide	0·23
Water	0·21
Total	99·44

The melting point was determined at 1317°C. A sample of the graphic-granite has also been analysed and found to contain:—

Silica	74·00
Alumina	14·23
Potash	8·80
Soda	1·96
Ferric oxide	0·07
Water	0·18
Total	99·64

This analysis[1] would show a percentage of nearly 29 of quartz to 69 of feldspar, a ratio which would have to be adjusted by the addition of hand-picked feldspar were the mineral to be utilized for pottery purposes.

[1] Both the above analyses were conducted for the owners by the Canadian Inspection and Testing Laboratories, Montreal.

A further analysis of a selected sample of spar from this deposit, conducted by N. L. Turner, of the Mines Branch, in 1914, follows:—

SiO_2	64·78
Al_2O_3	18·05
Fe_2O_3	0·46
FeO	0·03
CaO	0·40
MgO	0·02
Na_2O	2·72
K_2O	13·80
H_2O	0·12
BaO	0·01
	100·39

This analysis shows over 2 per cent more potash than the first of the preceding ones.

Que. Bur. Min., 1899, p. 27; 1911, p. 32.
Can. Min. Journ., Jan. 1, 1911, p. 27.

BRITISH COLUMBIA.

Mica-pegmatites are found on the western slope of the Rockies throughout a broad zone stretching southward from Tête Jaune Cache, on the Grand Trunk Pacific railway, to Revelstoke, on the Canadian Pacific railway. None of the dikes so far located are of exceptional size, and mica and garnet are present in sufficient quantity to render the greater part of the feldspar unfit for ceramic purposes. None of the pegmatites have been worked at all extensively for their mica, but a small quantity of fair grade muscovite has been secured from loose surface boulders and outcrops both in the vicinity of Tête Jaune itself and in the Big Bend district farther south. The outcrops are situated, for the most part, on the upper slopes and crests of the mountains, and are mostly inaccessible except by packing.

"White Mica Occurrences in the Tête Jaune Cache and Big Bend Districts of British Columbia," Mines Branch Summary Report for 1913, pp. 42–49.

LABRADOR.

This territory has given its name to the lime-soda feldspar "labradorite." Though of not uncommon occurrence as a constituent of many igneous rocks, especially basic types—diorite, diabase, norites, gabbros, etc.—the finest specimens known are from the original discovery at Point Pownal, or Pauls Island, near Nain, on the eastern Labrador coast.[1] The mineral here would appear to be a constituent of a gabbro, the rock being very coarse-grained and the feldspar occurring in large crystals, from which cleavage fragments of considerable size can be split. The Pauls Island labradorite is chiefly valued on account of the high degree of colour-play

[1] The situation of Pauls Island is erroneously given in many reports as in the Strait of Belle Isle, whereas it lies some 350 miles farther north.

exhibited by the cleavage faces, and the mineral is cut and polished as a semi-precious stone for buttons, sleeve links, scarf pins, etc.

Low mentions the occurrence of large and beautiful crystals of labradorite at several points inland, *e.g.* on the northeast side of Lake Michikamau and on the islands in Lake Ossokmanuan, both at the headwaters of the Hamilton river. The rock type indicated at these points is anorthosite.

Geol. Surv. Can. IV, Ann. Rep., 1888–89, Part K, p. 157.

Bell, R., Geol. Surv. Can., Rep. Prog., 1882–84, Part DD, p. 12.

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Geol. Surv. Can., Annual Reports.

PART II.

CHAPTER I.

THE FELDSPARS.

CHARACTERISTICS OF THE VARIOUS MEMBERS OF THE FELDSPAR GROUP OF MINERALS.

The generic term feldspar includes a number of minerals which, while for the most part forming a gradational, isomorphous series, yet possess a considerable range of composition, but which, on account of certain similarities—notably crystallization, cleavage, hardness and general appearance—have been grouped together in one family. The various members of the family represent essentially a replacement series between pure potassium aluminium silicate or orthoclase, at one end, pure sodium aluminium silicate or albite, and pure calcium aluminium silicate or anorthite, at the other end, the last named being the rarest of the three. None of these pure extremes are commonly met with in nature, the three bases potassium, sodium, and calcium nearly always replacing one another to some extent. The lime-soda and soda-lime members between albite and anorthite in composition are, thus, isomorphous mixtures of these two extremes.

The following comprise the various members of the feldspar group, with their theoretical compositions and characteristics. Each species possesses a number of minor varieties, which, however, are mostly named from individual occurrences, and, as such, are not important:—

Characteristics and Theoretical Composition of the Various Feldspar Groups.

Name	Composition	Theoretical Percentages	Remarks
Orthoclase (Potash feldspar)	$KAlSi_3O_8$	Silica........64·7 Alumina.....18·4 Potash......16·9	Common varieties: adularia and sanidine, the former in crystalline schists and metamorphic rocks and the latter in late volcanics. The common feldspar of granitic rocks. Often in large phenocrysts in porphyritic rocks of this type. White, grey, buff and reddish in colour. Crystallizes in the monoclinic system, as does also the next named: all the other members of the group, however, belong to the triclinic system.
Hyalophane	$(K_2, Ba)\ Al_2Si_4O_{12}$	Silica........51·6 Alumina.....21·9 Baryta......16·4 Potash......10·1	A rare variety containing barium.
Microcline................	$KAlSi_3O_8$.	As for orthoclase	Sodium usually replaces the potassium to some extent. Common as a constituent of granitic rocks; differs from orthoclase in its system of crystallization. A green variety is known as amazonstone.
Anorthoclase (soda-potash feldspar)	$(KAlSi_3O_8)\ (NaAlSi_3O_8)$ Ratio of sodium silicate to potassium silicate— 2 : 1, 3 : 1		Resembles orthoclase and microcline. Chiefly found in andesites and porphyrites.
Albite (soda feldspar)	$NaAlSi_3O_8$	Silica........68·7 Alumina.....19·5 Soda........11·8	Isomorphous with anorthite or lime feldspar. Between these two extremes a number of intermediate mixtures are known (see below). Colour white, bluish and green; often exhibits colour-play (peristerite). Occurs with orthoclase or microcline in many crystalline rocks. The albite-anorthite series are known as the plagioclase feldspars.
Oligoclase (soda-lime	$(NaAlSi_3O_8)\ (CaAl_2Si_2O_8)$	*For* Ab_3An_1	Colour, whitish, grey-greenish; occurs in granitic and

Oligoclase (soda-lime feldspar)	($NaAlSi_3O_8$) ($CaAl_2Si_2O_8$) Ratio of albite (Ab) to anorthite (An), Ab_6An_1 — Ab_3An_1	*For Ab_3An_1* Silica........62·0 Alumina.....24·0 Lime........ 5·3 Soda........ 8·7	Colour, whitish, grey-greenish; occurs in granitic and other crystalline rocks. The ratio of albite to anorthite (Ab : An) is not constant but is commonly as indicated.
Andesine (soda-lime feldspar)	($NaAlSi_3O_8$) ($CaAl_2Si_2O_8$) Ratio of Ab to An, Ab_3An_1—Ab_1An_1	*For Ab_1An_1* Silica........55·6 Alumina.....28·3 Lime........10·4 Soda........ 5·7	Another intermediate species. Not common.
Labradorite (lime-soda feldspar)	($NaAlSi_3O_8$) ($CaAl_2Si_2O_8$) Ratio of Ab to An, Ab_1An_1—Ab_1An_3	*For Ab_1An_3* Silica........49·3 Alumina.....32·6 Lime........15·3 Soda........ 2·8	Common as a constituent of certain basic rocks, with hornblende and pyroxene. Colour, grey, brown or greenish, exhibits commonly beautiful colour-play.
Anorthite (lime feldspar)	$CaAl_2Si_2O_8$	Silica........43·2 Alumina.....36·7 Lime........20·1	Usually contains some soda. Rare in the crystalline rocks; more often present in andesites, basalts, etc. Colour, white, grey or reddish. The variety bytownite includes intermediate species between anorthite and labradorite, and having the range Ab_1An_3—Ab_1An_6. Isomorphous with albite.

OCCURRENCE OF FELDSPAR.

Feldspar is one of the commonest minerals met with in the crystalline rocks, and is one of the essential constituents of almost all igneous types. According to Clarke,[1] the feldspars form nearly 60 per cent of the constituents of the igneous rocks. Potash spar, either the monoclinic variety orthoclase or the triclinic microcline, is the most common of the whole family, and is a constituent of all granites and pegmatites. It is the species usually quarried and employed in the ceramic and other industries. A little soda spar or albite is raised in Pennsylvania and Maryland.

The plagioclase spars (albite-anorthite group) are more common in the basic rocks, such as gabbro, basalt, etc., the extreme anorthite (lime feldspar) being approached as the proportion of silica in the original magma decreases. The more acid rocks contain usually the more siliceous spars,

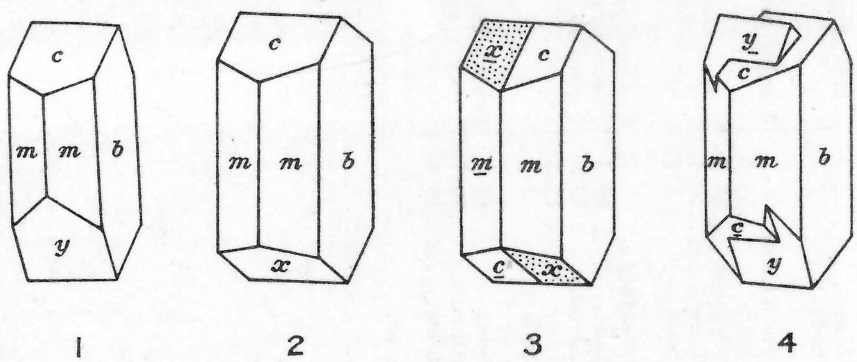
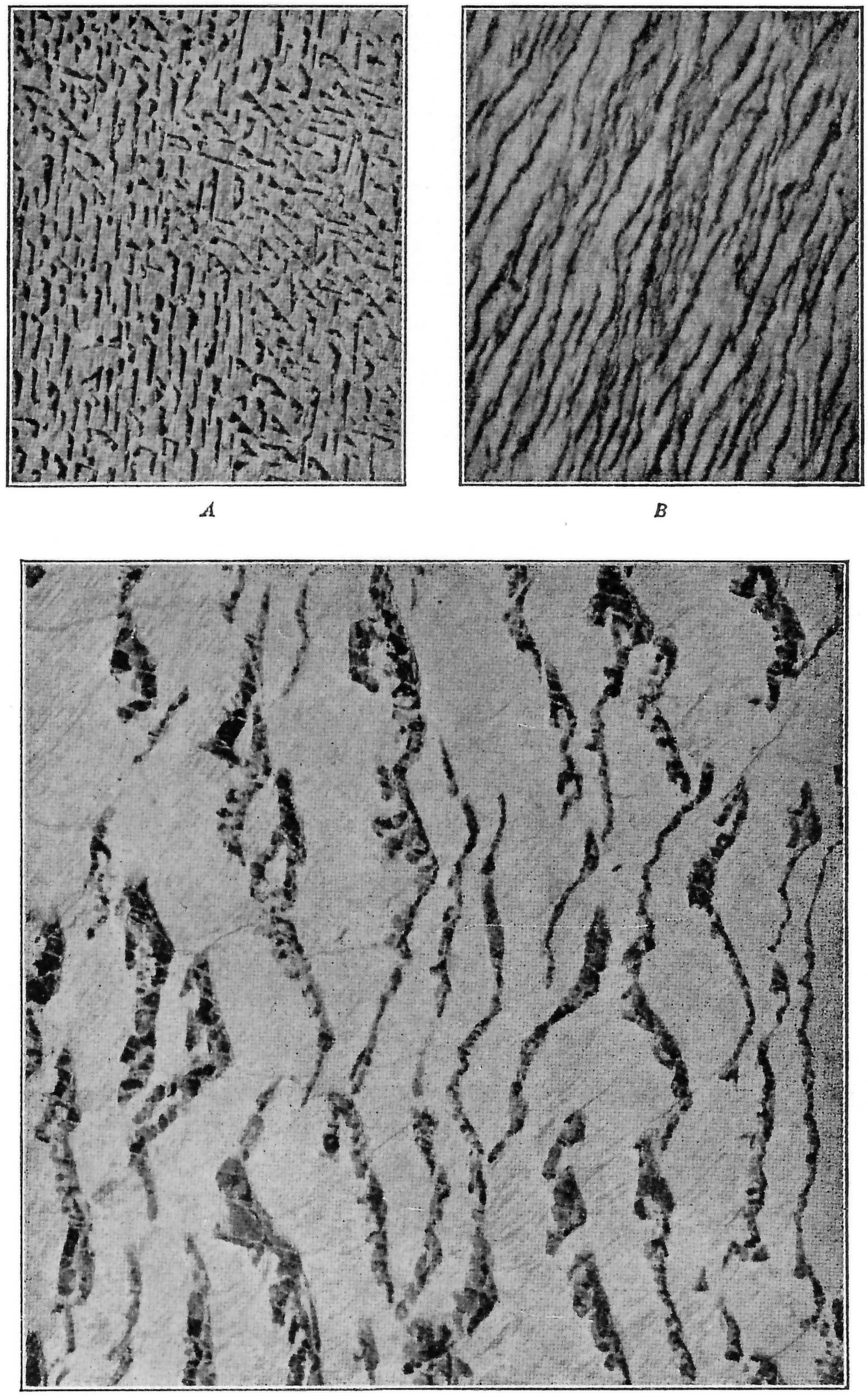


Fig. 10. Common types of orthoclase crystals (after Dana).
1 and 2, simple forms; 3 and 4, Carlsbad twins.

and vice versa. Anorthite is not uncommon as a contact metamorphic mineral in limestones. As a general thing, the feldspars are rock-forming minerals and are not found on ore veins, though there are one or two notable exceptions to this rule.

In the fine-grained igneous rocks, the feldspar, quartz, mica, hornblende, etc. are present as a mixture, the individual constituents of which are often only to be distinguished under the lens, or with difficulty with the naked eye. In the coarser types and more especially in the porphyritic varieties, the feldspar is often the most conspicuous of the constituents, large phenocrysts of orthoclase up to several inches in length being common in certain granites and porphyries. These crystals are commonly twinned according to the Carlsbad law (see below). In the "giant granites," or pegmatites, the feldspar individuals often attain enormous size, though the crystal outline is not always obvious. In such case, a number of crystals are commonly aggregated to form great ledges or benches of spar separated by bodies of quartz; these spar masses may contain many tons of almost

[1] Clarke, F. W., "Data of Geochemistry," Bull. No. 491, U.S. Geol. Surv., 1911, p. 348.



A B

C

Reproduced from Bull. No. 420, United States Geological Survey.

Intergrowth of feldspar and quartz, exhibiting characteristic graphic-granite structure. A, fine-grained graphic-granite from Bedford, N.Y.; B, fine-grained graphic-granite from Topsham, Maine; C, coarse graphic-granite from Topsham, Maine.

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[1] Bull. No. 42
[2] See Clarke,
[3] Grünwald, J

pure mineral, though a certain amount of included quartz is generally present in the form of stringers.

The peculiar intergrowth of quartz and feldspar known as "graphic-granite" where the quartz assumes forms resembling ancient cuneiform characters, is common in many pegmatites and spar bodies (see Plates VIII, XVIII). Graphic-granite may be fine or coarse-grained, the quartz pieces ranging up to about two inches in length. Bastin[1] found that the quartz content of both fine and coarse graphic-granite is fairly constant and averages about 23 per cent.

ALTERATION AND DECOMPOSITION OF THE FELDSPARS.

All the members of the family are readily altered, and their alteration products are numerous. Water alone suffices to attack them, carbonated waters exercise a high degree of decomposition, and acid waters are even more effective. Daubrée agitated fragments of potash spar with water by revolving in a cylinder for 192 hours, and obtained from 5 kilograms of spar 12·6 grammes of K_2O.

The alteration products of the feldspars are commonly kaolin (china clay) and quartz, as well as other hydrated silicates of alumina. The large kaolin deposits of Cornwall are variously regarded as having been formed by the decomposition of granitic feldspar by meteoric waters or by pneumatolytic agency; the latter theory is the more favoured of the two, and the chief attacking agent is surmised to have been a fluorine compound. When all of the alkali has not been removed, muscovite mica is a common resulting mineral. Many of the zeolite group of minerals, also, are regarded as hydrated feldspars. Scapolite is a common alteration product of the feldspar associated with the Canadian mica-pyroxenites, and epidote and zoisite may also be formed. One feldspar may even pass into another, cases of orthoclase altered to albite being known.[2]

Where the feldspar of a granite or pegmatite has been kaolinized by meteoric waters, the decomposed zone is usually only superficial, and at a relatively shallow depth the hard, unaltered rock is encountered.

Grünwald[3] cites interesting experiments on the decomposition of feldspar by electrolysis. A finely ground (200 mesh) potash spar containing 11·4 per cent alkali was made into a paste with distilled water and placed in an unglazed porous pot containing a carbon electrode, the pot being inserted in a large glass cylinder filled with distilled water. The second carbon electrode was introduced between the porous cell and the glass wall. The current used was 110 volts, the inner electrode being connected to the positive pole. When dry, ground spar was used, not more than 0·03 per cent of the alkali present could be extracted, but with wet, ground mineral, 0·3 to 0·4 per cent was obtained.

[1] Bull. No. 420, U. S. Geol. Surv., 1910, p. 14.
[2] See Clarke, F. W., *op cit.*, p. 568.
[3] Grünwald, J., "Raw Materials for the Enamel Industry," 1914, pp. 7–8.

In a later experiment, electrolysis was continued until the amount of alkali given off became inappreciable, when the paste was removed, reground, and again electrolysed. After fourteen repetitions of the above procedure, 3·6 per cent, or about one-third of the total content, was extracted. By continuing the process, the complete removal of the alkali, or, in other words, the total kaolinization of the feldspar, may be effected.

Fused spar is attacked more readily by water and carbonic acid than the crude mineral.

FUSION POINT OF THE FELDSPARS.

The melting point of the feldspars, as determined by a number of investigators, ranges from 1,115° C. to 1,520° C., these being the extreme lowest and highest figures for the entire group. The various results, as quoted by Clarke[1] are shown below, the temperatures being in degrees Centigrade:—

	Joly	Cusack	Doelter	Brun
Anorthite	.....	......	1,165–1,210	1,490–1,520
Labradorite	1,230	1,223–1,235	1,040–1,210	1,370
Andesine	.....	......	1,155–1,185	1,280
Oligoclase	1,220	......	1,135–1,185	1,260
Albite	1,175	1,172	1,115–1,170	1,259
Orthoclase	.....	......	1,185–1,220	......

CRYSTALLIZATION.

The whole of the feldspar group, with the exception of the most common species orthoclase and of the rare barium spar hyalophane, crystallize in the triclinic system; the two named are monoclinic. All the feldspars possess distinct cleavage in two directions, the cleavage faces being smooth and lustrous and inclined at 90° or nearly 90° to each other.

HARDNESS AND SPECIFIC GRAVITY.

The hardness in each case is 6 to 6·5 and the specific gravity ranges from 2·5 in the case of orthoclase to 2·76 for anorthite.

ANALYSES OF FELDSPARS.

The following analyses serve to indicate the range in composition of the feldspar commonly found in pegmatites and spar bodies, and are taken from the reports of Bastin[2] and Watts[3] already quoted:—

[1] Clarke, F. W., *op. cit.*, p. 279.
[2] Bull. No. 420, U. S. Geol. Surv., 1910, p. 9.
[3] Bull. No. 53, U. S. Bur. Min., 1913, p. 88.

Analyses of Feldspars from Various Sources.

	1	2	3	4	5	6
Silica............	64·7	64·98	66·23	65·95	76·37	65·87
Alumina..........	18·4	19·18	18·77	18·00	13·87	19·10
Ferric oxide.......	....	0·33	.....	0·12	.....	.....
Lime.............	....	.....	0·31	1·05	0·26	0·20
Magnesia.........	....	0·25	.....	.....	.....	.....
Potash...........	16·9	12·79	12·09	12·13	5·24	12·24
Soda.............	....	2·32	3·11	2·11	3·74	2·56
Water............	....	.....	.....	.....	0·30	0·64
Loss on ignition...	....	0·48	.....	.....	.....	.....

1. Theoretical composition of pure orthoclase or microcline.
2. Crude Norwegian spar, used at the Royal Porcelain Works, Charlottenburg, Sweden.
3. Crude No. 1 grade, pink microcline, from quarry of the Kingston Feldspar Mining Company (Richardson and Sons), Bedford township, Ontario.
4. Crude, pink microcline, from quarry of P. H. Kinkles' Sons, Bedford, Westchester county, N.Y.
5. Ground, No. 3 grade spar, from same locality as No. 4; used for glass making.
6. Ground sample of same spar as No. 3, taken at mill of Eureka Flint and Spar Company, Trenton, N.J.

The approximate mineral composition of samples Nos. 5 and 6, as calculated from the above analyses, is:—

	No. 5	No. 6
Quartz..	34·37	3·84
Orthoclase or microcline..............................	30·58	72·28
Albite..	32·83	22·59

The low quartz content of No. 6, a bin sample, shows the purity of the feldspar shipped from the Richardson quarry, Bedford, Ontario.

	7	8	9	10	11	12
Silica............	73·89	73·92	72·76	71·00	65·73	65·23
Alumina..........	13·75	14·26	15·47	16·31	19·28	20·09
Ferric oxide.......	0·26	0·30	.....	.....	.....	0·71
Lime.............	.....	.....	0·19	0·22	0·22	.....
Potash...........	9·00	8·99	9·28	8·66	10·26	11·60
Soda.............	2·10	2·06	2·35	3·44	4·08	2·00
Water............	0·24	0·11	0·15	0·12	0·48	.....
Loss on ignition...	....	.....	.....	.....	.....	0·36
	99·24	99·64	100·20	99·75	100·05	99·99

7. Cream-coloured, coarse graphic-granite, from the Fisher quarry, Topsham, Maine.
8. Medium grained graphic-granite, from same locality as No. 7.
9. Pinkish, fine graphic-granite, from Kinkles' quarry, Bedford, Westchester county, N.Y.
10. White, fine graphic-granite, from Andrew's quarry, Portland, Conn.
11. Sample of ground, selected No. 1 spar, nearly quartz-free, from quarry of the Maine Feldspar Company, Auburn, Maine.
12. Buff-coloured spar from the Golding quarry, Georgetown, Maine.

The following analyses are chiefly of spars from various mica mines in the United States:—

	13	14	15	16	17	18	19
Silica	64·48	62·95	65·37	65·40	63·90	64·30	64·92
Alumina	19·43	19·66	17·92	20·70	19·97	19·64	22·28
Ferric oxide	0·01	....	0·02	0·10	0·15	0·08	0·21
Lime	....	....	0·17	1·60	0·05	....	1·60
Potash	13·19	8·39	13·05	6·00	13·20	14·00	1·10
Soda	1·84	7·64	2·10	6·10	1·01	1·32	9·20
Water	0·90	....	0·17	0·30	0·60	0·50	1·00
Baryta	....	....	....	....	0·70	0·17	....
	99·85	98·64	98·80	100·20	99·58	100·01	100·31

13. Feldspar from the Witherspoon mica mine, Ashe county, N.C.
14. Spar from the Avery Meadow mica mine, Avery county, N.C.
15. Sample from the Plumtree mica mine, Avery county, N.C.
16. Lisle Knob mica mine, Macon county, N.C.
17. McGuire prospect, Macon county, N.C.
18. Southern Clay Company's mine, Macon county, N.C.
19. Albite, from workings of the Carolina Mineral Company, Mitchell county, N.C.

	20	21	22	23	24	25	26
Silica	65·68	65·18	64·93	65·15	64·85	68·18	68·75
Alumina	19·08	21·60	19·45	19·04	19·90	20·12	18·56
Ferric oxide	0·14	....	....	....	....	0·05	0·03
Lime	....	0·64	0·05	0·12	....	0·66	1·25
Potash	13·09	0·04	12·46	7·28	2·91	0·66	6·85
Soda	2·08	8·35	2·54	7·00	10·04	9·38	4·29
Water	0·30	....	0·40	....	....	0·20	0·10
	100·37	95·81	99·83	98·59	97·70	99·44	99·83

20. Microcline, from quarry of Carolina Mineral Company, Mitchell county, N.C.
21. Cloudland mica mine, Mitchell county, N.C.
22. Cook mica mine, Mitchell county, N.C.
23. Flat Rock mica mine, Mitchell county, N.C.
24. Wiseman mica mine, Mitchell county, N.C.
25. Ray mica mine, Yancey county, N.C.
26. McNichols Company's mine, Bedford county, Va.

Analyses of other feldspars and of china-stone are given on pages 70, 75, 80, and 82.

PEGMATITES.

Pegmatites, being the intrusive dike-rocks from which the greater part of the world's supply of feldspar is derived, a brief description of the character and general occurrence of such pegmatites is appended.

Pegmatite was the name originally applied to acidic dike-rocks having practically the same composition as a normal granite, but whose structure, instead of being fine and even-grained like granite, was not only coarse but exceedingly irregular. A synonym for pegmatite was "giant granite," and the large size often attained by the crystals or crystalline masses of the several constituents—mica, feldspar, quartz, tourmaline, etc.—of such dikes is probably their most striking feature. Instead of small crystals, the feldspar of pegmatites often forms enormous masses or aggregates of large crystals, such spar masses weighing sometimes up into the hundreds of tons. The individual crystals, however, are far from uniform in size, and small crystals often occur side by side with individuals measuring several feet. The "graphic-granite" intergrowth of quartz and spar, so often met with in pegmatite bodies, has been alluded to elsewhere (see p. 60).

Although the term pegmatite as originally employed included only acidic rocks of a granitic type, the term has since become general as applied to extremely coarse-grained phases of almost any intrusive, crystalline rock, whether basic or acidic, and we now have not only granite-pegmatites but also syenite-pegmatites as well as "pegmatitic" types of many pyroxenic and hornblendic rocks. Bastin[1] uses the term "soda-pegmatite" to describe the albite-hornblende dikes of Pennsylvania and Maryland.

Pegmatites are considered as having been formed during the cooling period following upon a period of igneous activity, and their material to consist of highly acid, residual magma, which, together with an excess of water vapour or superheated steam, was expressed or squeezed into shrinkage fissures and channels formed in the cooling, invaded rock adjacent to the main, earlier intrusive. The coarse structure and large size of the mineral individuals is regarded as due to the presence of water vapour.

The granite or acid pegmatites do not necessarily always consist of the same chief constituent minerals as a type-granite, that is to say of quartz, feldspar, and mica, though such a rock is what is generally understood by the term. With a greater preponderance, however, of either one or the other constituents, we find dikes consisting practically of pure quartz or pure feldspar, with or without mica. In many feldspar-pegmatites the mica is present in small amount only, in the form of small aggregates of yellowish scales, and is often conspicuously secondary, being a decomposition product of some other mineral, such as garnet or even of feldspar itself (cf. china-stone).

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[1] *Op cit.*, p. 68

Pegmatite, then, implies a rock, either basic or acidic and of no definite mineral composition, which possesses coarse and irregular structure, owing to unevenness of size of its principal constituent minerals, and occurs in a dike or vein-like form. The term where used in this report, however, is to be taken as meaning the granite-pegmatites, unless otherwise specified or indicated in the context.

Pegmatites are usually far from regular in form and width. As the solidified filling of shrinkage fissures or of openings due to dynamic movement, this is what would be expected. Pegmatite bodies vary in width from a few inches to a couple of hundred feet; 30–50 feet is a common width for the dikes exploited for either their mica or their spar content. As a rule the dike mass consists of a series of irregular swellings or lenses joined up by narrow necks, and it often is capped over by the enclosing country rock, so that only isolated patches or splashes of pegmatite material are visible on the surface. In foliated rocks, such as gneisses and schists, the course of the dikes usually parallels the foliation of the country. Where the enclosing rock is only slightly inclined, the pegmatites often take on the form of sills or ledges. The country rock adjacent to a large pegmatite body is often filled with narrow, more or less parallel stringers of similar material, which has been injected from the main mass into minor fissures and crevices on each side of the dike proper; the so-called injection-gneisses have originated in this manner. In some such injection-gneiss districts, pegmatite bodies of appreciable size are only occasionally met with, the entire gneiss area, instead, being seamed and veined with myriads of narrow, pegmatitic stringers sent off by a deep-seated, batholitic mass. Much of the gneiss area in Pontiac and Ottawa counties, Province of Quebec, is of this character.[1] In these smaller stringers, the segregation of the quartz and tourmaline in the central portions is often very marked.

In large granite areas, also, pegmatitic zones are often met with. In this case, the pegmatite material has probably followed shrinkage channels in the cooler positions of the intrusive mass itself, partially re-fusing the wall rock and thus obscuring any sharp contact, or has formed around large masses of engulfed rock. Pegmatite zones in granite may also, in some cases, represent direct segregations from the granitic magma.

In some instances, the difference in colour and composition of individual pegmatitic stringers in one and the same area, as well as the manner in which they cross and cut one another, show clearly that the intrusions were not contemporaneous, though all were probably derived from one and the same magma at different stages of its cooling, and are thus to be referred to a single period of geologic time. The pegmatites of Quebec and Ontario are confined to the Archæan series of rocks, and are nowhere found intruding the palæozoic sediments.

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[1] Plate IV, p. 10 of Bulletin No. 445, U. S. Geol. Surv., "The Geology of the Pegmatites and Associated Rocks of Maine," by E. S. Bastin, 1911, shows typical injection-gneisses.

GENERAL BIBLIOGRAPHY OF THE NATURE, OCCURRENCE, ETC., OF THE FELDSPAR GROUP OF MINERALS.

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Mineral Industry, Annual Volumes (mainly statistical).

CHAPTER II.

DISTRIBUTION OF FELDSPAR DEPOSITS.

Although potash-feldspar, as one of the chief constituents of pegmatites, is of world-wide occurrence, and though it is one of the most common of the rock-forming minerals, entering largely, as it does, into the composition of all the more important igneous rocks, deposits of proved economic value are relatively scarce, being confined practically to the United States, Canada, Sweden, and Norway.

To be of commercial importance a feldspar deposit must yield pure mineral needing little more than the roughest handpicking (the most frequent impurities met with are biotite and muscovite mica, quartz, garnet, tourmaline, and, often, near the contact with the country rock, hornblende,) the rock-body must be of sufficient width to permit of the extraction of a considerable daily tonnage by ordinary quarry methods (a single narrow dike can hardly be profitably exploited unless situated particularly favourably in a high rock-face, though a system of such dikes may prove worth working if the separating country rock can be handled and removed at a low cost); the deposit must be conveniently situated as regards transportation facilities.

That low extraction, handling, and transportation costs are a sine qua non in the feldspar business is obvious from the comparatively low value of the mineral—from $4.50 to $5.50 per ton delivered at the mill for the best No. 1 grade. As regards transportation costs, these are often the largest item that the producer has to meet, and not infrequently render worthless an otherwise promising deposit. The location of pottery works is naturally chosen with reference to an available supply of clay, the feldspar used and its source being of secondary importance.

Even a comparatively small percentage of impurities, such as mica, hornblende, tourmaline, etc., is sufficient to render a feldspar unfit for pottery purposes and reduces the price paid by from 50 cents to $1.50 per ton. The presence of 15 to 25 per cent of quartz, also, brings even otherwise pure mineral into the second grade class: the purest commercial spars generally run up to 5 per cent quartz, the two minerals being intimately mixed, and often in graphic-granite intergrowth.

Pegmatite dikes, though of common occurrence in many parts of the world, seldom yield a first class grade of feldspar that can be utilized as it comes from the quarry without a greater or lesser amount of handpicking. In the ordinary type of granite-pegmatite, even if mica, tourmaline, etc., be absent or only sparsely represented, the amount of quartz is nearly always sufficient to prevent the run-of-mine ranking as first grade mineral. In the United States, the bulk of the pegmatitic, run-of-mine feldspar is designated "No. 2" or "standard," and contains from 15 to 25 per cent quartz; the No. 1 grade is selected spar, and No. 3, more or less crude material high in quartz and containing such impurities as tourmaline, hornblende, biotite, etc. This last grade is used in glass manufacture but is unfit for pottery purposes.

The following analyses[1] show the composition of the No. 1 and No. 3 grades and also of pure orthoclase:—

	A	B	C
Silica (SiO_2)	64·7	76·37	65·87
Alumina (Al_2O_3)	18·4	13·87	19·10
Ferric oxide (Fe_2O_3)	....	....	....
Lime (CaO)	....	0·26	0·20
Magnesia (MgO)	....	....	....
Potash (K_2O)	16·9	5·24	12·24
Soda (Na_2O)	....	3·74	2·56
Water (H_2O)	....	0·30	0·64
Loss on ignition	....	....	....
	100·00	99·78	100·61

A. Pure orthoclase feldspar, theoretical composition.
B. Ground commercial glass spar, No. 3 grade, from Kinkles' quarry, Bedford, N.Y.
C. Ground commercial pottery spar, No. 1 grade, from Richardson quarry, Bedford, Ontario.

With regard to the No. 3 grade here represented, Bastin adds the following[2]: "A No. 3 grade, made up mainly of the albite-quartz mixture with some of the finer grained, pink graphic-granite, is also ground at Bedford for use in glass manufacture. It is somewhat higher in quartz and soda than grade No. 2, and muscovite, biotite and black tourmaline are not so carefully eliminated as in grades No. 1 and No. 2."

The approximate mineral composition of the material from which the above samples were taken, as indicated by the analyses, is as follows:—

	B	C
Quartz	34·37	3·84
Orthoclase	30·58	72·28
Albite	32·83	22·59
Moisture	0·30	0·64
Other constituents	1·63	1·22
	99·71	100·57

These analyses may be taken as indicating, as far as the quartz content is concerned, the two extremes among potash spars in commercial use in the United States.

[1] From a Table of Analyses on p. 9, Bull. 420, U. S. Geol. Surv., by E. S. Bastin, 1910.
[2] *Op. cit.* p. 62.

With further reference to the nature of the rock in each case, B represents the crude, quartz-feldspar residue, after grades No. 1 and No. 2 have been selected from the run-of-mine, and is from an ordinary granite-pegmatite deposit. C, on the other hand, is probably the purest grade of commercial spar quarried anywhere, and has undergone only the crudest hand sorting at that.

The Ontario feldspar deposits, of which the Richardson is by far the largest and most important, are quite distinct from ordinary granite-pegmatite bodies, and consist essentially of feldspar with often only a small admixture of quartz. Graphic-granite intergrowth of quartz and spar in these bodies is usually only zonal, and the quartz forms bosses, lenses, or benches in the mass of the spar. Development in the spar, near the contact with the enclosing gneiss, of large crystals of hornblende is not uncommon, but this contact material can readily be left standing or can be removed separately so as to avoid any admixture with the pure spar in the pit. The bosses or ledges of quartz also can often be quarried out separately, the mineral finding a ready market at the smelters. Thus, instead of having a rock mass formed either of a close intergrowth of quartz and spar or of large masses (crystals) of more or less pure spar separated by zones or masses of quartz, the Bedford, Ontario, spar bodies consist essentially of massive, reddish orthoclase in which occur here and there small lenses or bosses of quartz. Mica is conspicuously absent, only small aggregates of a yellowish variety (gilbertite ?) being encountered now and then. A little black tourmaline occurs, and occasionally a small pyritic zone is struck; these, with the hornblende mentioned above, are the only impurities met with, and they are seldom present in sufficient amount to seriously impair the quality of the run-of-mine.

The grey pegmatites of Quebec Province, on the other hand, as well as the red feldspar dikes of the Muskoka region in Ontario, contain many accessory minerals. The former are true granite-pegmatites, being made up of large crystals or crystalline masses of microcline and albite, quartz and mica, the latter sometimes, in large "books" of commercial size. Garnets, tourmaline, apatite, and other minerals in lesser amount, detract from the quality of the spar and render a great deal of hand sorting necessary. The Muskoka dikes are somewhat similar to the Bedford spar bodies, but contain more quartz, (graphic-granite structure being typical), and the quality of the mineral is seriously impaired by the large amount of biotite mica (in large plates) present.

Below are given brief notes on the feldspar deposits in the United States, Norway, and Sweden, etc., and on the china-stone industry in England.

SOUTH AUSTRALIA.

According to the South Australia Mines Record, 1908, p. 354, china-stone occurs on Kangaroo island, 9 miles southeast of Hog bay, in the Hundred of Dudley.[1] A small crushing and grinding mill was established

[1] See also Howe, *op. cit.*, p. 107.

here in 1908 and ran on the output of the quarry, the ground product being shipped to potteries at Adelaide, Melbourne, and Sydney. Kaolin occurs at the same place.

AUSTRIA-HUNGARY.

The only data available to the writer regarding the occurrence of commercial feldspar in Austria is that contained in the section on German imports in Mr. Griffith's report to the Mines Branch referred to below (see p. 72).

There would appear to be a few small producers of low grade spar (probably pegmatite or coarse granite) in Bohemia. The German Customs figures show an annual tonnage of about 5,000 metric tons of such spar imported annually for use in the manufacture of cheaper grades of pottery.

In Hungary, a few deposits of feldspar have been worked in the county of Krasso-Szöreny. No extensive development of the bodies has ever taken place, and the output was all consumed in domestic industries. The production is stated to have amounted to "three or four hundred railway truck loads yearly," which, allowing 20 tons to the truck, would be equivalent to 6,000–8,000 tons annually.

An analysis of pink spar from the granite of Chotoun, near Prague. Bohemia, yielded:—[1]

SiO_2	62·79
Al_2O_3	20·51
Fe_2O_3	0·47
BaO	2·83
K_2O	9·44
Na_2O	4·08
Loss on ignition	0·21
	100·33

Howe[2] also quotes two analyses of a white spar from Bischofsteinitz, near Pilsen:—

	1	2
SiO_2	65·85	64·67
Al_2O_3	19·38	20·14
Fe_2O_3	0·33	0·25
K_2O	11·18	11·35
Na_2O	3·74	3·58
Loss on ignition	0·25	0·36
	100·23	100·35

[1] Howe, *op. cit.*, p. 227.
[2] *Op. cit.*, p. 227.

BELGIUM.

No information regarding the occurrence of feldspar in Belgium is available, but the production in 1911 and 1912 as given in "Mines and Quarries," Home Office Report, Part IV, 1914, p. 425, was 800 cubic metres and 200 cubic metres respectively.

CANADA.

See Part I, pages 1-54.

FRANCE.

A pegmatite body has been worked at St. Yrieix, southwest of Limoges, for use as a china-stone. The rock is very free from any deleterious accessory minerals, and consists mainly of feldspar and quartz in graphic-granite intergrowth. This rock is largely used in the manufacture of Limoges ware.

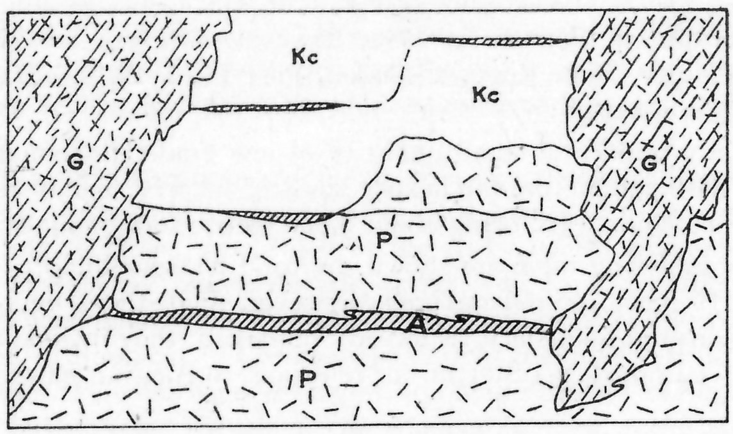

Fig. 11. Section through the "Robert" pegmatite quarry, St. Yrieix. (After Brongniart.) G. Reddish decomposed gneiss; A, altered schistose diorite; P, pegmatite; Kc, kaolin.

The fine-grained, partially kaolinized granite found in the vicinity of the tin mines at Montebras, Dept. Creuse, has also been employed as a china-stone (see Howe, *op. cit.*, p. 138).

According to the census of 1906, the porcelain and allied industries in France give employment to 14,700 persons. The number of porcelain works is 79, and of enamel factories 55.

No figures of production, imports, etc., of feldspar are available, as the mineral is classed with kaolin and "stone and earth used in the arts," under one heading.

GERMANY.

The information regarding the occurrence of feldspar in Germany is very meagre. According to a communication from Dr. Beyschlag, of the German Geological Survey, the deposits of spar in that country are of no economic importance.

From data kindly collected for the Mines Branch by Mr. W. L. Griffith, of the High Commissioner's office in London, it would appear that there are 17 firms engaged in mining feldspar in Germany, the total number of workmen employed being under 500. The material mined is probably a low grade pegmatite or coarse granite; it is nearly all exported to Austria-Hungary, the domestic demand being supplied almost entirely by Norway and Sweden. No figures of production are available, but the output is in any case small.

Of the above number of feldspar producers, seven are located in Bavaria, five in Oldenburg, and two in Thüringia.

Unfortunately, although almost all the spar raised in Germany appears to be exported to Austria, the figures of export give little idea of the quantity raised, since they include, also, the Scandinavian spar imported by the latter country, which is shipped via German ports, principally Stettin.

The output in Bavaria in 1912, however, as given in "Mines and Quarries," Home Office Report, London, Part IV, 1912, p. 457, was 6,666 metric tons, valued at £7·078.

Germany imports a small quantity of low grade, Bohemian feldspar, for use in the manufacture of cheaper kinds of pottery, the average import figures from 1906 to 1912 being about 5,000 metric tons annually.

In the following table are shown the total feldspar imports from 1907 to 1912. It must be remembered, however, that these figures do not represent consumption, since, as already remarked, they include a quantity of mineral consigned, via Stettin, for re-export to Austria, Russia, etc.

TABLE IV.

Imports of Feldspar into Germany 1907–1912 (In metric tons).

Country	1907	1908	1909	1910	1911	1912
Norway	22,690	19,667	20,476	25,358	24,477	25,196
Sweden	18,121	18,131	15,811	15,123	22,263	26,695
Austria-Hungary	4,580	4,273	4,877	4,634	5,962	5,864
Various	1,493	421	206	360	1,339	542
Total	46,884	42,492	41,370	45,475	54,041	58,297

The number of pottery and porcelain works in Germany is 196, in addition to which 22 establishments manufacture glazes. The number of enamel factories is 21.[1]

[1] The above data relating to the feldspar industry in Germany is taken from a report kindly compiled for the Mines Branch by the Canadian High Commissioner's office, London.

GREAT BRITAIN.

In Cornwall,[1] a coarse granite known as "Cornish stone" or "china-stone" has been quarried since 1759 in the St. Stephen district, near St. Austell. The rock is a peculiar local variety of the ordinary Cornish granite, and its occurrence is limited to a comparatively small area to the north of St. Stephen. In Howe's words (p. 135), "it is a pale granitic rock of medium coarseness, rarely so soft as china clay rock or so hard as the normal granite of the district, except in the case of the best hard variety now in great demand. It exhibits kaolinization of the feldspar sufficiently to give a rather powdery aspect to the fracture. The quartz and feldspar grains and crystals are clearly distinguishable in the hand specimen, and in some samples flakes of white or greenish mica, topaz, and purple fluorspar are also visible."

A conspicuous feature about china-stone is the absence in it of tourmaline and biotite mica, both of which minerals are typical of the normal Cornish granite. Consequently, it has been suggested that china-stone is not merely an altered zone of such granite, but is a distinct, local variety of the same. Albite feldspar, also, is far more abundant in the china-stone than in the granites.

Constant constituents of the china-stone are topaz, white mica (both primary, and also secondary after feldspar-gilbertite), and fluorspar.

According to Howe, (p. 136) "All the best Cornish china-stones have suffered alteration by pneumatolytic action, but in the harder varieties this has extended only to the formation of white mica after feldspar and the introduction of fluorspar. The changes closely resemble certain stages of greisening, but there has been less deposition of quartz, as the silica has been removed in some way. Much of the feldspar in these rocks is still very fresh, but the replacement by mica is more complete than in the greisens. In the softer china-stones there has been a certain degree of kaolinization. The feldspar becomes very soft, white and friable, so that it can be broken down with the fingers."

There appears to be no very sharp line of demarcation between the china-stone and the normal granite or the highly kaolinized china-clay rock; in some cases both china-stone and china-clay are worked side by side in the same excavation.

Four varieties of china-stone are recognized:—

1. Hard purple: a hard white rock with a faint purple tinge caused by the presence of purple fluorspar.
2. Soft or mild purple: a similar rock but soft.
3. Dry white stone: a soft white variety.
4. Buff stone: similar to the white, but slightly tinged with yellowish iron stain.

Where the above grades occur in one and the same quarry, the rock has to

[1] Notes from the "Handbook to the Collection of Kaolin, China-Clay and China-Stone in the Museum of Practical Geology," by J. Allen Howe, published by the Geological Survey of Great Britain, 1914. See particularly pp. 7 and 135.

undergo a process of hand sorting before it is raised, and at the same time any material containing an excess of mica is cobbed out.

At certain quarries, the stone undergoes crushing and grinding on the spot, while in other cases it is shipped to some near by spot where water power is available. A considerable tonnage, also, is consigned crude to the pottery works and is ground there.

When ground locally, the crushed rock is fed into grinding pans, each 12 to 14 feet in diameter, and having floors of hard china-stone blocks (pavers) inclined from the centre outwards. Each pan is surrounded by a wall of china-stone or brick 2 feet high. Grinding is effected by chasers of china-stone attached to four radial arms carried on a central, vertical shaft. The feed consists of rock crushed to 1 to 1½ inches, mixed with enough water to form a thin sludge when ground: a grinding takes 12 hours. The pans are emptied by opening a sluice in the wall and flushing the sludge down a launder to the micas, where the mica and coarser particles are separated. From these micas, the clay-water is led into settling pits, whence the settled clay is removed into the tanks by means of gravity through an opening in the lower end. In the tanks the clay is allowed to settle and evaporate, and is then dug out and taken to the drying shed, where it is dried on large floors built over a system of flues. The ground stone, in fact, undergoes precisely the same treatment as the china clay from the same district.

The highest grade of china-stone now quarried in Cornwall is that known as "hard purple."

Prices per ton, as given by Howe, for 1913, are as follows, and are f.o.b. Cornwall:—

	s.	d.
Hard purple, water ground	35	0
do lump	19	0
Mild purple, lump	18	0
White, lump	17	0

There are, in all, eighteen china-stone quarries in Cornwall.

The output of Cornish china-stone from 1897 to 1912, as given by Howe,[1] is as follows:—

[1] *Op. cit.*, p. 232.

TABLE V.

Tonnage and Value of Cornish China-stone raised from 1897 to 1912.

Year	Tons	Value (in £)*
1897	59,713	24,311
1898	59,725	23,950
1899	54,691	21,403
1900	61,204	24,790
1901	59,923	25,074
1902	57,882	26,451
1903	53,680	21,635
1904	66,994	30,941
1905	52,171	25,517
1906	57,174	29,812
1907	68,174	35,441
1908	75,473	37,315
1909	56,028	26,352
1910	68,607	31,036
1911	61,962	28,491
1912	73,284	35,147

* £1 = $4.87.

Export figures for china-stone alone are not available, but according to Grünwald,[1] the exports of pegmatite (china-stone ?) from Great Britain average over 35,000 tons annually.

Analyses of (A) "hard purple" and (B) "buff" Cornish stone yielded:[2]

	A	B
SiO_2	72·28	73·18
Al_2O_3	14·90	16·13
Fe_2O_3	0·50	0·52
MnO	0·01	0·02
CaO	1·66	0·61
MgO	0·15	0·14
K_2O	5·25	4·41
Na_2O	3·01	2·18
H_2O	0·81	2·01
P_2O_5	0·53	0·45
F	0·88	0·23
Cl	0·02	....
TiO_2	0·05	0·06
Li_2O	0·02	0·02
	100·07	99·96

[1] Grünwald, Julius, "Raw Materials of the Enamel Industry," 1914, p. 7.

[2] Howe, *op. cit.*, p. 192. See also p. 227 of the same author for further analyses of Cornish-stone.

Cornish-stone is used principally by glazers and is considerably cheaper than pure feldspar. Its function in bodies is to render them compact; in glazes it imparts solidity and close bond between the glaze and the article, as it contains both glaze and body ingredients. Fused at 1,500° C. (Seger cone 19) Cornish-stone melts to a white, vitrified mass.

Feldspar and Cornish-stone cannot readily be used to replace each other in glazes and bodies; added to a glaze composed of feldspar, clay and flint, however, it produces good results when the latter mixture alone will warp and crack. The chief objection to Cornish-stone is its variability of composition though this may be reduced to a minimum by careful sorting; it is lower priced than feldspar, the figures for lump "best hard purple," as given by Howe,[1] being 19s. ($4.62), and for water ground ditto, 35s. ($8.52), per ton f.o.b. Cornwall.

There are in Great Britain 90 porcelain and pottery works and 251 earthen and stoneware factories, the total number of persons employed in these industries in 1907 being 67,870.[2] The number of enamelling establishments (glass and iron) is 38.

According to Watts,[3] Cornish-stone forms the bulk of the flux material used in the English potteries.

An aplite dike which occurs near Meldon, Devonshire, at the edge of the Dartmoor granite, is reported by Howe as being quarried at the present time for use as a china-stone.

Jersey-stone.

A decomposed, partially kaolinized granite, somewhat similar but inferior to Cornish-stone, is quarried in a small way on the island of Jersey, Channel Islands, and is employed in the same manner as the latter.

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INDIA.

According to information furnished by the Director of the Geological Survey of India, little interest has ever been shown in the feldspar of the Bengal and Madras mica-bearing pegmatites and no investigation would appear to have been made as to the suitability of this spar for pottery purposes.

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[1] *Op. cit.*, p. 139.

[2] Figures obtained and furnished by the office of the Canadian High Commissioner, London.

[3] Watts, A. S., Trans. Am. Ceram. Soc., Vol. XVI, 1914, p. 81.

The mica areas are regarded as being too remote from water transport to permit of the feldspar being recovered and shipped out of the country, railway haulage being out of the question. It was announced at the beginning of 1913 that Messrs. H. Md. Badsha Sahib and Co., of Madras, contemplated shipping a trial consignment of such spar to the United States, but it is not known whether the shipment was ever made or with what results.

ITALY.

The combined production of feldspar and quartz in Italy in 1911 was 35,759 tons, but no mention is made as to how much of this tonnage represents feldspar and how much quartz.

It has not been possible to secure any data regarding the location of the deposits.

There are 34 establishments in Italy manufacturing porcelain and earthenware.

NEW SOUTH WALES.

According to a communication from E. F. Pittman, Government Geologist, coarse pegmatite carrying potash feldspar abounds in the Broken Hill district, though no attempt at extraction has ever been made.

It is probable that the locality referred to above includes the Thackaringa district, the pegmatites of which have yielded commercial sheets of muscovite mica.

NORWAY.

The feldspar production of Norway[1] is, similarly to that of Sweden, derived from pegmatite dikes which occur both as large irregular masses and as distinct veins, enclosed principally in gneiss. The spar extracted from these dikes is exclusively the potash variety, which is employed in pottery work, both in the body of the ware and also in the glaze, and on account of its purity is especially suited to this class of work. There is, also, a small production of so called "sunstone" or "aventurine spar" from the workings at Tvedestrand, Christiania-fjord; this class of spar is used to make buttons, cuff links, etc.

The Norwegian feldspar industry dates from about 1790, the first quarries being opened in the Arendal district, between Kragerö and Kristiansand. The largest workings were those of the Narestö quarry, between Tvedestrand and Arendal. Shipments of spar from this locality to the Royal Porcelain Works, at Copenhagen, commenced as far back as 1792.

Up to 1850, the production of Norwegian spar came chiefly from the Arendal district. Later, quarries were opened in other parts of the county, notably at Bergen, Kragerö, Farsund, Flekkefjord, Stavanger, Haugesund, Drammen, Österrisör, and Kristiansand.

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[1] Translation of a Report kindly furnished to the Mines Branch by the Royal Norwegian Foreign Office and compiled by the Trade Intelligence Bureau of Norway.

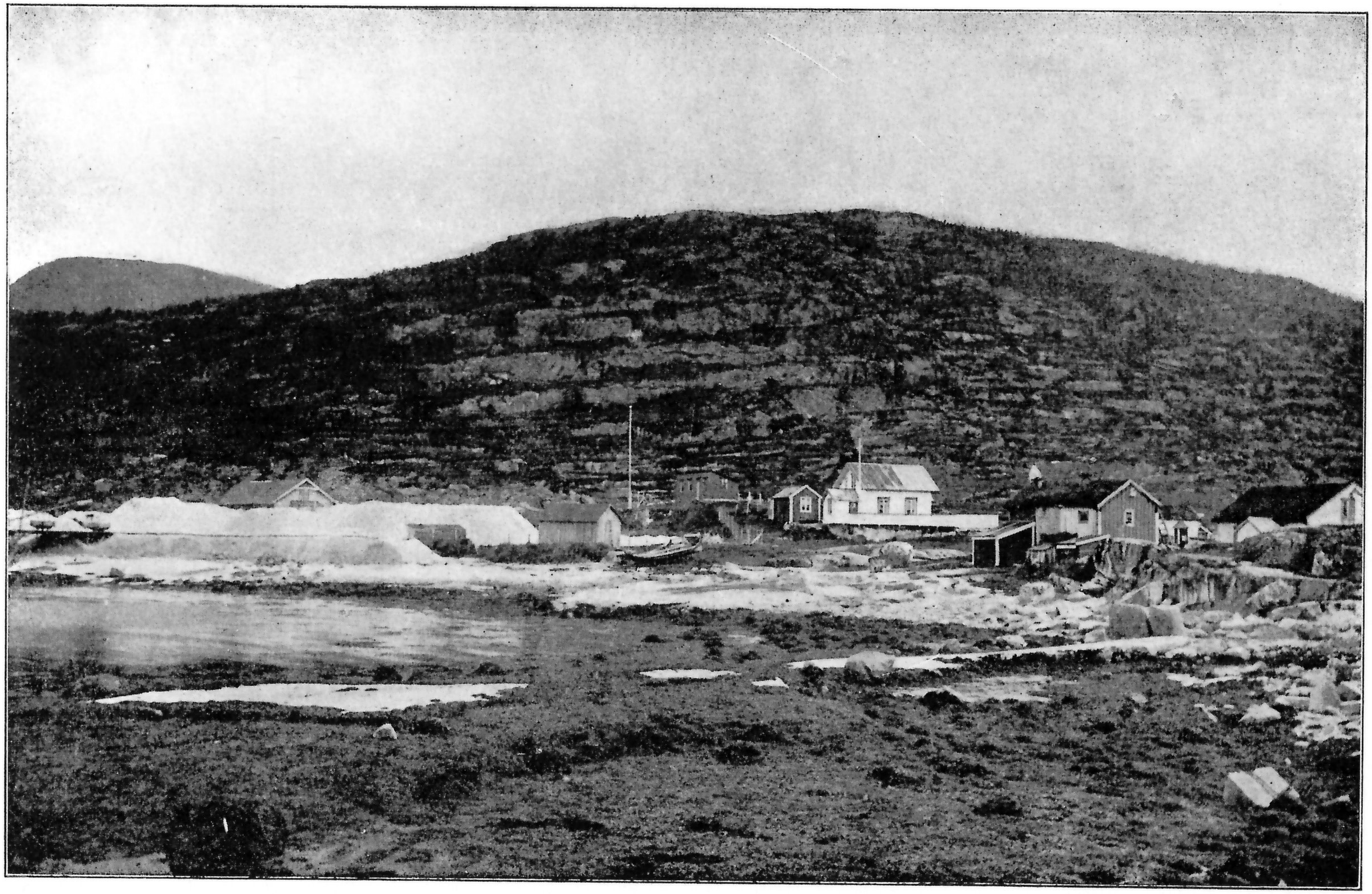
About 1880, quarrying commenced in the Smaalenene district, where the oldest workings are at Halvorsöi, and the development of these deposits proceeded rapidly.

More recently, feldspar has been worked in the northern portion of Norway, shipments of mineral coming more especially from Narvik and Bodö.

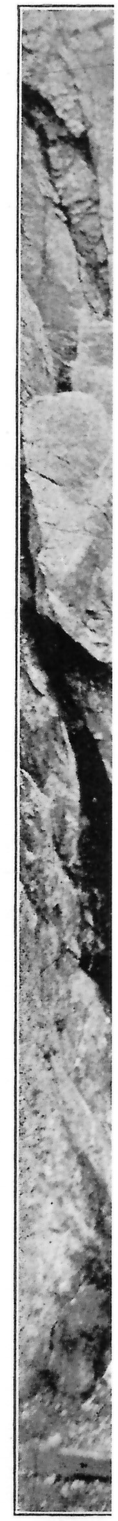
Figures of export are available from 1840, and between that year and 1855, shipments totalled 2,788 tons. From 1856 to 1876, 49,362 tons were exported; between 1868 and 1879, 40,291 tons; between 1880 and 1889, 74,314 tons; 1890 to 1899, 111,393 tons; 1900 to 1911, 319,508 tons. The average annual tonnage exported since 1907 is 35,000 tons.

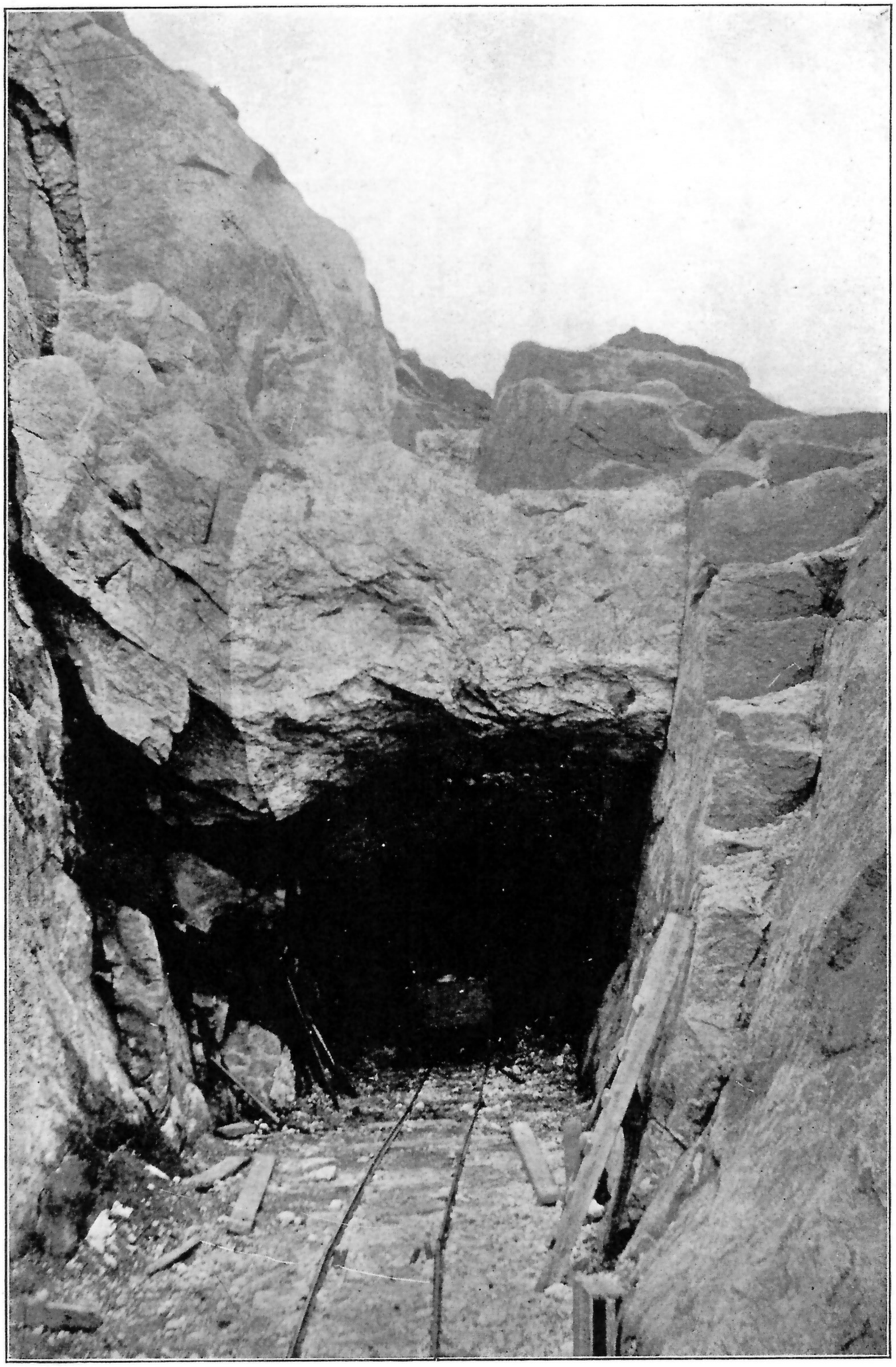
In the following table are shown the exports of spar from 1900 to 1912, with the destination of shipments:—

Plate XIX.



Hundholm feldspar quarry, Tysfjord, Norway.





Method of working feldspar dike, Mosken, Lofoten islands, Norway.

TABLE VI

Exports of Feldspar from Norway, 1900-1912, showing the destination by Countries.

(In metric tons).

	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Sweden	..	140	1	3	1	1	..	..	..	..	1	157	Not specified
Denmark	201	187	205	297	95	202	232	407	142	607	159	63	
Great Britain	778	1,141	983	1,286	1,032	1,336	1,331	2,141	3,302	3,269	4,281	3,379	
Russia	275	100	1,465	825	....	1,435	1,545	1,635	2,749	1,310	2,497	2,740	
Holland	2,006	520	825	1,307	1,767	1,643	1,700	2,339	1,960	1,320	769	1,068	
Belgium	2,109	4,012	3,984	1,908	3,841	3,149	3,726	3,633	4,232	5,303	3,595	4,746	
France	3,154	3,258	2,725	1,245	2,230	2,172	....	3,236	3,028	3,099	1,362	630	
Germany	9,020	8,645	9,110	10,970	11,684	12,399	12,493	19,221	18,439	21,093	26,663	21,635	
United States	65	70	276	239	185	171	....	....	....	85	180	95	
Portugal	....	250	17	100	....	....	....	....	....	....	....	....	
Spain	....	....	....	....	....	....	....	....	....	50	....	....	
Italy	....	....	....	410	....	....	....	....	....	303	....	350	
Other countries	....	....	....	....	....	....	2,809	359	585	....	....	....	
	17,608	18,323	19,591	18,590	20,835	22,508	23,836	32,971	34,437	36,439	39,507	34,863	39,844

In Howe[1] are quoted two analyses of Norwegian spar, the samples being taken respectively at Hagendorf, near Weiden, Bavaria, and at the Royal Porcelain Works, Charlottenburg:—

	1	2
SiO_2	64·80	64·98
Al_2O_3	19·83	18·18
Fe_2O_3	0·22	0·33
K_2O	11·63	12·79
Na_2O	3·23	2·32
MgO	.....	0·25
Loss on ignition	0·67	0·48
	100·38	100·33

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SWEDEN.

Feldspar mining[2] in Sweden dates from about 1790, the principal workings being situated in the Stockholm district.

The following table gives the quantity and value of the spar produced from 1901 to 1912, together with the number of workmen employed:—

TABLE VII.

Tonnage and Value of Feldspar produced in Sweden from 1901 to 1912 (In metric tons).

	1st Quality	2nd Quality	Total	Value in kröner*	No. of workmen
1901	5,561	7,941	13,502	163,941	21
1902	6,517	11,443	17,960	175,897	29
1903	10,916	8,476	19,392	218,944	21
1904	10,544	7,477	18,021	201,360	24
1905	10,340	8,884	19,224	191,982	25
1906	11,946	9,068	21,014	231,558	27
1907	12,636	7,608	20,244	241,975	24
1908	7,252	10,242	17,494	174,677	21
1909	7,584	8,188	15,772	166,323	29
1910	11,476	10,115	21,591	215,284	51
1911	......	......	36,235	335,625	51
1912	......	......	34,305	332,787	..

* The Swedish króne = $·268.

[1] *Op. cit.*, p. 227.

[2] Translation of a Report kindly prepared for the Mines Branch by H. E. Johansson, State Geologist, Stockholm.

The above figures are not strictly accurate, as they include, also, a certain amount of 3rd quality spar or graphic-granite.

It may be noted here that the production figures of Swedish feldspar from 1864 to 1908 are incorrectly stated in the "Mineral Industry" for the latter year to total about 28,000 tons, the statement being based on data contained in Bulletin, Vol. IX of the Geological Institute of the University of Upsala, 1908, p. 186. The correct translation of the article in question gives the above tonnage as the output of a single quarry at Ytterby.

The number of producers in 1911 was 77, and the total of 36,235 tons of spar produced was made up of 15,629 tons of 1st quality, 9,692 tons of 2nd quality, and 10,994 tons of 3rd quality and graphic-granite.

The most important producing quarries were situated at Kolsva, in the Vestmanland district, Margretelund, in the Stockholm district, and Dröm, in Östergötland, the production figures for the above being 4,739, 3,647, and 2,120 tons respectively.

Only a small amount of the feldspar produced is consumed in domestic potteries. In 1911 the domestic consumption was only 430 tons (two factories), and in 1912, 559 tons (three factories). Almost the entire output is consigned to continental porcelain works, principally by way of Stettin, Antwerp, and Russian ports.

At the present time, the combined outputs of Sweden (circa 35,000 tons) and Norway (circa 40,000 tons) suffice to fully supply the European market for feldspar.

The location of the principal quarries and deposits is shown on the accompanying sketch map. The spar bodies consist of pegmatite dikes which attain prominent development in the areas indicated, though pegmatites of little economic value are found, also, in other sections of the country.

The most important of such areas is the coast section around Stockholm. Here, the largest workings are those of Hersbacka, near Margretelund, a couple of miles northeast of Stockholm. The quarries have been worked since 1890, and have produced about 2,000 tons annually of first grade spar, besides a quantity of quartz.

The quarries at Ytterby, on the island of Resar, also in the Stockholm district, are among the earliest worked feldspar deposits in Sweden, having been in operation since 1790. The workings here attain a depth of nearly 550 feet, and from 1865 to 1911 this locality has produced a total of 30,414 tons of spar. The present yearly output is negligible. Another large quarry, at Svinninge, northwest of Ytterby, has not been worked in recent years.

The Ytterby pegmatite, with its associated minerals has been made the subject of a special paper by I. Nordenskjöld, (see reference at end). According to this writer, the Ytterby spar consists partly of reddish orthoclase and partly of lime-soda feldspar, the former preponderating.

Analyses of Ytterby and Svinninge spar are quoted:—[1]

	1	2	3
Silica	64·32	63·00	64·40
Alumina	19·41	23·00	19·30
Ferric oxide	0·14	0·30	0·30
Lime	trace	2·60	0·40
Magnesia	0·35	0·03	....
Potash	12·90	0·38	12·56
Soda	2·10	10·32	2·68
Loss on ignition	0·57	....	....
	99·79	100·13	99·64

1. Red microcline from Ytterby.
2. White soda-lime spar from Ytterby.
3. Red microcline from Svinninge.

The chief constituents in the Ytterby pegmatite are microcline-perthite, plagioclase, quartz, biotite, chlorite, and muscovite. The plagioclase spar is principally oligoclase; pure albite, or soda feldspar, is rare. Nordenskjöld gives, in addition, a list of 26 accessory minerals which occur in the dike. These include many rare earth minerals, such as fergusonite, gadolinite, orthite, xenotime, yttrotantalite, etc.

A further pegmatite district is that of the island of Orust, on the southwest coast, and the adjoining coast section of Bohus. This locality has been worked for spar since 1880, and a great many different outcrops have been exploited; only a few quarries have been actively worked, however. The largest occurrence of feldspar is at Sandvass, near Töllås, on the north part of the island. This, during the 17 years that it has been worked has produced about 25,000 tons of spar.

Among other feldspar localities are the north part of Halland and the adjoining section of Älfsborg; the district northeast of Vättern, where a number of fair sized deposits exist, but have not been worked in recent years; also at Kolmården, in the northeast portion of Östergötland, where a large spar body has been developed in the Dröm quarry during the last ten years.

Numerous pegmatite dikes are found scattered over central Sweden. Many of them have been worked for their quartz content, but there are, also, a few valuable feldspar bodies, as, for instance, at Kolsva, northeast of Köping, and at Granmuren, west of Sala, both in Vestmanland.

The Kolsva quarries are situated on unquestionably the largest feldspar bodies in Sweden. These workings were opened in 1896, and from this year to 1911 have produced 66,678 tons of spar, of which, it is true, the greater portion was second grade. The opening here is 400 feet long, 50–65 feet deep, and has a maximum width of 130–165 feet.

[1]Analyses by the Rörstrand Porcelain Works.

In the whole northern portion of Sweden there is known only one feldspar locality of any importance, namely the coast section around Luleå and Råneå, in Norbotten, where work has been conducted since 1906. The largest quarries are on Kallax island, in Luleå bay, and on the side of Mjöfjord, south of Råneå. A few scattered spar occurrences are known, also, farther inland in the same district.

Swedish feldspar is exported chiefly in crude, lump form, the price varying from 20 to 25 kröner[1] per ton for the best grades; second grade mineral brings barely half the above price.

It is only lately that crushing and grinding plants have been established, the works being situated at Klinktjärn, near Kolsva, in Örebro, and at Baldersnäs, near Stockholm. At the first named, the material handled consists of a graphic-granite containing about 20 per cent of quartz and a small amount of light coloured mica; the rock is, however, comparatively free from any iron-bearing minerals. The spar is first broken in a crusher and reduced to corn size in rolls. The mica is then removed by a special contrivance and obtained as a by product. The spar is ground fine in tube mills, after which it is freed of any iron particles by being passed beneath an electro magnet. The ground product is bagged and shipped to the continent.

Prices for ground Kolsva spar average $7·88 per ton c.i.f. Antwerp. The production of ground spar at the Klinktjärn mill in 1911 was 2,313 tons.

There are in Sweden seven porcelain factories and eight enamel works, the former employing 2,300 hands and the latter 1,500 hands.

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UNITED STATES.

The United States easily heads the list of feldspar producing countries. The mineral is obtained chiefly from the following states: California, Maine, New York, Connecticut, Pennsylvania, Maryland, and North Carolina, the marketed production in 1913 being 120,955 short tons, valued at $776,551. In all, some 50 quarries are in operation. The average price of the crude spar in 1913 was $3.31 per ton, and of the ground mineral, $8.31. Of the total output in this year, 37·53 per cent was marketed crude and 62·47 per cent ground.

Katz[2] estimates that of the total quantity marketed in 1913, 4,000 tons or 3·5 per cent was used as abrasives; 7,000 tons or 6 per cent was

[1] $5.36 to $6.70.
[2] Mineral Resources of the United States, 1913, Part III, p. 147.

used for roofing; 3,000 tons or 3 per cent was employed in structural uses; 1,000 tons or 1 per cent was sold as chicken grit; 1,200 tons or 1 per cent was used in glass-making; the remainder, over 100,000 tons, or 85 per cent, was used in ceramic industries.

The United States is thus the largest producer of feldspar in the world, the production figures for 1912 being 13,000 tons in excess of the china-stone output of Cornwall for the same year.

The bulk of the United States feldspar is of the potash variety, a small amount of albite, or soda feldspar, being also present in most quarries.

Three grades of spar are recognized by the dealers, No. 1, or clean spar with less than 5 per cent quartz; No. 2, or Standard, containing up to 20 per cent quartz; and No. 3, or roofing and grit grade.

By far the greater number of the feldspar quarries in the United States are working on granite-pegmatite bodies; only a few, in Pennsylvania and Maryland, being located on albite-hornblende dikes. Much of the pegmatitic material quarried is a fine to coarse-grained graphic-granite, and analyses show that in such rock a very nearly constant proportion between feldspar and quartz is maintained, the feldspar forming from 70 to 80 per cent of the rock and the quartz 20 to 30 per cent. Typical analyses of graphic-granite yielded:—

	A	B	C	D
SiO_2	73·89	73·92	72·76	71·00
Al_2O_3	13·75	14·26	15·47	16·31
Fe_2O_3	0·26	0·30	.....	....
CaO	....	....	0·19	0·22
Na_2O	2·10	2·06	2·35	3·44
K_2O	9·00	8·99	9·28	8·66
H_2O	0·24	0·11	0·15	0·12
	99·24	99·64	100·20	99·75

A. Coarse graphic-granite from the Fisher quarry, Topsham, Maine.
B. Medium grained graphic-granite from the same place.
C. Fine-grained rock from the Kinkle quarry, Bedford, New York.
D. Fine-grained rock from the Andrew quarry, Portland, Connecticut.

The proportions of quartz, feldspar, etc., in the above, as calculated from the foregoing analyses, are as follows:—

	A	B	C	D
Quartz	27·13	26·26	22·94	17·65
Potash spar	54·42	55·22	54·95	51·37
Soda spar	18·45	18·52	20·99	30·05
Other constituents	trace	trace	1·12	0·92

Bastin[1] points out that this demonstrated constant proportion of quartz to feldspar in both fine and coarse-grained graphic-granite is of practical importance, at any rate in as far as it applies to American rock (and there is no reason, also, to conclude that it is not universal) since it has been the practice in some quarries to discard the finer grained material on the supposition that it contains a larger percentage of quartz than the coarser kinds. Such a course is unwarranted, as both types are shown by analysis to be of practically identical composition. All graphic-granite, however, for employment in the ceramic industry should be mixed with sufficient pure feldspar to reduce the percentage of quartz to between 15 and 20 per cent, this being the standard for such purposes.

According to Vogt,[2] the proportion of quartz to feldspar in graphic-granite is constant, and the rock thus represents a eutectic mixture, having a composition of approximately 74 per cent feldspar and 26 per cent quartz.

The American pegmatites exhibit much the same characteristics as those of other parts of the world, and there is usually evident a lack of regularity in the distribution of the various constituent minerals. Thus, a deposit that is of good commercial quality as regards spar may grade within a short distance and in an irregular manner into a pegmatite that is worthless on account of the large proportion of quartz, biotite, tourmaline, garnet, etc., present.

In the case of nearly all the deposits, ordinary quarry methods are pursued in extracting the mineral. In a few Pennsylvania workings only, where the pegmatites form sills and are overlain by considerable country rock, short drifts have been run in from the main excavations.

The Maine, Connecticut, and New York pegmatite is conspicuously unaltered and hard, whereas in Pennsylvania and Maryland much of the surface rock is decomposed and partially kaolinized and can be worked by means of picks and bars. (Some of these quarries in the past yielded kaolin in their upper portions, but none is produced at the present time.) The difference in character of the surface rock in the regions mentioned is due to the fact that the former area has suffered a high degree of glaciation, while in the latter section no such action has taken place.

In most cases, after the rock has been broken in the quarry into pieces about 6 inches across, it has to undergo hand sorting, in order to remove the mica-bearing or quartzose material. This, of course, refers to the pottery grades; the poultry grit and roofing spar require no such cobbing. At the Pennsylvania and Maryland quarries, screening and even washing is in some cases necessary in order to clean the rock.

The cost of mining the spar at most quarries producing pottery mineral is reported as from $2 to $2.50 per long ton; poultry grit and roofing grades, on the other hand, can be raised for as low as 50 cents per ton. Haulage charges add about 40 cents per mile per ton to the above costs.

[1] *Op. cit.*, p 15.

[2] Vogt, J. H. L., "Die Silikatschmelzlösungen," 1904, pp. 117-128.

For the inferior grades of spar, a haul of more than a couple of miles usually renders working prohibitive.

The principal market for the ceramic grade of spar is at the large pottery centres of Trenton, N. J., and East Liverpool, Ohio.

The crude spar for use in the potteries is ground, with or without a preliminary crushing, in a chaser mill, consisting of two buhrstone wheels, 3 to 5 feet in diameter, travelling on a bed of the same material. The soda spar quarried in southeastern Pennsylvania is calcined before grinding.

The fines from the mill are fed to pebble mills, lined either with hardwood blocks or with a siliceous brick. The charge for most of the mills of this class is from 2 to 3 tons, though in some cases 6-ton mills are employed. Grinding takes 4 to 6 hours, and a fineness of 200-mesh is demanded.

Spar for use in the enamel and glass industries (that is, material of slightly inferior grade), does not require quite such fine grinding, 2 to 3 hours being the usual time allowed, and 75 per cent through a 200-mesh screen being the fineness found in a sample of such material. On the other hand, spar for use in abrasive soaps may be ground for as long as ten hours.

Poultry grit and roofing spar is first crushed in jaw or gyratory crushers and is then passed between steel rolls in a mill of the Maxecon type, from which it passes to Newaygo screens.

The following table shows the marketed production of ground and crude feldspar of all grades, by States, in 1913:—

TABLE VIII.

Marketed output of Feldspar in the United States in 1913, by States.
(In short tons).

	Crude		Ground		Total	
	Tons	$	Tons	$	Tons	$
California	1,113	3,838	......	......	1,113	3,838
Connecticut	10,166	35,867	10,122	79,903	20,288	115,770
Maine	(*a*)	(*a*)	38,114	346,779	(*b*)38,114	(*b*)346,779
Maryland	11,402	37,155	5,300	45,678	16,702	82,833
New York	6,859	21,304	15,891	97,756	22,750	119,060
Pennsylvania	3,685	19,454	5,944	56,397	9,629	75,851
Minnesota, North Carolina, and Vermont	(*c*)12,166	(*c*)30,931	193	1,489	12,359	32,420
Total (*d*)	45,391	148,549	75,564	628,002	120,955	776,551

(*a*) Included with Minnesota, etc.
(*b*) Exclusive of crude product.
(*c*) Includes crude product of Maine.
(*d*) Includes 3,953 tons, valued at $19,681, used as abrasive.

The recorded production for the five years 1909–1913 is shown in the following table:—

TABLE IX.

Production of Feldspar in the United States, 1909–1913.
(In short tons.)

	Crude		Ground		Total	
	Tons	$	Tons	$	Tons	$
1909............	25,506	70,210	51,033	354,392	76,539	424,602
1910............	24,655	81,965	56,447	420,487	81,102	502,452
1911............	28,131	88,394	64,569	490,614	92,700	579,008
1912............	26,462	89,001	60,110	431,561	86,572	520,562
1913............	45,391	148,549	75,564	628,002	120,955	776,551

As already noted, certain feldspar quarries in Pennsylvania and Maryland yield only soda-feldspar or albite, and have been opened up in dikes of so-called "soda pegmatite," which consists essentially of albite and hornblende. The country rock, in each case, is a dark coloured serpentine, and talc and fibrous serpentine are commonly developed along the contact. At two quarries in Cecil county, indeed, both spar and talc are won, the former being the secondary product. No quartz occurs in these dikes, though a small amount of muscovite and garnet occurs locally.

Taken by states, the feldspar occurrences are as under:—

California.

California is one of the newest comers into the ranks of feldspar producing states, and five quarries were in operation in 1913. Tulare county is the chief producing section, the quarries being situated near Visalia, Exeter, Springville, Lemon Cove, and Three Rivers, but workings have been opened, also, in San Diego and Monterey counties. The entire production of the State is used for ceramic purposes, the potteries being located at National City and Richmond, Cal., at which latter place the Western States Porcelain Co. is located.

Samples of spar, in the possession of the writer and which were taken from near Woody, Kern county, are of a very light buff shade and appear to be microcline; this spar is reported to contain 9 per cent of potash.

Connecticut.

The third most important state in point of production in 1913, the output coming from seven quarries. The bulk of the workings yield only No. 2 or Standard spar, much of which finds employment in the enamel, glass, abrasives, and soap industries. In some cases the highest grade is picked out for pottery purposes, the inferior material being utilized for poultry grit and roofing.

Maine.

The principal producing State in 1913, with seven quarries. All of the workings are in granite-pegmatite, which, in some instances (*e.g.* Hebron, in Oxford county) carries muscovite mica in economic quantities. A number of the pegmatites yield green tourmaline and beryls, and such rare minerals as columbite, herderite, etc., are sometimes met with. Biotite and garnet are common accessory minerals.

Maine spar is employed chiefly for ceramic purposes, the rock usually being hand cobbed in the quarries. The bulk of the output consists of graphic-granite, though occasionally large ledges of pure spar are encountered in the dikes. According to Watts,[1] the bulk of the Maine spar, as shipped to the potters, consists of about 15 per cent quartz, this ratio being aimed at by the operators, and obtained by mixing in a certain amount of pure, lump spar with the graphic-granite. This practice is said to be the result of the price offered by the potters, who are unwilling to alter the level paid several years ago, when a purer grade of spar was obtainable than is now the case; the only alternative is to quarry deeper or open new deposits, which quarry owners are not disposed to do.

Maryland.

This State stood fourth on the list of producers in 1913, and contained 12 active quarries, situated for the most part in Howard and Baltimore counties. The spar raised is used chiefly for pottery. The soda-pegmatite bodies are situated in Cecil county, and are similar in every way to those across the border in Pennsylvania; the larger number of quarries, however, are working on normal granite-pegmatite. At certain of the soda-pegmatite quarries, talc is obtained simultaneously with the spar.

New York.

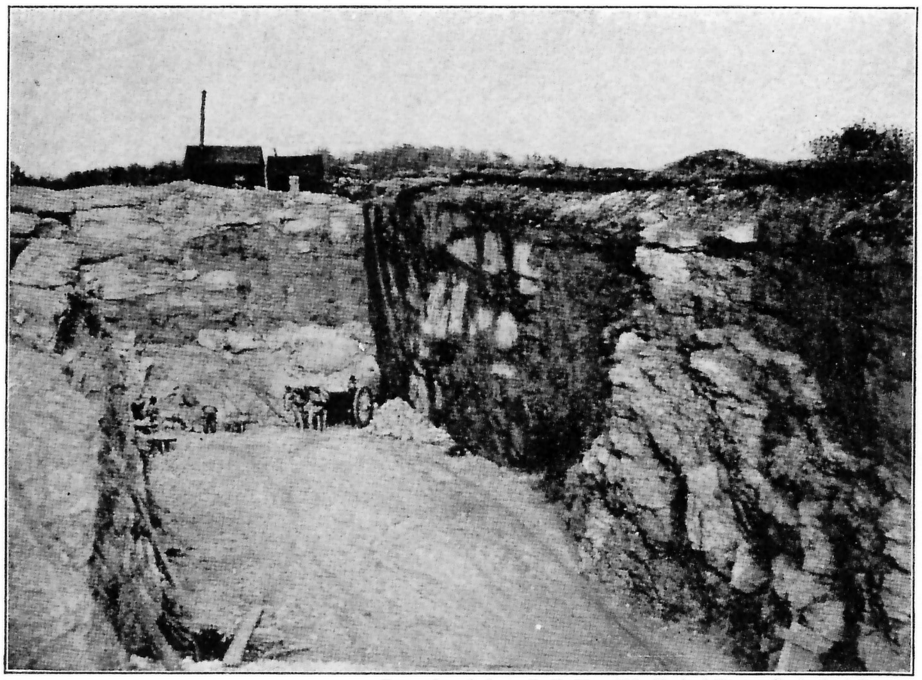
New York figured as the second largest feldspar producing State in 1913. About half the output in this year consisted of unsorted pegmatite, which was employed in a roughly crushed state for roofing, poultry grit, and concrete facing purposes. This material is obtained chiefly from the Adirondack region. The other half was ground fine and used in pottery, enamel, glass, and abrasive soap manufacture. The output comes mainly from five quarries.

North Carolina.

This State shipped a small tonnage in 1913 to grinding mills at Trenton, N.J., and East Liverpool, Ohio. From recent reports, there would

[1] Trans. Am. Ceram. Soc., Vol. XV, 1913, p. 465.

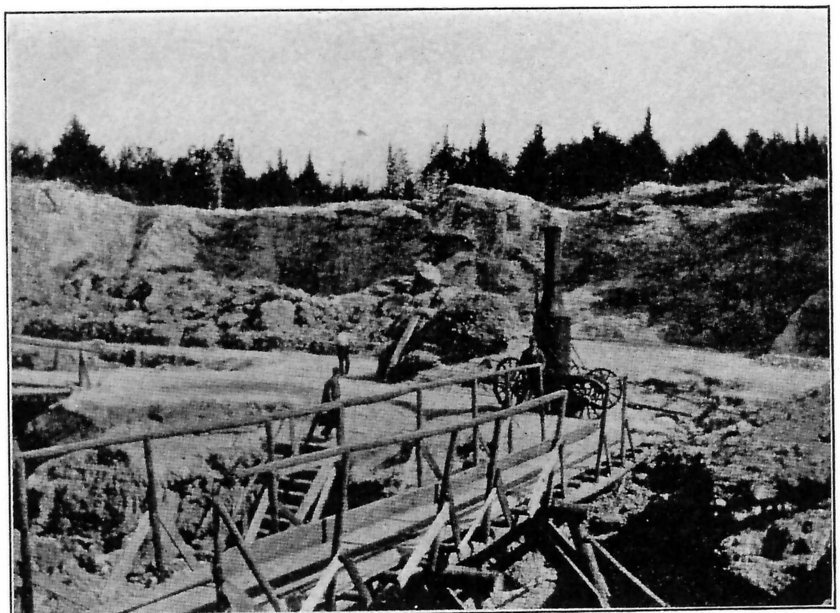
PLATE XXI.



Reproduced from Bull. No. 420, United States Geological Survey.

Pegmatite dike in granite-gneiss at feldspar quarry, East Glastonbury, Connecticut, U.S.A.

Plate XXII.



Reproduced from Bull. No. 420, United States Geological Survey.

Portion of Willes feldspar quarry, Topsham, Maine, U.S.A.

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appear to be considerable interest displayed in the feldspar occurrences of the State, notably in the Spruce Pine district, Mitchell county, where three quarries are in operation.

Pennsylvania.

Nearly all the quarries are situated in Chester and Delaware counties. While most of the occurrences consist of ordinary granite-pegmatite, those near the Maryland border are soda-pegmatites, and are enclosed in serpentine. There are nine large quarries besides a number of smaller ones, and the spar is employed for practically all purposes—from pottery to poultry grit.

Various States.

A small production was recorded in 1913 from Colorado, Minnesota, and Vermont, and the mineral has been worked in the past in Massachusetts, Tennessee, and Virginia. Occurrences are known, also, in Texas and Wisconsin, the pegmatite dikes at Baringer Hill, Llano county, in the former State having been extensively worked for rare earth minerals.

The Minnesota mineral appears to have been utilized solely for abrasive paper; according to Merrill[1] it is labradorite, being a constituent of a gabbro.

The feldspar resources of Georgia have lately been the subject of investigation by S. L. Galpin; no mineral has yet been quarried in the State.

Industrial.

The chief pottery centres of the United States are Trenton, New Jersey, and East Liverpool, Ohio. These two centres in 1909 (the year of the last census) produced 41 per cent of the total value of pottery products in the United States.[2] The value of the pottery, terra cotta, and fire clay products manufactured at Trenton in the above year was $7,175,801 and of similar products at East Liverpool $5,538,870.

The output of the Trenton factories is largely sanitary ware, while that of the East Liverpool works consists chiefly of white ware, C. C. ware,[3] etc.

Less important pottery centres in the United States are Philadelphia and Toughkenamon, Pennsylvania; Syracuse, New York; Coshocton and Sebring, Ohio; Chester and Wheeling, West Virginia.

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[1] Merrill, G. P., "The Non-Metallic Minerals," 2nd ed., 1910, p. 164.

[2] See 13th Census of the United States, 1910, Vol. X, p. 867.

[3] C. C. ware = cheaper grades of cream-coloured earthenware.

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CHAPTER III.

MINING, PREPARATION AND USES OF FELDSPAR.

Mining.

The process of extracting feldspar from the earth should more properly be termed quarrying than mining, as few, if any, spar workings are in any sense mines. Practically all the feldspar raised in any of the countries producing the mineral is obtained by the most ordinary quarry methods, large open pits being sunk along the line of the spar body, and only where a narrow dike is in the nature of a sill, or is overlain by a considerable capping of country rock, are drifts run in on it; such drifts are seldom of any great length, as it is obvious that extraction by such means would cost more than the market value of the spar warrants.

Feldspar is a mineral that it can only pay to extract by the cheapest and simplest means, and a spar body that does not lend itself to working by simple quarry methods is not a commercial proposition. This applies as well to mineral of the highest pottery grade as to that of slightly inferior quality, which is to be employed in the glass or enamel industries. Except under very favourable circumstances as regards situation and transportation facilities, a spar body yielding only the lower grades of mineral, suitable for poultry grit, roofing, abrasives, etc., cannot be profitably worked. A road haul of more than three or four miles in the case of such a deposit is usually an effectual bar to its development. In countries where labour is relatively cheap, however, a quantity of more or less pure, pottery spar may sometimes be hand cobbed out of material from such a low grade dike, the residue being utilizable for other purposes. Such methods cannot, however, be employed on the American continent; they might, possibly, be feasible in the case of the Indian mica-bearing pegmatites, but here, again, the low cost of production is offset by the high rail freight to the coast, there being no spar consuming industries worth mentioning in the country, and the whole output would be destined for export. As mentioned on p. 77, an attempt to export spar from India to the United States was reported in 1913, but with what success is not known to the author. Evidently the venture did not prove successful, or more would have been heard about it.

As a general thing, the feldspar mining industry is one of small operators, the individual quarries being worked only to limited capacity. In 1913, for instance, the total production of 121,000 tons in the United States was obtained from 48 separate quarries,[1] or an average of 2,500 tons per quarry. In Sweden, in 1911, the total output of 36,000 tons came from 77 quarries. On the other hand, the Canadian output of nearly 17,000 tons in the same year was practically the production of one company alone and

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[1] See Mineral Resources for 1913, Part II, pp. 149-151.

was taken from two quarries. Howe[1] lists 18 china-stone quarries in Cornwall in 1912, but it is not stated how many of these contributed to the total output of 73,284 tons in that year. The Tregargus quarry would appear to have been the largest producer, though the actual production figures are not given.

Watts[2] has drawn attention to the excessive waste practised in the operation of granite-pegmatites in the United States, particularly in North Carolina. The majority of the pegmatites in this section have been worked for mica, and immense quantities of semi-kaolinized spar are contained in the waste dumps around the mines. It appears that this spar is either broken so small or is so intimately mixed with impurities that it would not be practicable to recover it. The same waste of feldspar, however, would seem to be practised at the present time at many of the mica mines in the United States, and the advantage of conservation methods in this regard is pointed out in the above report. Many of the mica mines are, doubtless, too remote to permit of the hauling to rail of the spar extracted, but others should be able to realize a profit, especially if a crushing and grinding plant were installed and the mineral shipped ground to the potteries, etc. With ground spar selling at about $10 per ton, hand sorting and milling costs in conjunction with freight rates should permit of shipments being made at a profit.

As already mentioned, in the case of the Indian mica-pegmatites the mines are apparently too remote to permit of the spar standing the rail freight to a port and the additional ocean freight.

At many of the American spar mines, also, small, flake muscovite mica, useless for insulating and similar purposes, occurs in some quantity and is discarded; a great deal of this small mica could doubtless be recovered with a little care, and sold to mica grinding establishments.

The exact method to be followed in opening up a feldspar deposit depends essentially on a number of factors which, along more or less similar lines, govern the mode of development of any mineral body. These are, in the main, the situation of the outcrop—whether upon the flank or the summit of a ridge; the position the body occupies—whether it is flat, in the form of a sill, or more or less steeply inclined; the visible width, extent and shape of the body—whether the former is more or less constant along the outcrop or whether the body has the nature of an irregular lens; the nature and thickness of any overburden that may be present; and lastly, but most important, whether the entire spar body is homogeneous in composition throughout its width or exhibits zonal differentiation, the feldspar, mica, quartz, etc., being segregated in certain main portions of the mass. In some mica-pegmatites this latter feature is often quite pronounced, the mica being mainly confined to the vicinity of one or other of the dike walls, while any tourmaline, garnet, etc., that may be present similarly follow certain broad zones. In other cases, however, either no such segregation has taken place

[1] *Op. cit.*, p. 224.
[2] *Op. cit.*, p. 10.

or else it is not sufficiently obvious or pronounced to be of any assistance in mining.

In the majority of cases, a considerable portion of the material of a feldspar dike contains too much intimately mixed quartz or other impurities to permit of its being employed for any commercial purposes. It is a common thing for benches or bosses of quartz to separate similar masses (in some cases aggregates of very large crystals) of spar or of graphic-granite. Depending on the location of the quarry, it may or may not be profitable to ship this quartz to smelters, wood finishers, abrasives manufacturers, etc. Occasionally, such quartz masses are exceedingly ferruginous, carrying considerable quantities of pyrites; this iron content, of course, effectually renders the silica so much waste material, and it has to be either left in place (if possible) or else worked around as long as feasible and then extracted and consigned to the waste dump.

Such quartz masses enclosed in feldspar bodies are typical of the Bedford (Ontario) deposits. In the largest quarry in the district, a large mass of quartz, in some portions high in pyrites, occupies almost the centre of the spar body (here some 150 feet wide) and has been left standing, the spar being extracted on all sides. In normal granite-pegmatites the quartz occurs usually in smaller masses and often cannot be saved separately; while in the coarser granites, which in some cases are worked for their spar content, the silica is present as an integral part of the rock.

As a general thing, it may be said that a feldspar body, unless exceptionally favourably situated as regards transportation facilities, or unless its natural position renders it capable of being worked with a minimum of expense, is hardly worth exploiting unless it possesses a width of at least 25 feet. Smaller bodies have been worked, of course, but the difficulties of quarrying from a narrow excavation, once a moderate depth has been reached, are such as to send up working costs to an excessive figure. Feldspar, also, is usually bought on a contract basis of a guaranteed supply of so many thousand tons, and the operator of a small deposit may thus find the latter half of his contract run away with the profits realized on the surface mineral. There is always the likelihood, too, that the dike will still further narrow in depth, or that the quantity of quartz present will increase; in addition to which there is nearly always a certain amount of waste incurred along the walls, owing to the presence of iron-bearing minerals in the contact zone.

Some of the larger pottery works in the United States own their own feldspar quarries, and either operate them themselves or have them worked by contract. At the same time, several firms obtain a considerable tonnage of high grade spar from Canada. Practically the whole of the Canadian production is contracted for in advance by American potters.

Open cut quarrying is ordinarily the process followed in developing a feldspar body. Any overburden present along the outcrop must, of course, be removed, and straight sinking is carried out upon the zone of purest spar visible at the surface. In the case of a moderately narrow body—25 to 50 feet—it is well to commence sinking across the whole width of the dike, unless certain zones obviously are composed of worthless material; in this way, a better idea of the character of the dike material as a whole can be obtained. Quartz masses and ledges being so prevalent in spar bodies, the presence of such a quartz zone on the surface does not by any means indicate that it will persist in depth, and the mineral is quite likely to be present merely as a stringer or splash in the spar. To leave and work around such a small quartz mass is often more productive of difficulties than its extraction and handling as waste. In a wider dike, which exhibits a more or less well defined banding or zonal arrangement of spar, quartz, mica, etc., the spar zone may be wide enough to sink upon without difficulty, and the handling of dead dike rock may thus largely be avoided.

In the case of a narrow dike outcropping in the face of a ridge or hill, attack may be made by means of a drift run in along the spar body, with subsequent overhead stoping. Such a method of spar extraction is never followed on the American continent on account of the expense attached, but it appears to be practised in Norway, (see Plate XX). Drifting and stoping are, however, practised frequently in the mica-pegmatites of the United States where the mica is the objective. In India, the mica-pegmatites have been habitually tunnelled with a net work of tortuous passages, the object being to avoid the removal of more dead rock than absolutely necessary, owing to the primitive methods of handling, all material being raised to the surface by means of baskets either carried or passed from hand to hand by a line of natives.

The methods adopted in the extraction of feldspar thus call for little comment, ordinary quarry procedure being followed almost universally, and the exact method of attack being governed by local conditions in each case, the chief factors being the character of the dike material (whether homogeneous or zonal), the width of the spar body, and the position of the outcrop. The general nature of feldspar quarries is apparent from the various photographs of workings in this report.

In the case of shallow workings on a more or less level terrain, the rock is hoisted by means of derricks to a loading platform or pocket, whence it is loaded into wagons, tram-cars, or scows, as the case may be. With increasing depth cable hoists are usually substituted for the derricks, and in large excavations, inclined skipways may be installed. If the quarry is in the nature of an open cut on sloping ground or in the side of a hill, a tramway may be laid on the floor of the cut and the rock run out to the store pile.

Sorting.

In most spar quarries the rock has to undergo some sort of hand sorting to free the purer mineral from adhering quartz, mica, and other impurities, and this cobbing is usually carried out on the floor of the pit, light hammers being employed to break up the larger lumps. In quarries yielding pottery spar such hand cobbing is almost always essential, though at one quarry in Ontario, the spar is sufficiently clean in most parts of the pit to necessitate hardly any sorting, and the blasted rock is loaded direct onto the hoist trays. In the case of quarries which yield principally or solely a grade of spar suitable for such purposes as glass-making, poultry grit, roofing, etc., careful hand sorting is not required.

The impurities, in the shape of accessory minerals commonly present in feldspar bodies, include quartz, muscovite and biotite micas, beryl, garnet, tourmaline, hornblende, apatite, and pyrites. Some pegmatites carry, also, a number of less common minerals, such as pitch blende, samarskite, and other minerals containing rare earths; the Norwegian pegmatites are noted for the quantity and variety of such minerals that they carry.

Some pegmatites are of the two-feldspar type, that is, they consist of a mixture of albite and microcline, often intimately intergrown (perthite or microperthite). The two spars, in such case, cannot be separated by hand sorting. In other spar bodies, the albite is sometimes found in zones in the microcline, and the two varieties may then be separated fairly cleanly (*e.g.* the Villeneuve mine, Ottawa county, Que.)

A small amount of quartz and muscovite mica is hard to avoid even in the best spars, and as these minerals exert little influence on the colour of porcelains and glazes, they are not deleterious as long as the amount present is small. Appreciable amounts of muscovite, however, materially affect the fusibility of the spar, lowering the fusion point.

Watts[1] found that 30 per cent of quartz raised the deformation point of a feldspar-quartz cone less than two cones, or 40° C., and that a mixture of 95 per cent feldspar and 5 per cent quartz begins to deform at the same temperature as pure feldspar, though it becomes fluid much more quickly than the latter. A mere cone test, therefore, is not sufficient to indicate the percentage of quartz present in a feldspar. As a general thing, commercial spars range up to 20 per cent of quartz, it often proving too expensive to reduce the quartz content below 10–15 per cent by hand sorting.

Iron, whether as the sulphide or oxide, at once bars a spar from practically any use whatever, and weathered, surface mineral is frequently worthless on account of its iron-stained character. One half of one per cent is the maximum permissible Fe_2O_3 content in spars for any industrial purpose.

Beryl is harmful only in as much as it lowers the fusion point of spar containing it, Watts obtaining his greatest deformation with 20 per cent beryl and 80 per cent spar. Greater percentages of beryl were not tested.

Biotite mica is not commonly present in feldspar or pegmatite bodies. Notable exceptions are the red spar dikes of the Muskoka region, in Ontario, where the mineral occurs in large amount and in big sheets (up to 18 inches across), effectually spoiling the quality of the feldspar. It is

[1] *Op. cit.*, p. 27.

found both near the contact with the enclosing gneiss and also on seams in the mass of the dikes, and it is impracticable to cob it out entirely. Biotite occurs, also, in intergrowth with muscovite in some mica-pegmatites of the lower St. Lawrence, in the Province of Quebec, (*e.g.* Lac Pied des Monts, Bergeronnes, etc.). The iron content (commonly 5–20 per cent Fe_2O_3 + FeO) of this mineral renders spar containing it useless for pottery and enamel purposes.

Garnet in any amount renders feldspar useless as it both impairs the colour of the fused mineral and lowers its fusion point. According to Watts, five per cent of andradite, or iron garnet, lowered the deformation point at least one cone below pure spar, while one per cent imparted a pale brown or green colour to the fused sample. No test was made of spessartite, or manganese garnet, which is sometimes found in pegmatites.

Tourmaline, on account of its iron content (the tourmaline of pegmatites and spar dikes is commonly schörl, or iron tourmaline, though certain of the Maine pegmatites carry a good deal of green and pink, gem tourmaline) imparts a strong coloration to feldspar. Watts used five per cent in a test, and this amount produced no effect on the deformation point.

Hornblende is not usually met with in pegmatites, but is a common mineral in the contact zone of Canadian spar dikes. It is usually confined to a narrow strip immediately bordering the contact. Its iron content necessitates the discarding of such contact material. Hornblende also occurs with albite in certain spar deposits of Pennsylvania and Maryland.

In addition to removing the above mentioned iron-bearing minerals, it is important, also, that care be taken to eliminate any surface soil that may have become mixed with the spar in the stock piles.

As mentioned elsewhere (p. 59), feldspar is quite readily attacked by pure or carbonated waters, kaolin or china-clay resulting when decomposition is complete. Kaolin, resulting from the breaking down of feldspar by the agency of surface or meteoric waters is rare in northern latitudes, owing to the removal by ice during the Glacial period of the clay deposits so formed. Such residual kaolins are, however, met with in the south. Both kaolin and semi-kaolinized feldspar occur side by side in Cornwall, kaolinization here being the result of pneumatolytic action, and persisting in depth. In unglaciated areas, also, the upper portions of pegmatites are generally formed on more or less kaolinized feldspar, which in depth grades into hard, unaltered mineral.

According to Watts,[1] the reddish, buff, brown, cream, and green spars do not lose their shades upon fusing, and are, therefore, not to be considered as suitable for pottery purposes as the white spars. The intensity of colour of the mineral, according to the above writer, is no direct indicator of the colour the fused product will assume. In general, the feldspars which fuse to the most colourless or white glazes are those which are pure white or colourless. The next in order are the pale brown and nearly transparent

[1] Trans. Am. Ceram. Soc., Vol. XVI, 1914, p. 93.

feldspars. The next are the cream feldspars. These are generally opaque or nearly so. The next are the brown and buff feldspars. The last, and most highly coloured when fused, are the sea-green or olive-green feldspars. This classification is for feldspars which do not contain any foreign material other than that distributed uniformly as a colorant through the entire mass.

PREPARATION FOR VARIOUS USES.

The commercial use of feldspar was originally limited practically to the pottery industry, and this trade, including the sanitary and electrical ware and enameled brick and tile business, continues to consume by far the greater part of the spar raised.

In Sweden and Norway, feldspar for use in European porcelain works was quarried as far back as 1790, these countries being then the sole source of supply of the mineral. Scandinavia, in fact, continues to supply about half the European consumption of feldspar; the output from the above countries being about 75,000 tons in 1912. Cornwall supplies about the same quantity of china-stone, which is a peculiar variety of granite, and is crushed and ground in the same way as spar; it serves practically the same purpose as feldspar in pottery manufacture.

In more recent years, the uses of spar have been extended to the enamel-ware (cooking and household utensils) and opalescent glass trades, and a quantity of coarsely ground, low grade mineral is employed as poultry grit, and as a covering for tar roofing papers.

A small amount is utilized in abrasive soaps, particularly window glass soaps, and the mineral also enters into the composition of emery and carborundum wheels, in which it serves as a flux to bond the abrading particles.

A few tons of the highest grade of selected potash spar (dental spar) are used in the manufacture of artificial teeth.

Within the past few years, and more particularly since the outbreak of the war and the consequent cessation of shipments of German potash, considerable attention has been devoted to the question of the extraction of potash from feldspar. A number of patents have been taken out with this end in view and large sums of money have been expended in experimental research; up to the time of writing, however, there is no evidence to show that any of the suggested processes can be considered commercially practicable, the cost of extraction being prohibitive. (See also p. 115).

A recent innovation, also, is the use of very finely ground potash spar as a fertilizer in the same way as ground phosphate rock (floats) is sometimes employed. Reports show that attempts have been made in the United States to introduce a product consisting essentially of crude, ground feldspar, phosphate rock and limestone, which, it is claimed, possesses fertilizing properties; one such mixture is named stone-meal. Whatever fertilizing value such a mixture may have, it is out of all proportion to the claims made, and the ground feldspar is probably the least valuable of the several ingredients. Considerable investigation has been carried out in the United States upon the value of ground, crude spar as a fertilizer, and the tests have shown that the applications produced practically no tangible results that could be traced to the potash content of the spar. The breaking down of the silicate by soil acids (even when the mineral is extremely finely ground) and the liberation of the potash in a form available to plant growth, appear to be such gradual processes that there can be no prospect of any immediate valuable results being produced by the application of such material.

Grinding.

Feldspar for all purposes has to be either crushed or ground, according to the use to which it is to be put. The milling takes place, variously, at the quarries or at the works, according to the requirements of the consumers.

In some cases, where the mineral is more or less kaolinized, preliminary calcination may be employed, in order to remove the combined water. Heating and quenching of the spar before milling is practised, also, at the Sparvetta quarry, near Sylmar, Maryland; here the operation is conducted in order to shatter the mineral and facilitate grinding.

As a general thing, however, the crude, block spar is fed to a jaw crusher and broken to about 2″ size, after which it proceeds to a chaser mill. This consists of two buhrstone wheels, 3 to 5 feet in diameter and about 1 foot thick, attached to radial arms carried on a vertical shaft. The wheels travel on a bed made of blocks of similar stone, and effect the preliminary grinding of the spar.

As feldspar cleaves readily under the hammer into pieces small enough to be charged to the chaser mill, a jaw crusher is often dispensed with and the rock is simply broken with sledges to the requisite size.

The material from the chasers is screened and the fines pass to pebble mills, the oversize being returned to the stones.

The pebble mills are lined either with hardwood blocks or with siliceous brick. The cylinders are 6 to 7 feet long, and take a charge of 2 to 3 tons of spar, though larger mills, taking 4 to 6 tons at a charge are sometimes used. It is most important that the spar, during grinding, be kept out of all contact with steel surfaces, as even a very small amount of iron dust is sufficient to render the material useless for pottery purposes. Less than 1 per cent of iron oxide imparts a yellow tinge to the fused spar.

The duration of grinding in the pebble mills is gauged by trial in each case, and the material is bagged direct without any screening. If much mica be present, however, it may be necessary to screen it out at this stage. Four to six hours is the usual length of time allowed for grinding, and the fineness demanded is 200 mesh.

The above procedure is that usually followed in grinding spar in all producing countries, though certain modifications may be introduced. Cornish-stone is ground wet in chaser mills, and the spar is then cleaned and recovered in settling pits. (See page 74). In the Swedish mills the ground spar from the tube mills is freed of any iron particles that may have been introduced in the grinding by being passed under an electro magnet. The mica, also, is removed before grinding by a special contrivance.

The majority of spars are light coloured, either white, grey, or pinkish, and grind quite white, but those from certain localities, as, for instance, from the Bedford and Verona districts, in Ontario, have often quite a dark, reddish-brown or brick-red shade, and these still possess a pinkish tint even when finely ground.

Spar for certain sanitary ware, etc., is not always ground as fine as 200 mesh, 160, 120, and even as low as 60 mesh being sometimes employed.

USES.

Ceramic Industry.[1]

Pottery bodies: Most all whiteware pottery bodies are composed of a mixture of materials, the chief of which are kaolin or china clay, ball clay, feldspar, and flint. In this mixture feldspar acts as a flux, or, in other words, it is the constituent that cements the body together at high temperatures.

The composition of a typical white earthenware body is:—

Kaolin	23 per cent
Ball clay	23 "
Flint	36 "
Feldspar	18 "

and of a vitrified whiteware body:—

Kaolin	23 per cent
Ball clay	23 "
Flint	18 "
Feldspar	36 "

These two recipes illustrate very well the function of feldspar in the mixture. If burned at the same temperature, say 1,300 degrees C., the first body will be porous, but the second body will be vitrified. If a larger proportion of feldspar were used in the vitrified body, the wares made from such a body would probably soften and warp in the kiln. The tableware, known as porcelain or china, is translucent and the composition of a typical body for this purpose is:—

China clay	50 per cent
Flint	30 "
Feldspar	20 "

The temperature of burning in this case is as high as 1,450 degrees C., so that if the feldspar content were much greater than 20 per cent the ware would not keep its shape during the firing.

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[1] For the following details regarding the use of feldspar in the ceramic industry, the writer is indebted to Mr. J. Keele, of the Ceramic Division of the Mines Branch.

Furthermore, porcelain is always burned in a reducing fire; thus, discolouration as well as softening may result from the use of an excess of feldspar.

Many of the English recipes for pottery bodies and glazes or enamels, given in books on these subjects, call for Cornish stone as one of the ingredients. For commercial reasons in this country, it is sometimes desirable to prepare substitutes for Cornish-stone. The readiest way is to use a mixture of flint,[1] feldspar and kaolin instead, according to the following mixture:—

Flint	40 per cent
Kaolin	19 "
Feldspar	41 "

Glazes: All whiteware articles are coated with a glaze, which is generally transparent. The glazes are made up of mixtures of the same materials used in the body, but with the addition of more fluxing materials, so that the glaze matures at a lower temperature than the body, two separate firings being necessary.

A simple form of porcelain glaze is:—

Feldspar	167 parts
Whiting	70 "
Kaolin	52 "
Flint	108 "

This requires a high temperature to mature, but a lower temperature than a porcelain body.

A white earthenware or wall-tile glaze, which matures at a much lower temperature, is:—

Feldspar	111 parts
Whiting	30 "
Kaolin	13 "
Flint	37 "
White lead	90 "
Zinc oxide	12 "

Enamels for Clay Wares.

Glazes are generally understood to be transparent, so that the colour of the body to which they are applied is revealed, but enamels are opaque and conceal the clay body.

The white earthenware glaze given above can be changed to an enamel of almost any colour, by the addition of small amounts of the metallic

[1] The silica for use in pottery bodies in England is obtained by grinding the flint nodules which occur so plentifully in the chalk of the southern and eastern portion of that country.

The silica commonly used in American pottery bodies is ground quartz sand or quartzite, and incorrectly bears the name of flint.

oxides. For example, three parts of cobalt oxide will produce blue, eight parts of copper oxide will produce green, and an opaque white enamel is obtained by the addition of tin oxide. These coloured glazes or enamels are used extensively in the clay industry as coatings on architectural terra cotta, wall-tile, and brick.

An infinite number of combinations of glaze materials are made, so as to adjust them to fit the requirements of body shrinkage, fusibility, and colour. Orthoclase feldspar is invariably present in these mixtures.

The following notes on the required properties in a spar to be employed for pottery purposes are taken from a paper by H. E. Ashley, in Transactions of the American Ceramic Society, Vol. XII, 1910, pp. 435-438. While a few per cent of soda in a pottery spar are usual and immaterial, a high soda spar is objected to because it gives a dull ring to ware made from it. Mixtures of soda and potash feldspars have a lower melting point than pure potash spar, and are more in favour for glazes than for bodies.

As has already been noted, the presence of quartz in feldspar has little influence on the melting point, the minimum temperature being reached with 25 per cent SiO_2.

As it is difficult to judge with the eye the percentage of quartz present in a crude spar, the only safe method of ascertaining the quantity is by analysis.

Hornblende, tourmaline, biotite mica, and other iron-bearing minerals, show in the fired samples or finished ware as very fine, black specks, and impart a greyish cast to the article; they must, therefore, be carefully eliminated from the crude spar.

A low fusion point in a feldspar may be caused by (1) mechanically admixed soda feldspar; (2) soda and potash feldspar in crystallographic intergrowth; (3) mechanically admixed quartz; (4) feldspar which has crystallized with an unusually high amount of silica. Thus, four samples all showing the same melting point may exhibit very different properties in a mix, and fusion point cannot be taken as indicating the composition of the raw material.

The more finely ground a feldspar is, the better, as it thus obtains a more uniform distribution through the body. If it is in coarse grains, it will have to flow in order to fill the pores and cement the clay and quartz grains, while if in a state of fine division it has merely to soften in position. In this way the body itself does not approach so near to fusion, its particles are less disturbed, and the tendency to warp and bend is reduced.

The Cornish-stone used in England in lieu of feldspar consists roughly of 11 per cent kaolin, 22 per cent quartz and 67 per cent feldspar, and is a semi-decomposed granite. Comparative tests made on this material and an artificial mixture of kaolin, quartz and feldspar in equivalent proportions to these minerals as contained in the rock, failed to show any material difference in the behaviour of the two substances.

Enamelled Metal.

For this purpose a fineness of 80 mesh usually is sufficient. For the white glazes, iron-free spar is as necessary as in the pottery trade, one half of one per cent being the permissible limit. The absence of appreciable amounts of quartz, mica, and other impurities, also, is stipulated for.

Thorpe[1] gives the following notes on the enamelling of culinary and other metal ware: Soft sheet steel is commonly used for hollow ware. The object to be enamelled having been carefully cleaned by pickling in an acid bath is coated with a thin layer of enamel (the ground enamel). This primary coating or ground need not be opaque, and generally contains a little cobalt or nickel oxide. A suitable material is obtained by fusing a mixture of flint or quartz 30 parts, borax 25, and feldspar 30. This product is then ground with kaolin 10·75 parts, feldspar 6, and magnesia 1·25; the clay tends to lessen the fusibility. The finely powdered ground enamel is mixed with water to a creamy consistency and applied to the ware, slightly heated; after the coating has dried, the object is fired in a muffle furnace at a temperature rather under 1,000°. After this stage of enamelling the ware is scrubbed to remove scale, and a second coating (the cover enamel) is applied, this time opaque white. This cover enamel may be made from a mixture of flint 37·5 parts, borax 27·5, tin dioxide 30, soda 15, nitre 10, ammonium carbonate 7·5, and magnesia 7. This mixture is fritted (*i.e.* fused, in order to render the water-soluble ingredients insoluble and thus prevent them unmixing on being made into a paste), quenched in water, and then ground in a ball mill or between buhr stones to 120 mesh with flint 6·12 parts, tin dioxide 3·66, soda 0·7, and magnesia 0·7. Grinding may take as much as 30 hours and is best effected in water. The cover enamel is dried to a powder and dusted over the ground enamel already on the red hot ware. The ware is then carefully fired again in a muffle at a lower temperature than that of the first firing. In some cases, a third coat of enamel is applied, while in other cases the ground layer is dispensed with and only a single white coating used. . . . In some enamels, like granite ware, the colour is applied by spraying.

It is estimated that in Germany and Austria, in which countries the enamelware industry has found its greatest development, close on 50,000 people are employed in the production of this class of goods.

Feldspar is the main ingredient in enamels as it supplies the silica and silicates, in addition to which the alkali and alumina exert a favourable influence on the opacity.

The bulk of the 40 to 50 per cent of silica which ordinary enamels contain is furnished by the feldspar, whether quartz be used or not. The percentage ratio of spar to quartz present in the raw mixture employed for first class enamels varies between wide limits. The following figures are quoted by Grünwald:—[2]

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[1] Dictionary of Applied Chemistry, Vol. II, 1912, p. 335.

[2] *Op. cit.*, p. 11.

Class of Enamel	Extreme Percentage Ratios of Feldspar to Quartz
Ground	25 : 21 to 40 : 1
Common white	15 : 30 to 39 : 0
Soft white	25 : 9
Acid-free white	6 : 47 to 17 : 40
White for cast iron	39 : 0 to 26 : 13
Powder white	26 : 0
Blue	29 : 18 to 44 : 0

The above are not necessarily the extreme limits for enamel mixtures, but are those given for current trustworthy enamels.

The ingredients for typical enamels for use on cast iron, as given by Grünwald,[1] are:—

	White	Blue
Borax	22·3 parts	21 parts
Feldspar	46 "	46 "
Soda	12 "	15 "
Saltpetre	0·75 "	2 "
Stannic oxide	15·5 "	1–2 cobalt oxide
Fluorspar	1 "	5 "

For further data on the subject of enamelling, see the following: Philipp Eyer, "Die Eisenemaillierung," Leipzig, 1907; Paul Randau, "Die Fabrikation des Emails und das Emaillieren," Vienna, 4th Ed., 1909; "Enamels and Enamelling," English Translation of P. Randau by Charles Salter, London, 1900; Julius Grünwald, translated by Hubert Hodgson, "The Theory and Practice of Enamelling on Iron and Steel," London, 1909; also, by the same author and translator, "Raw Materials for the Enamel Industry," London, 1914.

Opalescent Glass.

A small amount of spar is used in this industry. The mineral employed is not usually of first grade, and in the United States is classed as No. 3 by the producers. The material may contain more free quartz and mica than pottery spar, and small amounts even of ferro-magnesian minerals do not preclude its use. A feldspar high in soda is especially suitable for this purpose. Fine grinding is not so essential, and the grinding period is limited to two or three hours.

Artificial Teeth.

Only the most carefully selected white, potash spar is employed, and the consumption is small. The Villeneuve mine, Ottawa county, Province

[1] *Op. cit.*, p. 216.

of Quebec, yields a grade of spar well suited to this purpose, and a small tonnage is shipped every year to manufacturers in the United States.

According to Mineral Industry, Vol. XX, 1911, p. 267, the composition of artificial teeth consists of 80 per cent feldspar and 20 per cent quartz, which is fused at cone 9 (1,310° C.) and then finely ground. Five per cent of bone ash is added to the above mixture in order to impart a natural appearance, and a natural colour is produced by oxides of titanium, nickel, copper, iron, etc.

For the following particulars relative to the manufacture of artificial teeth from feldspar, the author is indebted to Mr. H. C. Meyer, chemist to the Foote Mineral Company, of Philadelphia, who, on request, kindly furnished the desired information:

"Most manufacturers grind the spar in the dry state after first having split it up into thin cleavages by hand to assure themselves that the material contains no mica or ferruginous minerals. Mica is considered the most detrimental of any of the impurities, as it is impossible to reduce it to the same degree of fineness as the feldspar. After the material has been broken into thin cleavages, it is either placed in drag mills (arastras) and ground in the dry state, or thrown into tub mills, which are very similar to the drag mills except that they have a water-tight body, and reduced to about 120 mesh. Very fine material is floated off, as it is considered objectionable. When grinding dry, the screening problem is very simple. In the wet state, of course, it is necessary to dry the pulp after grinding, and by either process the material is finally passed through a bolting cloth reel.

"So far as we know, none of the American manufacturers calcine their spar before grinding. One or two of the English manufacturers, however, do this, placing the spar in the lump form in large saggers and burning in an ordinary pottery kiln. They claim that this preliminary calcining develops the impurities so that they can be readily detected and cobbed off.

"Potash feldspar is, of course, the main ingredient of the artificial tooth. By itself, however, the spar would yield a semi-translucent body, and to prevent this, bone ash is generally added to produce necessary opacity. In addition to this, a small percentage of silica and kaolin is also added, about 19% of the former and 16% of the latter being used, with possibly a little flux.

"Each manufacturer has his own particular tooth formula and very great secrecy is observed in the mixing rooms.

"To secure the necessary life-like tint, specially prepared titanium oxide is utilized in the proportion of one half of one per cent to several per cent, depending on the shade desired.

"After the various ingredients have been properly mixed in the dry state, they are moistened with water containing a little rice starch, and the mass worked up to a stiff dough. It is then taken to the moulding room and formed in steel dies by hand, this work generally being done by children or young girls. When taken from the mould, the tooth is soft, but on drying, the starch hardens it up so that it can be readily handled without danger of breakage.

"Holes are then drilled in the back of each tooth for the insertion of a metal pin by which the tooth is fastened to the artificial gum. For the better grades of teeth, this small pin, measuring about 6 mm. in length and nearly 1 mm. in diameter, is made of platinum, but in the cheaper grades of teeth it is made from nickel alloy.

"After the platinum pin has been inserted, the teeth are placed on fire-clay slides on a bed of coarse silex, pins down, and placed in a specially constructed furnace, fired with petroleum. Here they are first placed in a pre-heating chamber and finally in the muffle of the furnace where they are subjected to a temperature of at least 2,200° F. This vitrifies the tooth, and after a final inspection for imperfections, they are ready to be placed on the market."[1]

Abrasive Soaps and Wheels.

The spar used in abrasive soaps is ground even finer than that for pottery purposes, its function being to scour or abrade without scratching. In emery and carborundum wheels, also, fineness is desired in order that the spar may be thoroughly and evenly incorporated with the other constituents; its function here, however, is to act as a bond or cement, the spar fusing when the wheels are baked.

Roofing Spar and Poultry Grit.

These trades employ only the waste spar, which is unfit for any of the above purposes. Any coarse granitic rock, in fact, is suitable for roofing or grit, and the waste chip from granite-working quarries is sometimes crushed for the purpose.

Such impurities as mica, tourmaline, quartz, etc., are no drawback, and indeed for roofing are desirable, as they impart a dark shade to the grit covering. For the latter purpose, also, a greenish or buff coloured spar is preferable to a white or light coloured.

The feldspar is first crushed in a jaw or gyratory crusher and is then passed through steel rolls. A Kent Maxecon mill answers the purpose. It may then be screened over vibrating screens of the Newaygo type. A fineness of about 12 mesh is sufficient for this class of material.

The price of $3 to $3.50 offered for this class of spar, crushed, indicates that only waste rock can be employed for the purpose and that quarrying operations for this grade of mineral alone cannot be considered.

Fertilizer or Potash Extraction.

Feldspar to be of value for any process that may aim at utilizing its potassium content must be high grade microcline or orthoclase. The theoretical percentage of potash in pure orthoclase is 16·9, but this percentage is never realized in the natural mineral. Dana quotes a high potash spar (15·99 per cent K_2O) from French creek, Pennsylvania, and others slightly lower from Carlsbad, Baveno, etc. As a general thing, the content of K_2O in commercial spars is under 14 per cent, and this refers to pure, selected samples; the average of quarry material as shipped probably does not contain much over 10 per cent. Bastin[2] gives 9·28 per cent as the highest percentage in four samples of graphic-granite analysed.

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[1] See also Watts, A. S., "Dental Porcelains," Trans. Am. Ceram. Soc., Vol. XVII, 1915, pp. 190–199.
[2] *Op. cit.* p. 14.

The potash of microcline and orthoclase feldspars—even when the minerals are exceedingly finely ground—is practically insoluble by any cheap, commercial process hitherto devised, although as already stated, numerous investigators have in recent years been working on the problem and several have claimed to have perfected methods of recovery practicable on a commercial scale.

The earliest attempt along these lines was made as far back as 1847, and since then dozens of patented processes have appeared. Most of the processes are thermic, and involve fusing or calcining a mixture of ground spar and some salt, such as an alkali sulphate or chloride, with or without carbon, limestone, etc. In this way the potash present in the spar is converted to the sulphate or some other soluble salt and can be recovered by leaching the furnaced charge.

A list of the various patents that have appeared in the United States, England, and Canada, and having as their object the recovery of the potash of feldspar, is given as an appendix to this report.

At the time of writing, although a number of investigators claim success for their processes, no demonstrated, commercial method has been evolved. Many of the extraction processes are admittedly feasible on a laboratory scale, but are too costly to be worked in actual practice.

Prices.

The following scale of prices of feldspar has been taken from Bastin's Bulletin already referred to, p. 14, and relates to the 1910 market in the United States:—

	Crude, per long ton	Ground, per short ton
	$	$
Maine:		
No. 2 or Standard	2·50–3·00	....
Northern New York:		
Crushed pegmatite for roofing and poultry grit	....	3·00–3·50
Southern New York:		
No. 1	4·25–4·50	8·50–9·00
No. 2 or Standard	3·50–4·00	6·00–6·50
Connecticut:		
No. 2 or Standard	3·50–4·00	5·50–6·50
Pennsylvania:		
No. 2 or Standard	3·75–4·50	7·50–9·00
Maryland:		
No. 2 or Standard	3·50–4·00	....
Trenton, N.J.:		
No. 1 (Canadian)	5·50	10·50
No. 2 or Standard	5·00–5·25	9·00–9·50

The above prices for crude mineral show but little variation from those for 1913, quoted by Katz in Mineral Resources of the United States, for

1913, p. 149, but the ground product brought from 10 to 12 per cent more in the latter year.

Crude No. 1 spar brings from 50 cents to $1.50 more per ton than No. 2, and crude No. 3 about the same amount less. Ground No. 1 is worth from $2 to $4 more per ton than ground No. 2. The prices for extremely finely ground spar for soaps, etc., are proportionately higher. Ground, dental spar sells at $6 to $8 per barrel of 350 pounds.

Canadian, block dental spar was valued at the mine at $22 per ton in 1914.

Of the price of $5.50 per ton for No. 1, crude Canadian spar quoted in the above table, delivered at Trenton, N. J., about $2 represents freight charges, leaving about $3.50 per ton for the mineral at the mine.

As already emphasized, feldspar is a mineral that cannot stand heavy transportation costs, (except, perhaps, in the case of the superfine dental spars), and any attempt at exploiting remote deposits that necessitate a long road haul, or even a short road haul with subsequent expensive rail freight charges, must necessarily end in failure.

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APPENDIX.

Abstracts of the Patents Issued in the United States, Great Britain, and Canada for the Recovery of the Potash Content of Feldspars.

Newton, Brit. Pat. No. 2421, 1854, proposed to release the potash of feldspar by grinding the mineral, mixing it with caustic lime and soda ash, and forming the mixture into heaps, which are kept moist with water. After a month "the soluble silicate is formed."

Bickell, U. S. Pat. No. 16,111, 1856, heated in a reverberatory furnace a mixture of 1 part feldspar, 0·5 parts phosphate of lime, and 3 to 4 parts lime. Furnacing was continued at a light red heat for two hours. On leaching the furnaced product with water, caustic potash is obtained in solution, or the material may be ground and employed direct as a fertilizer.

Ward and Wynants, Brit. Pat. No. 3,185, 1857, proposed to mix powdered feldspar and fluorspar with chalk and lime, and heat to a yellow-red heat for several hours. The furnace product is leached with hot water and the recovery is said to be 90 per cent of the potash present in the spar.

Newton, Brit. Pat. No. 413, 1858, proposed to obtain alkalies from feldspar, etc., by acting upon it with acids containing fluorine, such as hydrofluosilicic acid, the latter being prepared by special methods described in the patent.

Vanderburgh, U. S. Pat. No. 43,534, 1864, subjected a mixture of feldspar and an alkali to the action of superheated steam, and separated the silica, potash, and alumina by decantation.

Lock, Brit. Pat. No. 773, 1866, recovered the potassium silicate from feldspar by mixing the powdered mineral with caustic lime and water, boiling; decanting the solution and evaporating.

Anderson, Brit. Pat. No. 2801, 1867, proposed to recover potassium salts from feldspar, etc., by heating and passing through the charge carbon dioxide, nitrogen or producer gas.

Davis and Aitken, Brit. Pat. No. 4048, 1876, heated a mixture of phosphate rock, silica, (or some insoluble silicate, such as feldspar), and alkali sulphate, with or without carbon. The fused mass was then lixiviated, and a solution of alkali phosphate obtained, which may be evaporated, or the fused product may be ground and employed direct as a fertilizer.

Blackmore, U. S. Pat. No. 513,001, 1894, mixed powdered feldspar, calcium chloride and lime with water and furnaced in a retort at 1,100° C. for two hours. The furnaced material was leached with water and potassium chloride obtained by evaporation of the solution. In this process, the superheated steam produced in the retort is supposed to materially assist the decomposition.

Gibbs (Imray), British Patent No. 24,525, 1897, proposed to fuse a mixture of feldspar and lime or alkali carbonate in the electric furnace and recover the potash and alumina from the slag.

Imray (Gibbs), Brit. Pat. No. 13,134, 1898, mixes feldspar with phosphate rock and heats in an electric furnace to fusion point, subsequently grinding the cooled mass, which contains potash and phosphoric acid in available form. Or the fused product may be leached with water, and the potash, etc., recovered by evaporation.

Rhodin, U. S. Pat. No. 641,406, 1900, mixes 40 parts of slaked lime, 40 parts of salt, and 100 parts of powdered spar, and heats to 900° C. From 80 to 90 per cent of the potash is converted into potassium chloride. The residue may be employed in glass-making. (Also Can. Pat. No. 69,451, 1900.)

O'Brien, Brit. Pat. No. 5,559, 1902, utilizes leucite by treating with phosphoric acid, aluminium and potassium phosphates being formed.

Blackmore, U. S. Pat. No. 772,206, 1904, obtained carbonate of potash by exposing a sludge of ground feldspar and water to the action of carbon dioxide gas under 500 pounds pressure, the treatment being continued intermittently for several hours.

Gibbs, U. S. Pat. No. 772,612, 1904, boils powdered feldspar with a mixture of sulphuric and hydrofluosilicic acids, filters out the suspended silica and recovers the potash and alumina as potash-alum by crystallization. The hydrofluosilicic acid acts as a catalyser. In U. S. Pat. No. 772,657 this acid alone is employed.

Swayze, U. S. Pat. No. 789,074, 1905, fuses a mixture of 2 parts feldspar, 1 part gypsum, and coal in a blast furnace. Potassium sulphate is first formed, which at a higher temperature, is reduced to the sulphide, which is volatilized and recovered in water. (Also Can. Pat. No. 97,601.)

Swayze, Can. Pat. No. 97,601, 1906, produces potassium sulphate by heating a mixture of feldspar, gypsum and carbon, collecting the volatilized potassium sulphate in water and evaporating the solution.

Cushman, U. S. Pat. No. 851,922, 1907, mixed powdered feldspar with water to form a thin sludge. This sludge was then placed in a wooden container, which was set inside another larger vessel in which water was then placed. Electrodes are introduced, the positive pole being in the inner vessel and the negative in the outer. On the passage of a current, the potash, soda, and other soluble bases are partially liberated and pass into the water of the outer vessel. By agitating the sludge, or adding thereto a small amount of hydrofluoric acid, an almost complete recovery of the potash is effected. (See p. 59.)

Swayze, U. S. Pat. No. 862,676, 1907, first renders feldspar amorphous by heating the pulverized mineral, and then digests with a solution of caustic potash under pressure. A liquor containing potassium silicate and aluminate is thus obtained, from which carbonate of potash may be recovered by any well known means.

McKee, U. S. Pat. No. 869,011, 1907, heats a mixture of 5 parts of "potash-bearing mineral containing mica" and 1 part each of limestone and common salt in a rotary kiln for 2 hours. The calcined product is leached with water, and the resulting solution evaporated to yield a potassium salt (presumably the chloride).

Pohl, Canadian Patent No. 112,033, 1908, powders natural materials containing alumina, silicic acid and potash, such as feldspar, mixes with quicklime, moistens with water, and subjects to the action of steam. (Also U. S. Pat. No. 952,278.)

Gibbs, U. S. Pat. No. 910,662, 1909, mixes powdered feldspar with milk of lime and digests for from 12–24 hours under a pressure of 125–150 pounds. The resulting sludge is filtered and the residue washed until free from alkali. The first filtrate and the wash water are evaporated, and the crystallized salt fused, caustic potash being obtained. (Also Can. Pat. No. 110,087.)

Coates, U. S. Pat. No. 947,795, 1910, proposes to produce a fertilizer which shall consist of "breaking down rock bearing micro-organisms whereby the insoluble salts of phosphorus, potash and lime in the rock are rendered available for fertilizing purposes, and a sterilized practically solid food for bacteria inoculated with a special culture mixture." In other words, he proposes to decompose feldspar by means of micro-organisms.

Carpenter, U. S. Pat. No. 959,841, 1910, proposed to render the potash of feldspar available for plant growth by heating the mineral and quenching in water, the idea being to destroy the crystalline structure and render the mineral amorphous.

Cushman, U. S. Pat. No. 987,436, 1911. A mixture of 100 parts of feldspar, 20 parts of lime and 10–20 parts of salt is powdered and fed onto a revolving drum 3 feet in diameter to form a layer $1\frac{1}{2}$ inches deep. Strong calcium chloride solution is sprinkled on this and forms calcium oxychloride producing at the same time a "balling" of the powder. These balls are separated, and the residue re-treated with calcium chloride solution. The "balled" material is fed onto a rotary kiln, into which powdered coal is blown, and raised to a temperature below the volatilization point of the potassium chloride. The final product is ground and used as a fertilizer; it contains 6 per cent of potash. The residue is claimed to be free from iron and can be used in pottery, glazes, or cement manufacture. (Also Can. Pat. No. 140,390.) The method of forming clumps or aggregates in a powdered material is covered by Coggeshall's U. S. Pat. No. 987,554.

Thompson, U. S. Pat. No. 995,105, 1911. Feldspar is ground to 100 mesh and mixed with an alkali sulphate and an alkali chloride, preferably acid sodium sulphate and sodium chloride, in the proportions of 5 parts to 5 parts to 1·8 part respectively. The mixture is fused, allowed to cool, re-ground and leached with water, sodium and potassium sulphates being recovered by crystallization. Close controlling of the temperature is essential for good results and the recovery is 80–90 per cent. (This process is reported to have been operated in the United States on a commercial scale by the Spar Chemical Co., of Baltimore.) (Also Can. Pat. No. 138,858, 1912.)

Hart, U. S. Pat. No. 997,671, 1911, fuses a mixture of feldspar, barytes, and powdered coal, and treats the fused product with sulphuric acid. Sulphates of potassium, barium, and aluminium are thus obtained, and on evaporation the solution yields potash alum. The residue consists chiefly of barium sulphate and silica, and may be used in paint manufacture.

Lawton, U. S. Pat. No. 1,029,378, 1912, proposes to mix feldspathic material, previously calcined and quenched in water, with organic matter, such as straw, leaves, etc., and water. The process of decay and fermentation liberate acid and heat which attack and break down the silicates. The idea, thus, is to reproduce more or less natural conditions as present in the soil.

Peacock, U. S. Pat. No. 1,030,122, 1912, recovers the silica, potash, and alumina of feldspar by crushing and calcining the mineral, adding to it a concentrated solution of carbonate of either soda or potash in such amount that the combined alkali of the solution and of the feldspar is chemically equivalent to the silica present (160 pounds alkali: 100 pounds silica), and digesting with superheated steam. In this way all the silica is converted to silicate of potassium or sodium. The digested product is cooled, washed and filtered, and the residue is washed and treated with carbon dioxide to convert any alkali present into carbonate. On re-washing, pure alumina is obtained, and the wash water, together with the filtered solution from the digester, is also treated with CO_2, and the soluble alkali silicate converted into carbonate. Gelatinous silica may be recovered from the solution in a filter press or centrifugal apparatus.

Neil, U. S. Pat. No. 1,034,281, 1912, recovers the potash, alumina, and silica of feldspar in a series of steps. The crude spar is first ground fine and fed into a charge of fused alkali sulphate in a furnace, the amount of such sulphate employed being from 10–25 per cent of the spar. Through the fused mass sulphur dioxide gas and steam are forced, which reduce the potash and alumina to sulphates. The fused mass is then discharged into water, the sulphates dissolving and being separated from the silica, etc., by decantation or filtration. Ammonia gas is led through the solution to precipitate the iron and alumina, which are separated by filtering, and milk of lime is added to the liquor to fix the ammonia. The solution then contains calcium sulphate in suspension, and potassium, magnesium and sodium sulphates in solution. The former is removed by filtration and the residual liquor evaporated, the sulphates crystallizing out. If a pure potash spar is employed in the process, the amounts of sodium and magnesium sulphates present in the crystallized salt will not be sufficient to impair the same for use as a fertilizer, but they may be removed, if desired, by further treatment. (Also Brit. Pat. No. 22,557, 1912: Can. Pat. No. 150,875, 1913.)

Messerschmitt, Canadian Patent No. 141,015, 1912, heats natural alkali containing silicates, such as feldspar, with lime, leaches the furnaced product for the alkali, and treats the residue with nitric acid. Caustic lime is added to the solution obtained from the residues, and the mixture is lixiviated and calcined with the addition of lime. The final residues may be used in the manufacture of clay products.

Peacock, U. S. Pat. No. 1,035,812, 1912, calcines a mixture of ground feldspar and carbonate of lime, pulverizes and screens, and adds enough soda or potash to furnish one equivalent for each molecule of alumina present. This mixture is then boiled with enough water to form a thin sludge. Alkali aluminate goes into solution and is obtained by filtering, and passing carbon dioxide through the solution. The alumina obtained undergoes a further purification.

In U. S. Patent No. 1,036,897, 1912, Peacock modifies the foregoing process by first calcining the mixture of feldspar and limestone in order to render the former mineral amorphous, in which condition it more readily parts with its potash content. Any volatilized potash at this stage passes off with the carbon dioxide and is recovered as carbonate.

Cowles, U. S. Pats. Nos. 1,040,893, 1,040,894, 1,040,977, 1,041,598, and 1,041,599, 1912, grinds a mixture of feldspar and phosphate rock and sinters at 1,000° C. The resulting product is leached with either sulphuric or hydrochloric acid, and potash alum or the double chloride, phosphoric acid and bicalcic silicate are obtained.

Morse and Sargent, U. S. Pat. No. 1,041,327, 1912, heat powdered feldspar with gypsum at 1,000° C. until sulphur dioxide ceases to be evolved. Then, in a second stage of the process, an alkaline chloride is added, and heating continued at 600° C. The products obtained are sulphuric and sulphurous acids and potassium chloride, the latter being recovered by leaching the fused mass and evaporating the solution. The residue may be burned for cement.

Peacock, U. S. Pat. No. 1,046,327, 1912, mixes ground feldspar and phosphate rock in such proportions that the lime in the phosphate and the silica and alumina in the spar will be present in chemically equivalent amount. The mass is then heated to 1,500° C. and the fused product quenched in water. The cinder is then crushed to 100 mesh, mixed with water to form a thin sludge and subjected in a digester to the action of superheated steam. Potassium hydrogen phosphate K_2HPO_4 is formed and goes into solution, and is obtained by filtering and washing the digester sludge and evaporating the solution obtained.

Gelleri, U. S. Pat. No. 1,058,686, 1913, calcines feldspar with lime or with an oxide or carbonate of an alkaline earth metal or magnesium. After this preliminary calcining, the material is fed into a closed chamber and subjected to the action of ammonium carbonate vapour, whereby the silicates are completely decomposed, and the whole of the alkali metal may be recovered in the form of carbonate by leaching with water. The preliminary calcining may be omitted. The reaction is as follows:—

$$6KAlSI_3O_8 + 3(NH_4)_2CO_3 + 3H_2O = 3K_2CO_3 + 3Al_2O_3 \cdot 6SiO_2 \cdot 6H_2O + 6NH_3 + 12SiO_2.$$

The residue may be re-heated, and this forms a good Portland cement material. (See also U. S. Pat. No. 1,078,495.) In U. S. Pat. No. 1,078,496, carbon dioxide gas is substituted for the ammonium carbonate vapour. (Also British Pat. No. 4842, 1913.)

Hart, U. S. Pat. No. 1,062,278, 1913, fuses a mixture of feldspar, potassium or sodium sulphate and carbon, and obtains glassy potassium or sodium aluminium silicate. This glass is treated with sulphuric acid to obtain silica and a solution from which potash alum may be recovered by evaporation. The residual liquor is evaporated to dryness, fused with carbon and the fused product leached with water, potassium or sodium aluminate being dissolved and recovered by the usual methods.

Bassett, U. S. Pat. No. 1,072,686, 1913, obtains both potash and a material suitable for pottery or enamel manufacture by mixing 50 parts of ground feldspar with 50 parts of sodium chloride and heating to 800°–900° C. for 1–2 hours. The hot mass is quenched in water by dumping into a vat containing 2–5 parts of water to 1 part of the fused product. Potassium and sodium salts are obtained by crystallization from the solution, and the residue, which consists of feldspathic material in which the potash is replaced by soda, is dried and ground, and may be used for the purposes mentioned above.

Lindblad, Brit. Pat. No. 23,898, 1913, fuses a mixture of feldspar, coal and iron ore in an electric furnace. Iron silicate and a slag containing soluble potash are obtained, the latter being recovered by lixiviation and evaporation.

Messerschmitt, U. S. Pat. No. 1,076,508, 1913, extracts the potash from potash-bearing minerals, such as feldspar, by powdering the mineral and forming a mixture of 1,000 pounds of spar, 600 pounds of basic calcium nitrate, 120 gallons of water and 200 pounds of lime. This mixture is introduced into a digester and heated under a pressure of 50–125 pounds for 10–20 hours. The sludge obtained is leached with water, and a solution of potassium nitrate is obtained. Any calcium nitrate present is thrown down by the addition of an alkali carbonate to the solution and filtered out. The final solution is then evaporated. (The material specifically mentioned in the patent specification is phonolite, but the process should be applicable, also, to feldspar.) See also U. S. Pat. No. 1,087,132.

Doremus and Hoyt, Can. Pat. No. 150,899, 1913, treat feldspar with aqueous hydrofluoric acid, separate the insoluble silicofluoride and aluminium compound and heat with sulphate of lime. The heated mass is leached with water, and potassium sulphate recovered by evaporation. (Also U. S. Pat. No. 1,054,518.)

Stillman, Can. Pat. No. 151,580, 1913, grinds feldspar, mixes it with potassium carbonate in sufficient amount to convert all the silica present to potassium silicate and fuses at a high temperature. The fused product is ground and leached with cold water, potassium aluminate and caustic potash going into solution. The solution is rendered alkaline with ammonia, and an ammonium salt is added to precipitate all the alumina of the potassium aluminate as hydrated alumina. The mixture is then filtered, and carbon dioxide is led into the solution obtained. Carbonate of potash is formed and recovered by evaporation. An alternative procedure is to dissolve the potassium silicate in the fused product with boiling water, decompose with carbon dioxide and evaporate. (Also U. S. Pat. No. 1,106,984.)

Messerschmitt, U. S. Pat. No. 1,089,716, 1914, proposes a modification of the process by which potash is recovered by leaching with water a calcined mixture of feldspar, limestone and other substances. This modification consists in first pouring over the fused mass a small amount only of water. This causes a slaking action to result, and the clinkers, etc., expand and disintegrate to a fine powder, yielding a granulated material that can be more readily leached than the crude, furnace product.

In U. S. Pats. Nos. 1,091,033 and 1,091,034, 1914, Bassett heats for two hours at a bright red heat a mixture of 40 parts of ground feldspar, 40 parts of acid sulphate of soda, 14·4 parts of common salt and 1–3 parts of carbon. The cooled mass is leached with water, and potassium sulphate recovered by evaporation from the solution. It is claimed that the carbon reduces a portion of the acid sodium sulphate to sulphide, and that the sulphide acts as a catalytic agent to break up the feldspar and liberate the potash. After all of the carbon is consumed, the sodium sulphide is oxydised and reverts to sulphate. (Also Can. Pats. Nos. 160,214 and 160,213.) In the second patent is described a method of separating the sodium and potassium sulphates in a solution similar to the above, whereby sodium chloride is added to the saturated liquor, which is then heated to 60°–170° C. Crystals of sodium sulphate form and are removed, leaving potassium sulphate.

Messerschmitt, U. S. Pat. No. 1,091,230, 1914, takes the finely divided carbonate of lime obtained in the Chance-Clauss soda process, mixes it with powdered feldspar and water to form a sludge, and heats the whole at a red heat, subsequently leaching with water. The use of the by-product lime carbonate is proposed in order to obviate grinding limestone.

Bassett, U. S. Pat. No. 1,095,306, 1914 proposes to recover the alumina and potash of feldspar by mixing five parts of feldspar with three parts of sodium carbonate and two parts of sodium chloride and heating. The reaction is:
$3KAlSi_3O_8 + 3NaCl + 2Na_2CO_3 = 2Na_2O\cdot 9SiO_2 + 3NaAlO_2 + 2CO_2 + 3KCl$. The furnaced product is then extracted with water, and a solution of sodium aluminate and potassium chloride is obtained. Carbon dioxide gas is passed through this solution, and gelatinous aluminium hydrate is formed. This is separated and can be dried or treated with sodium carbonate to form sodium aluminate. The solution remaining contains sodium

bicarbonate, potassium bicarbonate, and sodium chloride. To it is added sodium hydroxide, and sodium and potassium carbonates are formed. The solution is then heated to circa 60° C., and the sodium chloride and carbonate are thrown down and separated, the potassium carbonate remaining in solution and being then similarly recovered by further evaporation.

In U. S. Pat. No. 1,103,910, 1914, Willson and Haff fuse a mixture of feldspar and phosphate rock at circa 1,000° C., and grind the fused product; this is then suspended in water and sulphur dioxide is bubbled through it. The potash and phosphoric acid are thereby dissolved and may be recovered by evaporation of the solution. The furnace vapours, which may contain volatilized phosphoric acid and potash, are led into the powdered and dried product, where they are absorbed and enrich the material.

Alternatively, carnallite or kainite may be heated with feldspar in the same manner, and aqueous chlorine, hydrochloric acid or bisulphite liquor may replace the sulphur dioxide. The claim covers a fertilizer comprising a powder formed from a fused mass containing an alkali and a phosphate, enriched with vapours of potash, phosphoric acid and ammonia.

Cowles, U. S. Pat. No. 1,111,881, 1914, subjects powdered feldspar in a rotary kiln to the action of vapour of salt and water, with or without the addition of carbon, the claim being for a "method of making alkali-silico-aluminate richer in alkali than feldspar." (See also U. S. Pat. No. 1,123,693.)

Brown, U. S. Pat. No. 1,123,841, 1914. A mixture of calcium chloride, calcium carbonate and feldspar is fused in an oxydising atmosphere (circa 1,300°C.) Potassium chloride is formed, volatilizes, and is collected in a condensing apparatus. The residue may be employed to make slag brick, roofing grit, cement, etc.

Peacock, U. S. Pat. No. 1,124,798, 1915, proposes to recover the potash of flue dust produced in cement works making cement from rock rich in feldspar, by leaching the dust first with water to recover any water-soluble potash and then with a hot solution obtained by leaching superphosphate, potassium phosphate being formed.

Melkman, Can. Pat. No. 160,183, 1915, heats to redness for two hours a mixture of 100 parts of ground feldspar, 50 parts of sulphuric acid, 50 parts of sodium chloride and 3–7 parts of carbon. The furnaced product is leached with hot water, and the sodium and potassium sulphates recovered in successive stages by evaporation.

Spar Chemical Co., Can. Pat. No. 160,212, 1915. A mixture of two parts of ground spar and one part of salt is heated in a current of air at a yellow heat. The heated mass in quenched in cold water and potassium chloride recovered from the solution.

Coolbaugh and Quinney, U. S. Pat. No. 1,125,007, 1915, mix feldspar with gypsum or limestone, heat to fusion point, cool rapidly and crush to fine powder. This powder is then leached with water containing a small percentage of sulphuric acid, and the potassium aluminium sulphates obtained in solution are separated by crystallization. A recovery of 90–92 per cent of the potash contained in the feldspar is claimed.

Drury, Can. Pat. No. 160,257, 1915, fuses a mixture of 50 parts of feldspar, 16·8 parts of lime and 15 parts of iron oxide (hematite). The silica of the feldspar combines with the lime and iron and the potash becomes soluble in weak acids.

Herzefeld and Hauser, U. S. Pat. No. 1,125,318, 1915, mix four parts of powdered feldspar with one part of the mother liquor obtained in the production of potassium chloride from crude carnallite, and heat the mixture to 300°C. for 5-15 hours.

In U. S. Pats. Nos. 1,129,224 and 1,129,505, 1915, Peacock mixes powdered feldspar with ground coke or coal. This is then heated to 1,200°–1,400°C. in a reducing atmosphere, and the low carbides K_2C and Al_2C are formed:

$$2KAlSi_3O_8 + 8C = K_2C + Al_2C_3 + 6SiO_2 + 4CO.$$

If a nitrogen atmosphere be employed in the furnace, nitrides or carbonitrides of potassium and aluminium are obtained.

These carbides, nitrides or carbo-nitrides may be treated with superheated steam in an autoclave, and alumina and either caustic potash or carbonate of potash recovered respectively.

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CATALOGUE

OF

MINES BRANCH PUBLICATIONS.

CANADA

DEPARTMENT OF MINES

HON. P. E. BLONDIN, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER

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†3. Investigation of the different electro-thermic processes for the smelting of iron ores and the making of steel, in operation in Europe. Report of Special Commission—by Eugene Haanel, Ph.D., 1904.

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†11 Asbestos: its occurrence, exploitation, and uses—by Fritz Cirkel, M.E., 1905. (See No. 69.)

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†23. Iron ore deposits along the Ottawa (Quebec side) and Gatineau rivers. Report on—by Fritz Cirkel, M.E.

24. General report on the mining and metallurgical industries of Canada, 1907–8.

†25. The tungsten ores of Canada. Report on—by T. L. Walker, Ph.D.

26. The mineral production of Canada, 1906. Annual report on—by John McLeish, B.A.

†27. The mineral production of Canada, 1907. Preliminary report on—by John McLeish, B.A.

†27a. The mineral production of Canada, 1908. Preliminary report on—by John McLeish, B.A.

†28. Summary report of Mines Branch, 1908.

29. Chrome iron ore deposits of the Eastern Townships. Monograph on—by Fritz Cirkel. (Supplementary section: Experiments with chromite at McGill University—by J. B. Porter, E.M., D.Sc.)

30. Investigation of the peat bogs and peat fuel industry of Canada, 1908, Bulletin No. 1—by Erik Nystrom, M.E., and A. Anrep. Peat Expert.

32. Investigation of electric shaft furnace, Sweden. Report on—by Eugene Haanel, Ph.D.

47. Iron ore deposits of Vancouver and Texada islands. Report on—by Einar Lindeman, M.E.

†55. The bituminous, or oil-shales of New Brunswick and Nova Scotia; also on the oil-shale industry of Scotland. Report on—by R. W. Ells, LL.D.

† Publications marked thus † are out of print.

58. The mineral production of Canada, 1907 and 1908. Annual report on—by John McLeish, B.A.

NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1907–08.*

†31. Production of cement in Canada, 1908.

†42. Production of iron and steel in Canada during the calendar years 1907 and 1908.

43. Production of chromite in Canada during the calendar years 1907 and 1908.

44. Production of asbestos in Canada during the calendar years 1907 and 1908.

†45. Production of coal, coke, and peat in Canada during the calendar years 1907 and 1908.

46. Production of natural gas and petroleum in Canada during the calendar years 1907 and 1908.

59. Chemical analyses of special economic importance made in the laboratories at the Department of Mines, 1906–07–08. Report on—by F. G. Wait, M.A., F.C.S. (With Appendix on the commercial methods and apparatus for the analyses of oil-shales—by H. A. Leverin, Ch.E.)

Schedule of charges for chemical analyses and assays.

†62. Mineral production of Canada, 1909. Preliminary report on—by John McLeish, B.A.

63. Summary report of Mines Branch, 1909.

67. Iron deposits of the Bristol mine, Pontiac county, Quebec. Bulletin No. 2—by Einar Lindeman, M.E., and Geo. C. Mackenzie, B.Sc.

†68. Recent advances in the construction of electric furnaces for the production of pig iron, steel, and zinc. Bulletin No. 3—by Eugene Haanel, Ph.D.

69. Chrysotile-asbestos: its occurrence, exploitation, milling, and uses. Report on—by Fritz Cirkel, M.E. (Second edition, enlarged.)

†71. Investigation of the peat bogs and peat industry of Canada, 1909–10; to which is appended Mr. Alf. Larson's paper on Dr. M. Ekenberg's wet-carbonizing process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. Anrep, Jr.; also a translation of Lieut. Ekelund's pamphlet entitled "A solution of the peat problem," 1909, describing the Ekelund process for the manufacture of peat powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. Anrep. (Second edition, enlarged.)

† Publications marked thus † are out of print.

82. Magnetic concentration experiments. Bulletin No. 5—by Geo. C. Mackenzie, B.Sc.

83. An investigation of the coals of Canada with reference to their economic qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others.
    Vol. I—Coal washing and coking tests.
    Vol. II—Boiler and gas producer tests.
    †Vol. III—
        Appendix I
            Coal washing tests and diagrams.
    †Vol. IV—
        Appendix II
            Boiler tests and diagrams.
    †Vol. V—
        Appendix III
            Producer tests and diagrams.
    †Vol. VI—
        Appendix IV
            Coking tests.
        Appendix V
            Chemical tests.

†84. Gypsum deposits of the Maritime provinces of Canada—including the Magdalen islands. Report on—by W. F. Jennison, M.E. (See No. 245.)

88. The mineral production of Canada, 1909. Annual report on—by John McLeish, B.A.

Note.—*The following parts were separately printed and issued in advance of the Annual Report for 1909.*

†79. Production of iron and steel in Canada during the calendar year 1909.

†80. Production of coal and coke in Canada during the calendar year 1909.

85. Production of cement, lime, clay products, stone, and other structural materials during the calendar year 1909.

89. Proceedings of conference on explosives. (Fourth edition).

90. Reprint of presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Eugene Haanel, Ph.D.

92. Investigation of the explosives industry in the Dominion of Canada, 1910. Report on—by Capt. Arthur Desborough. (Fourth edition).

†93. Molybdenum ores of Canada. Report on—by Professor T. L. Walker Ph.D.

100. The building and ornamental stones of Canada: Building and ornamental stones of Ontario. Report on—by Professor W. A. Parks, Ph.D.

† Publications marked thus † are out of print.

102. Mineral production of Canada, 1910. Preliminary report on—by John McLeish, B.A.

†103. Summary report of Mines Branch, 1910.

104. Catalogue of publications of Mines Branch, from 1902 to 1911; containing tables of contents and lists of maps, etc.

105. Austin Brook iron-bearing district. Report on—by E. Lindeman, M.E.

110. Western portion of Torbrook iron ore deposits, Annapolis county, N.S. Bulletin No. 7—by Howells Frechette, M.Sc.

111. Diamond drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with introductory by A. W. G. Wilson, Ph.D.

118. Mica: its occurrence, exploitation, and uses. Report on—by Hugh S. de Schmid, M.E.

142. Summary report of Mines Branch, 1911.

143. The mineral production of Canada, 1910. Annual report on—by John McLeish, B.A.

NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1910.*

†114. Production of cement, lime, clay products, stone, and other materials in Canada, 1910.
†115. Production of iron and steel in Canada during the calendar year 1910.
†116. Production of coal and coke in Canada during the calendar year 1910.
†117. General summary of the mineral production of Canada during the calendar year 1910.

145. Magnetic iron sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie, B.Sc.

†150. The mineral production of Canada, 1911. Preliminary report on—by John McLeish, B.A.

151. Investigation of the peat bogs and peat industry of Canada, 1910–11. Bulletin No. 8—by A. Anrep.

154. The utilization of peat for fuel for the production of power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910–11. Report on—by B. F. Haanel, B.Sc.

167. Pyrites in Canada: its occurrence, exploitation, dressing and uses. Report on—by A. W. G. Wilson, Ph.D.

170. The nickel industry: with special reference to the Sudbury region, Ont. Report on—by Professor A. P. Coleman, Ph.D.

† Publications marked thus † are out of print.

† Publications marked thus † are out of print.

262. The mineral production of Canada during the calendar year 1912. Annual report on—by John McLeish, B.A.

NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1912.*

238. General summary of the mineral production of Canada during the calendar year 1912. Bulletin on—by John McLeish, B.A.

†247. Production of iron and steel in Canada during the calendar year 1912. Bulletin on—by John McLeish, B.A.

†256. Production of copper, gold, lead, nickel, silver, zinc, and other metals of Canada, during the calendar year 1912—by C. T. Cartwright, B.Sc.

257. Production of cement, lime, clay products, stone, and other structural materials during the calendar year 1912. Report on—by John McLeish, B.A.

†258. Production of coal and coke in Canada, during the calendar year 1912. Bulletin on—by John McLeish, B.A.

266. Investigation of the peat bogs and peat industry of Canada, 1911 and 1912. Bulletin No. 9—by A. Anrep.

279. Building and ornamental stones of Canada--Vol. III: Building and ornamental stones of Quebec. Report on—by W. A. Parks, Ph.D.

281. The bituminous sands of Northern Alberta. Report on—by S. C. Ells, M.E.

283. Mineral production of Canada, 1913. Preliminary report on—by John McLeish, B.A.

285. Summary report of the Mines Branch, 1913.

291. The petroleum and natural gas resources of Canada. Report on—by F. G. Clapp, A.M., and others:—
Vol. I—Technology and exploitation.
Vol. II—Occurrence of petroleum and natural gas in Canada.
Also separates of Vol. II, as follows:—
Part 1, Eastern Canada.
Part 2, Western Canada.

299. Peat, lignite, and coal: their value as fuels for the production of gas and power in the by-product recovery producer. Report on—by B. F. Haanel, B.Sc.

303. Moose Mountain iron-bearing district. Report on—by E. Lindeman, M.E.

305. The non-metallic minerals used in the Canadian manufacturing industries. Report on—by Howells Fréchette, M.Sc.

309. The physical properties of cobalt, Part II. Report on—by H. T. Kalmus, B.Sc., Ph.D.

† Publications marked thus † are out of print.

320. The mineral production of Canada during the calendar year 1913. Annual report on—by John McLeish, B.A.

Note.—*The following parts were separately printed and issued in advance of the Annual Report for 1913.*

315. The production of iron and steel during the calendar year 1913. Bulletin on—by John McLeish, B.A.
†316. The production of coal and coke during the calendar year 1913. Bulletin on—by John McLeish, B.A.
317. The production of copper, gold, lead, nickel, silver, zinc, and other metals, during the calendar year 1913. Bulletin on—by C. T. Cartwright, B.Sc.
318. The production of cement, lime, clay products, and other structural materials, during the calendar year 1913. Bulletin on—by John McLeish, B.A.
319. General summary of the mineral production of Canada during the calendar year 1913. Bulletin on—by John McLeish, B.A.

322. Economic minerals and mining industries of Canada. (Revised Edition).

323. The products and by-products of coal. Report on—by Edgar Stansfield, M.Sc., and F. E. Carter, B.Sc., Dr. Ing.

325. The salt industry of Canada. Report on—by L. H. Cole, B.Sc.

331. The investigation of six samples of Alberta lignites. Report on—by B. F. Haanel, B.Sc., and John Blizard, B.Sc.

333. The mineral production of Canada, 1914. Preliminary report on—by John McLeish, B.A.

334. Electro-plating with cobalt and its alloys. Report on—by H. T Kalmus, B.Sc., Ph.D.

336. Notes on clay deposits near McMurray, Alberta. Bulletin No. 10—by S. C. Ells, B.A., B.Sc.

338. Coals of Canada: Vol. VII. Weathering of coal. Report on—by J. B. Porter, E.M., Ph.D., D.Sc.

344. Electro-thermic smelting of iron ores in Sweden. Report on—by Alfred Stansfield, D. Sc., A.R.S.M., F.R.S.C.

346. Summary report of the Mines Branch for 1914.

351. Investigation of the peat bogs and the peat industry of Canada, 1913–1914. Bulletin No. 11—by A. Anrep.

384. The Mineral production of Canada during the calendar year 1914. Annual Report on—by John McLeish, B.A.

Note.—*The following parts were separately printed and issued in advance of the Annual Report for 1914.*

348. Production of coal and coke in Canada during the calendar year, 1914. Bulletin on—by J. McLeish, B.A.

349. Production of iron and steel in Canada during the calendar year, 1914. Bulletin on—by J. McLeish, B.A.

350. Production of copper, gold, lead, nickel, silver, zinc, and other metals, during the calendar year, 1914. Bulletin on—by J. McLeish, B.A.

383. The production of cement, lime, clay products, stone and other structural materials, during the calendar year 1914. Bulletin on—by John McLeish, B.A.

385. Investigation of a reported discovery of phosphate at Banff, Alberta. Bulletin No. 12—by H. S. de Schmid, M.E., 1915.

401. Feldspar in Canada. Report on—by H. S. de Schmid, M.E.

406. Description of the laboratories of the Mines Branch of the Department of Mines, 1916. Bulletin No. 13.

408. Mineral production of Canada, 1915. Preliminary report on—by John McLeish, B.A.

411. Cobalt alloys with non-corrosive properties. Report on—by H. T. Kalmus, B.Sc., Ph.D.

413. Magnetic properties of cobalt and of Fe_2Co. Report on—by H. T. Kalmus, B.Sc., Ph.D.

The Division of Mineral Resources and Statistics has prepared the following lists of mine, smelter, and quarry operators: Metal mines and smelters, General list of mines (except coal and metal mines), Coal mines, Stone quarry operators, Manufacturers of clay products and of cement, Manufacturers of lime, and Operators of sand and gravel deposits. Copies of the lists may be obtained on application.

IN THE PRESS

388. The building and ornamental stones of Canada—Vol. IV: building and ornamental stones of the western provinces. Report on—by W. A. Parks, Ph.D.

419. Production of iron and steel in Canada during the calendar year, 1915. Bulletin on—by J. McLeish, B.A.

420. Production of coal and coke in Canada during the Calendar year, 1915, Bulletin on—by J. McLeish, B.A.

421. Summary report of the Mines Branch for 1915.

FRENCH TRANSLATIONS

971. (26a) Rapport annuel sur les industries minérales du Canada, pour l'année 1905.

†4. Rapport de la Commission nominée pour étudier les divers procédés électro-thermiques pour la réduction des minerais de fer et la fabrication de l'acier employés en Europe—by Eugene Haanel, Ph.D. (French Edition), 1905.

26a. The mineral production of Canada, 1906. Annual report on—by John McLeish, B.A.

†28a. Summary report of Mines Branch, 1908.

56. Bituminous or oil-shales of New Brunswick and Nova Scotia; also on the oil-shale industry of Scotland. Report on—by R. W. Ells, LL.D.

81. Chrysotile-asbestos, its occurrence, exploitation, milling, and uses Report on—by Fritz Cirkel, M.E.

100a. The building and ornamental stones of Canada: Building and ornamental stones of Ontario. Report on—by W. A. Parks, Ph.D.

149. Magnetic iron sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie, B.Sc.

155. The utilization of peat fuel for the production of power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910–11. Report on—by B. F. Haanel, B.Sc.

†156. The tungsten ores of Canada. Report on—by T. L. Walker, Ph.D.

169. Pyrites in Canada: its occurrences, exploitation, dressing, and uses.. Report on—by A. W. G. Wilson, Ph.D.

179. The nickel industry: with special reference to the Sudbury region, Ont. Report on—by Professor A. P. Coleman, Ph.D.

180. Investigation of the peat bogs, and peat industry of Canada, 1910–11. Bulletin No. 8—by A. Anrep.

195. Magnetite occurrences along the Central Ontario railway. Report on—by E. Lindeman, M.E.

†196. Investigation of the peat bogs and peat industry of Canada, 1909–10, to which is appended Mr. Alf. Larson's paper on Dr. M. Ekenburg's wet-carbonizing process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. Anrep; also a translation of Lieut. Ekelund's pamphlet entitled "A solution of the peat problem," 1909, describing the Ekelund process for the manufacture of peat powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. Anrep. (Second Edition, enlarged.)

197. Molybdenum ores of Canada. Report on—by T. L. Walker, Ph.D.

† Publications marked thus † are out of print.

†198. Peat and lignite: their manufacture and uses in Europe. Report on—by Erik Nystrom, M.E., 1908.

202. Graphite: its properties, occurrences, refining, and uses. Report on—by Fritz Cirkel, M.E., 1907.

204. Building stones of Canada—Vol. II: Building and ornamental stones of the Maritime Provinces. Report on—by W. A. Parks, Ph.D.

219. Austin Brook iron-bearing district. Report on—by E. Lindeman, M.E.

223. Lode Mining in the Yukon: an investigation of quartz deposits in the Klondike division. Report on—by T. A. MacLean, B.Sc.

224a. Mines Branch Summary report for 1912.

†226. Chrome iron ore deposits of the Eastern Townships. Monograph on—by Fritz Cirkel, M.E. (Supplementary section: Experiments with chromite at McGill University—by J. B. Porter, E.M., D.Sc.).

231. Economic minerals and mining industries of Canada.

233. Gypsum deposits of the Maritime Provinces of Canada—including the Magdalen islands. Report on—by W. F. Jennison, M.E.

246. Gypsum in Canada: its occurrence, exploitation, and technology. Report on—by L. H. Cole, B.Sc.

260. The preparation of metallic cobalt by reduction of the oxide. Report on—by H. T. Kalmus, B.Sc., Ph.D.

263. Recent advances in the construction of electric furnaces for the production of pig iron, steel, and zinc. Bulletin No. 3—by Eugene Haanel, Ph.D.

†264. Mica: its occurrence, exploitation, and uses. Report on—by Hugh S. de Schmid, M.E.

265. Annual mineral production of Canada, 1911. Report on—by John McLeish, B.A.

280. The building and ornamental stones of Canada, Vol. III; Province of Quebec. Report on—by Professor W. A. Parks, Ph.D.

286. Summary Report of Mines Branch, 1913.

287. Production of iron and steel in Canada during the calendar year 1912. Bulletin on—by John McLeish, B.A.

288. Production of coal and coke in Canada, during the calendar year 1912. Bulletin on—by John McLeish, B.A.

† Publications marked thus † are out of print.

289. Production of cement, lime, clay products, stone, and other structural materials during the calendar year 1912. Bulletin on—by John McLeish, B.A.

290. Production of copper, gold, lead, nickel, silver, zinc, and other metals of Canada during the calendar year 1912. Bulletin on—by C. T. Cartwright, B.Sc.

307. Cataologue of French publications of the Mines Branch and of the Geological Survey, up to July, 1914.

308. An investigation of the coals of Canada with reference to their economic qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others.
Vol. I—Coal washing and coking tests.
Vol. II—Boiler and gas producer tests.
Vol. III—
Appendix I
Coal washing tests and diagrams.
Vol. IV—
Appendix II
Boiler tests and diagrams.

314. Iron ore deposits, Bristol mine, Pontiac county, Quebec, Report on—by E. Lindeman, M.E.

321. Annual mineral production of Canada, during the calendar year 1913. Report on—by J. McLeish, B.A.

IN THE PRESS

292. The petroleum and natural gas resources of Canada. Report on—by F. G. Clapp, A.M., and others.
Vol. I.—Technology and exploitation.

306. The non-metallic minerals used in the Canadian manufacturing industries Report on—by Howells Fréchette, M.Sc.

310. The physical properties of the metal cobalt, Part II. Report on—by H. T. Kalmus, B.Sc., Ph.D.

MAPS

†6. Magnetometric survey, vertical intensity: Calabogie mine, Bagot township, Renfrew county, Ontario—by E. Nystrom, 1904. Scale 60 feet to 1 inch. Summary report 1905. (See Map No. 249.)

†13. Magnetometric survey of the Belmont iron mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, 1905. Scale 60 feet to 1 inch. Summary report, 1906. (See Map No. 186).

†14. Magnetometric survey of the Wilbur mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, 1905. Scale 60 feet to 1 inch. Summary report, 1906.

†33. Magnetometric survey, vertical intensity: lot 1, concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch. (See Maps Nos. 191 and 191A.)

†34. Magnetometric survey, vertical intensity: lots 2 and 3, concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch. (See Maps Nos. 191 and 191A.)

†35. Magnetometric survey, vertical intensity: lots 10, 11, and 12 concession IX, and lots 11 and 12, concession VIII, Mayo township, Hastings county. Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch. (See Maps Nos. 191 and 191A.)

*36. Survey of Mer Bleue peat bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nystrom, and A. Anrep. (Accompanying report No. 30.)

*37. Survey of Alfred peat bog. Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nystrom and A. Anrep. (Accompanying report No. 30.)

*38. Survey of Welland peat bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nystrom and A. Anrep. (Accompanying report No. 30.)

*39. Survey of Newington peat bog, Osnabruck, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nystrom and A. Anrep. (Accompanying report No. 30.)

*40. Survey of Perth peat bog, Drummond township, Lanark county, Ontario—by Erik Nystrom and A. Anrep. (Accompanying report No. 30.)

†41. Survey of Victoria Road peat bog, Bexley and Carden townships, Victoria county, Ontario—Erik Nystrom and A. Anrep. (Accompanying report No. 30).

*48. Magnetometric survey of Iron Crown claim at Nimpkish (Klaanch) river, Vancouver island, B.C.—by E. Lindeman. Scale 60 feet to 1 inch. (Accompanying report No. 47).

Note.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

*49. Magnetometric survey of Western Steel Iron claim, at Sechart, Vancouver island, B.C.—By E. Lindeman. Scale 60 feet to 1 inch. (Accompanying report No. 47.)

*53. Iron ore occurrences, Ottawa and Pontiac counties, Quebec, 1908—by J. White and Fritz Cirkel. (Accompanying report No. 23.)

*54. Iron ore occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel. (Accompanying report No. 23.) Out of print.

†57. The productive chrome iron ore district of Quebec—by Fritz Cirkel. (Accompanying report No. 29.)

†60. Magnetometric survey of the Bristol mine, Pontiac county, Quebec—by E. Lindeman. Scale 200 feet to 1 inch. (Accompanying report No. 67.)

†61. Topographical map of Bristol mine, Pontiac county, Quebec—by E. Lindeman. Scale 200 feet to 1 inch. (Accompanying report No. 67.)

†64. Index map of Nova Scotia: Gypsum—by W. F. Jennison.

†65. Index map of New Brunswick: Gypsum—by W. F. Jennison.

†66. Map of Magdalen islands: Gypsum—by W. F. Jennison....

(Accompanying report No. 84).

†70. Magnetometric survey of Northeast Arm iron range, Lake Timagami, Nipissing district, Ontario—by E. Lindeman. Scale 200 feet to 1 inch. (Accompanying report No. 63.)

†72. Brunner peat bog, Ontario—by A. Anrep.

†73. Komoka peat bog, Ontario— " "

†74. Brockville peat bog, Ontario— " "

†75. Rondeau peat bog, Ontario— " "

†76. Alfred peat bog, Ontario— " "

†77. Alfred peat bog, Ontario, main ditch profile—by A. Anrep.

(Accompanying report No. 71.) (Out of print.)

†78. Map of asbestos region, Province of Quebec, 1910—by Fritz Cirkel. Scale 1 mile to 1 inch. (Accompanying report No. 69.)

†94. Map showing Cobalt, Gowganda, Shiningtree, and Porcupine districts —by L. H. Cole. (Accompanying Summary report, 1910.)

†95. General map of Canada, showing coal fields. (Accompanying report No. 83—by Dr. J. B. Porter.)

†96. General map of coal fields of Nova Scotia and New Brunswick. (Accompanying report No. 83—by Dr. J. B. Porter.)

†97. General map showing coal fields in Alberta, Saskatchewan, and Manitoba. (Accompanying report No. 83—by Dr. J. B. Porter.)

Note.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†98. General map of coal fields in British Columbia. (Accompanying report No. 83—by Dr. J. B. Porter.)

†99. General map of coal field in Yukon Territory. (Accompanying report No. 83—by Dr. J. B. Porter.)

†106. Geological map of Austin Brook iron-bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman. Scale 400 feet to 1 inch. (Accompanying report No. 105.)

†107. Magnetometric survey, vertical intensity: Austin Brook iron-bearing district—by E. Lindeman. Scale 400 feet to 1 inch. (Accompanying report No. 105.)

†108. Index map showing iron-bearing area at Austin Brook—by E. Lindeman. (Accompanying report No. 105.)

*112. Sketch plan showing geology of Point Mamainse, Ont.—by Professor A. C. Lane. Scale 4,000 feet to 1 inch. (Accompanying report No. 111.)

†113. Holland peat bog Ontario—by A. Anrep. (Accompanying report No. 151.)

*119–137. Mica: township maps, Ontario and Quebec—by Hugh S. de Schmid. (Accompanying report No. 118.)

†138. Mica: showing location of principal mines and occurrences in the Quebec mica area—by Hugh S. de Schmid. Scale 3·95 miles to 1 inch. (Accompanying report No. 118.)

†139. Mica: showing location of principal mines and occurrences in the Ontario mica area—by Hugh S. de Schmid. Scale 3·95 miles to 1 inch. (Accompanying report No. 118.)

†140. Mica: showing distribution of the principal mica occurrences in the Dominion of Canada—by Hugh S. de Schmid. Scale 3·95 miles to 1 inch. (Accompanying report No. 118.)

†141. Torbrook iron-bearing district Annapolis county, N.S.—by Howells Fréchette. Scale 400 feet to 1 inch. (Accompanying report No. 110.)

146. Distribution of iron ore sands of the iron ore deposits on the north shore of the River and Gulf of St. Lawrence, Canada—by Geo. C. Mackenzie. Scale 100 miles to 1 inch. (Accompanying report No. 145.)

†147. Magnetic iron sand deposits in relation to Natashkwan harbour and Great Natashkwan river, Que. (Index Map)—by Geo. C. Mackenzie. Scale 40 chains to 1 inch. (Accompanying report No. 145.)

†148. Natashkwan magnetic iron sand deposits, Saguenay county, Que.—by Geo. C. Mackenzie. Scale 1,000 feet to 1 inch. (Accompanying report No. 145.)

Note.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†152. Map showing the location of peat bogs investigated in Ontario—by A. Anrep. (See Map No. 354.)

†153. Map showing the location of peat bogs, as investigated in Manitoba—by A. Anrep.

†157. Lac du Bonnet peat bog, Manitoba—by A. Anrep.

†158. Transmission peat bog, Manitoba— " "

†159. Corduroy peat bog, Manitoba— " "

†160. Boggy Creek peat bog, Manitoba— " "

†161. Rice Lake peat bog, Manitoba— " "

†162. Mud Lake peat bog, Manitoba— " "

†163. Litter peat bog, Manitoba— " "

†164. Julius peat litter bog, Manitoba— " "

†165. Fort Frances peat bog, Ontario— " "

(Accompanying report No. 151.)

*166. Magnetometric map of No. 3 mine, lot 7, concessions V and VI, McKim township, Sudbury district, Ont.—by E. Lindeman. (Accompanying Summary report, 1911.)

†168. Map showing pyrites mines and prospects in Eastern Canada, and their relation to the United States market—by A. W. G. Wilson. Scale 125 miles to 1 inch. (Accompanying report No. 167.)

†171. Geological map of Sudbury nickel region, Ont.—by Prof. A. P. Coleman. Scale 1 mile to 1 inch. (Accompanying report No. 170.)

†172. Geological map of Victoria mine—by Prof. A. P. Coleman.

†173. " Crean Hill mine—by Prof. A. P. Coleman

†174. " Creighton mine—by Prof. A. P. Coleman.

(Accompanying report No. 170.)

†175. " showing contact of norite and Laurentian in vicinity of Creighton mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†176. " Copper Cliff offset—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†177. " No. 3 mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†178. " showing vicinity of Stobie and No. 3 mines—by Prof. A. P. Coleman. (Accompanying report No. 170.)

Note.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†185. Magnetometric survey, vertical intensity: Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†185a. Geological map, Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†186. Magnetometric survey, Belmont iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†186a. Geological map, Belmont iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†187. Magnetometric survey, vertical intensity: St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†187a. Geological map, St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†188. Magnetometric survey, vertical intensity: Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†188a. Geological map, Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†189. Magnetometric survey, vertical intensity: Ridge iron ore deposits, Wollaston township, Hastings county, Ontario—by E. Lindeman. 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†190. Magnetometric survey, vertical intensity: Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†190a. Geological map, Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†191. Magnetometric survey, vertical intensity: Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†191a. Geological map, Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†192. Magnetometric survey, vertical intensity: Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

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†192a. Geological map, Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†193. Magnetometric survey, vertical intensity: Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†193a. Geological map, Kennedy property, Carlow township, Hastings county Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†194. Magnetometric survey, vertical intensity: Bow Lake iron ore occurrences, Faraday township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†204. Index map, magnetite occurrences along the Central Ontario railway—by E. Lindeman, 1911. (Accompanying report No. 184.)

†205. Magnetometric map, Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman, 1911. (Accompanying report No. 303.)

†205a. Geological map, Moose Mountain iron-bearing district, Sudbury district, Ontario, Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman. (Accompanying report No. 303.)

†206. Magnetometric survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: northern part of deposit No. 2—by E Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†207. Magnetometric survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 8, 9, and 9A—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208. Magnetometric survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposit No. 10—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208a. Magnetometric survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: eastern portion of Deposit No. 11—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208b. Magnetometric survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: western portion of deposit No. 11—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208c. General geological map, Moose Mountain iron-bearing district, Sudbury district, Ontario—by E. Lindeman, 1912. Scale 800 feet to 1 inch. (Accompanying report No. 303.)

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†210. Location of copper smelters in Canada—by A. W. G. Wilson. Scale 197·3 miles to 1 inch. (Accompanying report No. 209.)

†215. Province of Alberta: showing properties from which samples of coal were taken for gas producer tests, Fuel Testing Division, Ottawa. (Accompanying Summary report, 1912.)

†220. Mining districts, Yukon. Scale 35 miles to 1 inch—by T. A. MacLean. (Accompanying report No. 222.)

†221. Dawson mining district, Yukon. Scale 2 miles to 1 inch—by T. A. MacLean. (Accompanying report No. 222.)

*228. Index map of the Sydney coal fields, Cape Breton, N.S. (Accompanying report No. 227.)

†232. Mineral map of Canada. Scale 100 miles to 1 inch. (Accompanying report No. 230.)

†239. Index map of Canada showing gypsum occurrences. (Accompanying report No. 245.)

†240. Map showing Lower Carboniferous formation in which gypsum occurs in the Maritime provinces. Scale 100 miles to 1 inch. (Accompanying report No. 345.)

†241. Map showing relation of gypsum deposits in Northern Ontario to railway lines. Scale 100 miles to 1 inch. (Accompanying report No. 245.)

†242. Map, Grand River gypsum deposits, Ontario. Scale 4 miles to 1 inch. (Accompanying report No. 245.)

†243. Plan of Manitoba Gypsum Co.'s properties. (Accompanying report No. 245.)

†244. Map showing relation of gypsum deposits in British Columbia to railway lines and market. Scale 35 miles to 1 inch. (Accompanying report No. 245.)

†249. Magnetometric survey, Caldwell and Campbell mines, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†250. Magnetometric survey, Black Bay or Williams mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†251. Magnetometric survey, Bluff Point iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†252. Magnetometric survey, Culhane mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

Note.—1. Maps marked thus * are to be found only in reports.
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†253. Magnetometric survey, Martel or Wilson iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†261. Magnetometric survey, Northeast Arm iron range, lot 339 E.T.W. Lake Timagami, Nipissing district, Ontario—by E. Nystrom. 1903. Scale 200 feet to 1 inch.

†268. Map of peat bogs investigated in Quebec—by A. Anrep, 1912.

†269. Large Tea Field peat bog, Quebec " "

†270. Small Tea Field peat bog, Quebec " "

†271. Lanoraie peat bog, Quebec " "

†272. St. Hyacinthe peat bog, Quebec " "

†273. Rivière du Loup peat bog " "

†274. Cacouna peat bog " "

†275. Le Parc peat bog, Quebec " "

†276. St. Denis peat bog, Quebec " "

†277. Rivière Ouelle peat bog, Quebec " "

†278. Moose Mountain peat bog, Quebec " "

†284. Map of northern portion of Alberta, showing position of outcrops of bituminous sand. Scale $12\frac{1}{2}$ miles to 1 inch. (Accompanying report No. 281.)

†293. Map of Dominion of Canada, showing the occurrences of oil, gas, and tar sands. Scale 197 miles to 1 inch. (Accompanying report No. 291.)

†294. Reconnaissance map of part of Albert and Westmorland counties, New Brunswick. Scale 1 mile to 1 inch. (Accompanying report No. 291.)

†295. Sketch plan of Gaspé oil fields, Quebec, showing location of wells. Scale 2 miles to 1 inch. (Accompanying report No. 291.)

†296. Map showing gas and oil fields and pipe-lines in southwestern Ontario. Scale 4 miles to 1 inch. (Accompanying report No. 291.)

†297. Geological map of Alberta, Saskatchewan, and Manitoba. Scale 35 miles to 1 inch. (Accompanying report No. 291.)

†298. Map, geology of the forty-ninth parallel, 0·9864 miles to 1 inch. (Accompanying report No. 291).

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†302. Map showing location of main gas line, Bow Island, Calgary. Scale 12½ miles to 1 inch. (Accompanying report No. 291.)

†311. Magnetometric map, McPherson mine, Barachois, Cape Breton county, Nova Scotia—by A. H. A. Robinson, 1913. Scale 200 feet to 1 inch.

†312. Magnetometric map, iron ore deposits at Upper Glencoe, Inverness county, Nova Scotia—by E. Lindeman, 1913. Scale 200 feet to 1 inch.

†313. Magnetometric map, iron ore deposits at Grand Mira, Cape Breton county, Nova Scotia—by A. H. A. Robinson, 1913. Scale 200 feet to 1 inch.

†327. Map showing location of Saline Springs and Salt Areas in the Dominion of Canada. (Accompanying Report No. 325.)

†328. Map showing location of Saline Springs in the Maritime Provinces. Scale 100 miles to 1 inch. (Accompanying Report No. 325.)

†329. Map of Ontario-Michigan Salt Basin, showing probable limit of productive area. Scale 25 miles to 1 inch. (Accompanying Report No. 325.)

†330. Map showing location of Saline Springs in Northern Manitoba. Scale 12½ miles to 1 inch. (Accompanying Report No. 325.)

†340. Magnetometric map of Atikokan iron-bearing district, Atikokan Mine and Vicinity. Claims Nos. 10E, 11E, 12E, 24E, 25E, and 26E, Rainy River district, Ontario. By A. H. A. Robinson, 1914. Scale 400 feet to 1 inch.

†340a. Geological map of Atikokan iron-bearing district, Atikokan Mine and Vicinity. Claims Nos. 10E, 11E, 12E, 24E, 25E, and 26E, Rainy River district, Ontario. By A. H. A. Robinson, 1914. Scale 400 feet to 1 inch.

†341. Magnetometric map of Atikokan iron-bearing district, Sheet No. 1, Claims Nos. 400R, 401R, 402R, 112X, and 403R. Rainy River district, Ontario. By E. Lindeman, 1914. Scale 400 feet to 1 inch.

†341a. Geological map of Atikokan iron-bearing district. Sheet No. 1. Claims Nos. 400R, 401R, 402R, 112X, and 403R, Rainy River district, Ontario. By E. Lindeman, 1914. Scale 400 feet to 1 inch.

†342. Magnetometric map of Atikokan iron-bearing district. Sheet No. 2. Claims Nos. 403R, 404R, 138X, 139X, and 140X, Rainy River district, Ontario. By E. Lindeman, 1914. Scale 400 feet to 1 inch.

†342a. Geological map of Atikokan iron-bearing district. Sheet No. 2. Claims Nos. 403R, 404R, 138X, 139X, and 140X, Rainy River district, Ontario. By E. Lindeman, 1914. Scale 400 feet to 1 inch.

† Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†343. Magnetometric map of Atikokan iron-bearing district. Mile Post No. 140, Canadian Northern railway, Rainy River district, Ontario. By E. Lindeman, 1914. Scale 400 feet to 1 inch.

†343a. Geological map, Atikokan iron-bearing district. Mile Post No. 140, Canadian Northern railway, Rainy River district, Ontario. By E. Lindeman, 1914. Scale 400 feet to 1 inch.

†354.	Index Map, showing location of peat bogs investigated in Ontario—	by A. Anrep, 1913–14.
†355.	Richmond peat bog, Carleton county, Ontario—	" "
†356.	Luther peat bog, Wellington and Dufferin counties, Ontario—	" "
†357.	Amaranth peat bog, Dufferin county, Ontario—	" "
†358.	Cargill peat bog, Bruce county, Ontario—	" "
†359.	Westover peat bog, Wentworth county, Ontario—	" "
†360.	Marsh Hill peat bog, Ontario county, Ontario—	" "
†361.	Sunderland peat bog, Ontario county, Ontario—	" "
†362.	Manilla peat bog, Victoria county, Ontario—	" "
†363.	Stoco peat bog, Hastings county, Ontario—	" "
†364.	Clareview peat bog, Lennox and Addington counties, Ontario—	" "
†365.	Index Map, showing location of peat bogs investigated in Quebec—	" "
†366.	L'Assomption peat bog, L'Assomption county, Quebec—	" "
†367.	St. Isidore peat bog, La Prairie county, Quebec—	" "
†368.	Holton peat bog, Chateauguay county, Quebec—	" "
†369.	Index Map, showing location of peat bogs investigated in Nova Scotia and Prince Edward Island—	" "
†370.	Black Marsh peat bog, Prince county, Prince Edward Island—	" "
†371.	Portage peat bog, Prince county, Prince Edward Island—	" "
†372.	Miscouche peat bog, Prince county, Prince Edward Island—	" "
†373.	Muddy Creek peat bog, Prince county, Prince Edward Island—	" "
†374.	The Black Banks peat bog, Prince county, Prince Edward Island—	" "

†Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†375. Mermaid peat bog, Queens county, Prince Edward Island..........................by A. Anrep, 1913–14

†376. Caribou peat bog, Kings county, Prince Edward Island— " "

†377. Cherryfield peat bog, Lunenburg County, Nova Scotia— " "

†378. Tusket peat bog, Yarmouth county, Nova Scotia— " "

†379. Makoke peat bog, Yarmouth county, Nova Scotia— " "

†380. Heath peat bog, Yarmouth county, Nova Scotia— " "

†381. Port Clyde peat bog, Shelburne county, Nova Scotia— " "

†382. Latour peat bog, Shelburne county, Nova Scotia— " "

†383. Clyde peat bog, Shelburne county, Nova Scotia— " "

†387. Geological map Banff district, Alberta, showing location of phosphate beds—by Hugh S. de Schmid, 1915. (Accompanying report No. 385.)

†390. Christina river map showing outcrops of bituminous sand along Christina valley; contour intervals of 20 feet—by S. C. Ells, 1915. Scale 1,000 feet to 1 inch.

†391. Clearwater river map, showing outcrops of bituminous sand along Clearwater valley; contour intervals of 20 feet—by S. C. Ells, 1915. Scale 1,000 feet to 1 inch.

†392. Hangingstone-Horse rivers, showing outcrops of bituminous sand along Hangingstone and Horse River valleys: contour intervals of 20 feet—by S. C. Ells, 1915. Scale 1,000 feet to 1 inch.

†393. Steepbank river, showing outcrops of bituminous sand along Steepbank valley; contour intervals of 20 feet—by S. C. Ells, 1915. Scale 1,000 feet to 1 inch.

†394. McKay river, 3 sheets, showing outcrops of bituminous sand along McKay valley; contour intervals of 20 feet—by S. C. Ells, 1915. Scale 1,000 feet to 1 inch.

†395. Moose river, showing outcrops of bituminous sand along Moose valley; contour intervals of 20 feet—by S. C. Ells, 1915. Scale 1,000 feet to 1 inch.

Address all communications to—

DIRECTOR MINES BRANCH,
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SUSSEX STREET, OTTAWA.

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