

CANADA MINES BRANCH

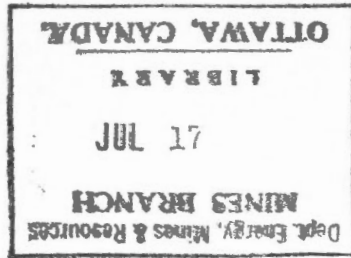
REPORT NO. 607

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622(21)
G212F

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CANADA
DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN McLEISH, DIRECTOR

INVESTIGATIONS IN 1922

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(Annual Summary Report of the Mines Branch, pp. 7-70)

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SUMMARY REPORT OF MINES BRANCH INVESTIGATIONS, 1922

MINERAL RESOURCES DIVISION

I

MINERAL PIGMENTS

Howells Fréchette

In continuation of the investigation on mineral pigments in eastern Canada a number of deposits were visited and examined in Ontario, Quebec and New Brunswick. In all cases these deposits had been recently brought to the attention of the Department through samples submitted for examination.

Ontario

Northern Ontario.—On the east bank of the Abitibi river, on lot 27, concession I, Kennedy township, about 8 miles east of Cochrane, springs issuing from the margin of a sand flat deposit iron ochre over an area of about six acres. Over the greater part the deposit is too thin to be of any commercial interest, but at a few points it reaches a depth of two feet or more. Carbonate of lime has been deposited along with the iron oxide in certain sections of the area, though much of the deposit is sufficiently pure for the production of calcined red oxide for paint manufacture. In view of the shallowness of the deposition, and the admixture of carbonate of lime in places, the deposit cannot be regarded as a potential producer of iron ochre for paint manufacture, as the tonnage of good material is insufficient to warrant the installation of a plant to prepare it for the market. A limited amount of crude oxide could be produced for use in purification of gas should market conditions be favourable.

Probably the most important aspect in which this and other smaller deposits just outside the town of Cochrane should be viewed is as an indication of favourable conditions having existed for the laying down of such deposits. Search along the lower margins of sand areas, especially those which have been subject to the leaching action of swamp water, may disclose larger deposits at present hidden by moss or other vegetable growth.

Central Ontario.—A small group of deposits of iron ochre were examined on lot 29, concession XV, Monmouth township, Haliburton county, about two miles west of Wilberforce and half a mile north of the railway.

These deposits, unlike those near Cochrane, evidently owe their origin to iron leached from rock in place, probably from pyrite occurring in quartzite or amphibolite, for the sand and gravel in the immediate neighbourhood was insufficient to account for the amount of iron ochre deposited.

The deposits lie in a small ravine and are in the form of mounds, built up around springs, which flatten out into thin layers merging into one another. The largest mound covers about 1,000 square feet and rises to a height of at least six feet above the general level of the ravine. Owing to the presence of layers of hard bog ore the bottom of the deposit could not be reached with the sampling drill, and the exact depth determined. Deposition at this point has ceased, the spring having found a new outlet about fifty feet to the west. Here a mound is in course of formation and has reached a thickness of four feet. There are other lesser mounds. In all about one acre is covered with the ochre, though so thinly in most places that it could not profitably be dug. While a considerable tonnage of iron ochre, suitable for calcining for the production of red oxide, could be obtained from this group of deposits, it is insufficient to warrant the erection of a plant. The material is suitable for gas purification and it might be possible to market it profitably for that purpose.

Quebec

Drummond County.—At one time quite a flourishing industry in digging bog iron ore was carried on in this county, but with the disappearance of the small blast furnace no further attention was paid to the deposits. In some cases, associated with the hard bog ore there was a considerable proportion of the earthy iron oxide or iron ochre. No attempt was made to save this for the production of paint except merely for local use. One of the deposits, on lot 11, range II, Simpson township, was examined and found to consist largely of a good grade of iron ochre suitable for the production of calcined red oxide, but the deposit is shallow and irregular as to depth and very limited in area. The district, however, offers a reasonable amount of promise for systematic prospecting, as indications of ochre are seen for many miles both on the north and south sides of the St. Francis river.

St. Rémi d'Amherst.—A few hundred feet to the southeast of the present workings of the Canadian China Clay Co., Ltd., on lot 6, range VI south, Amherst township, Labelle county, there is a showing of yellow ochre. The ochre in this case is of the clay-base type, that is, the material is a clay stained yellow by iron oxide and not simply an earthy hydrated oxide of iron precipitated from a water solution by oxidation such as iron ochre. It corresponds to the French yellow ochre of commerce and produces a paint which compares favourably as to colour and tinting power with that pigment. At the point where this is exposed, along the edge of a railway cutting, there is an overburden of gravel three to four feet thick, which would have to be trenched through in order to determine the tonnage available. The attention of the management of the company was called to the value of the material as a pigment, and to the fact that it was the first example of which we have record of material of this grade in eastern Canada. Later samples of similar material were received from New Brunswick, and the deposits from which they were obtained were examined.

New Brunswick

A number of samples of rather highly coloured clays were submitted by interested parties in St. John, to be examined as possible raw material for the manufacture of paints. They consisted of red, buff and yellow clays, which, when ground in oil, produced paints of poor quality as to opacity, intensity of colour and brilliance, except in the case of the yellow clay, which may be classed as a fairly high grade yellow ochre. The other colours were unsuitable as pigments, except possibly as cheap fillers for linoleum manufacture.

Opportunity offered to visit the deposits from which the above mentioned samples were obtained and an examination was made of them in October.

Northumberland County.—About six miles southeast of Howard station, to the west of Cain river, between Otter brook and the mouth of Sabbies river, there are several exposures of coloured clay. In the bed of a small creek in the southern part of the area indicated above, an unctuous blue-grey clay outcrops from under about five feet of gravel. Within this bluish clay are streaks and small pockets of bright yellow ochre of good grade, but as the quantity apparently is very small, and also due to its mixture with the other clay, it is of no commercial value.

To the northward there are a number of clay areas many acres in extent. The general colour of this clay is buff, though the upper half foot is frequently of a stronger yellow colour. None of it is suitable for paint manufacture.

Kings County.—Clays resulting from the weathering of Carboniferous shales are exposed along the sides and floor of a small valley on the road from St. John to Smithtown, near Damascus. The prevailing colour of the clay is red, but it contains streaks and small patches of greyish white silty clay and yellow clay.

The red clay is similar to much occurring throughout New Brunswick and Nova Scotia. It cannot be regarded as valuable for pigment purposes as it lacks brilliance of colour and opacity when ground in oil. It might be used as a filler in the manufacture of linoleum. The white silty material is worthless. The yellow clay would make good paint similar to French yellow ochre, but it occurs in too small quantity to be of any value, and the indications do not point to the likelihood of more extensive deposits.

II

ALKALI DEPOSITS, WESTERN CANADA

L. H. Cole

INTRODUCTORY

The examination of the alkali lakes of western Canada, begun during the field season of 1921, was continued during the summer of 1922. The work was hindered to some extent during the entire season by the unusual amount of rainfall which occurred in the localities in which the lakes are situated. None of the deposits examined were entirely dry at any time during the work, and most of the drilling was carried on with from six inches to one foot of brine on top of the crystal bed.

The methods employed in the examination were the same as those of the previous season, a description of which is given in the Summary Report of the Mines Branch for 1921. The work was commenced at Vincent lake, 12 miles northwest of Tompkins, Sask., and the season was spent in the area lying to the west of Swift Current, Sask., between the main line of the Canadian Pacific railway and the Empress branch of the same line.

SODIUM SULPHATE DEPOSITS

Three large deposits were drilled and sampled and preliminary work was done on a dozen other deposits.

The deposits examined were very similar to those previously studied. The thickness of the crystal bed varied greatly in the several deposits, and also from place to place in the same lake. One drill hole cut through 30 feet of solid crystals before encountering the underlying mud. This is the greatest depth of crystals so far proven by the investigation.

The drilling done to date on six deposits has proven the presence of 17,000,000 tons of crystals, 90 per cent of which can be considered hydrous sodium sulphate.

DESCRIPTION OF DEPOSITS

The following brief description of the deposits examined during the season is only preliminary and will be supplemented in the final report.

Vincent Lake, Sask.

This lake, situated in townships 14 and 15, range 22, west of the 3rd meridian, occupies an undrained basin surrounded by morainic hills which rise in places some 50 feet above the normal level of the lake. There is a crystal bed of varying thickness, 30 feet of crystals being encountered in one of the drill holes. The crystal bed covers an area of approximately 325 acres with an average depth of 10 feet.

The following analyses* are of material from this deposit:—

	Hole No. 7	Hole No. 11	Hole No. 17
Insoluble.....	6.00%	6.00%	11.00%
Iron oxide and alumina.....	0.70	0.60	1.23
Calcium carbonate.....	.....	.....	2.76
Calcium sulphate.....	1.94	1.57	.....
Magnesium carbonate.....	.....	.....	1.55
Magnesium sulphate.....	2.92	2.20	.....
Sodium chloride.....	0.74	0.77	0.82
Sodium sulphate.....	86.51	87.71	82.08

*Analyses made on dried material.

This deposit is approximately 11 miles northwest of Tompkins, Sask., on the Canadian Pacific railway.

Chain Lake, Sask.

This is a long narrow lake situated in sections 10, 15, 16 and 21, tp. 18, range 20, west of the 3rd meridian. The surrounding country is comparatively flat-lying and the depression is correspondingly shallow. There is a crystal bed with an average depth of 2.25 feet.

The crystal bed covers approximately 70 acres.

An average analysis of the dried material from this lake is as follows:—

	Per cent
Insoluble.....	7.75
Iron oxide and alumina.....	2.00
Calcium carbonate.....	2.05
Calcium sulphate.....	3.00
Magnesium sulphate.....	4.48
Sodium sulphate.....	79.50

The deposit lies approximately 16 miles to the southwest of Cabri, Sask., a station of the Swift Current-Empress branch of the Canadian Pacific railway.

The water in another lake lying one-half mile to the south is strongly alkaline but no crystal bed was encountered in it.

Snakehole Lake, Sask.

This lake is situated on sections 11, 12, and 13, tp. 18, range 19, west of the 3rd meridian, and is 7 miles south of Cabri station on the Canadian Pacific railway. There is a large crystal bed in the bottom of this lake covering approximately 460 acres. A depth of 20 feet of crystals was encountered in one hole. Numerous springs feed into this lake. At the north end of the depression the banks rise almost vertically in places to a height of 100 feet above the lake level, the slopes of the surrounding hills being more gentle towards the southern end of the deposit. Scattered through the crystal bed are numerous mud holes varying from a few feet to many feet in diameter.

An average analysis of the dried material from this deposit is as follows:—

	Per cent
Insoluble.....	4.00
Iron oxide and alumina.....	0.55
Calcium sulphate.....	2.06
Magnesium sulphate.....	5.24
Sodium chloride.....	0.75
Sodium sulphate.....	87.44

Wiseton, Sask.

There are two lakes 21 miles south of Wiseton, Sask., situated in section 32, tp. 23, range 12, west of the 3rd meridian. These lakes cover approximately 270 acres but there was no crystal bed visible.

An average sample of the brine from these two lakes gave the following results in parts per million:—

Insoluble.....	20
Calcium sulphate.....	20
Magnesium sulphate.....	200,000
Sodium chloride.....	9,500
Sodium sulphate.....	80,000

OPERATING DEPOSITS

Three deposits are being developed at the present time and plans are under way for the opening up of several others.

Salts and Chemicals, Ltd.

At Dana, Sask., a half-million dollar plant is nearing completion, to extract salt cake and other chemical products from the brines of Muskiki lake, formerly Houghton lake, 23 miles west of Humboldt, Sask. The

company operating this deposit is The Salts and Chemicals, Ltd., controlled by Canadian and United States interests. The refining plant of this company, which was formerly at Kitchener, Ont., is now being removed to the lake. When this plant is in operation it is estimated that the output will be 30,000 tons of salt cake per year, besides Epsom and other salts recovered as by-products. A small village has been established at the lake with housing accommodation for 60 men. When the plant is working at fuller capacity 100 men are to be employed.

Bishopric and Lent Co.

At Frederick lake, five miles southwest of Dunkirk, Sask., and 38 miles from Moose Jaw, Sask., another salt cake recovery plant has been erected by The Bishopric and Lent Co., with head offices at Cincinnati, Ohio. This plant is practically completed, and as soon as it proves commercially successful, further units are to be added to increase the output. At the present time 20 men are employed at this plant.

Soda Deposits, Ltd.

At a lake five miles north of Fusilier, Sask., an experimental plant has been operated by a company called Soda Deposits, Ltd., with head office at Calgary, Alta. This deposit, although somewhat smaller than some of the other deposits, contains sodium sulphate in a very pure state, and several shipments have already been made. This company hopes in the near future to be in a position to put its product regularly on the market.

MAGNESIUM SULPHATE AND SODIUM CARBONATE DEPOSITS

In British Columbia, several deposits of magnesium sulphate were visited, as well as a number of occurrences of sodium carbonate.

Spotted Lake, B.C.

This lake lies approximately one-half mile north of the southern entrance to Richter's pass. The nearest town to the deposit is Oroville, Washington, U.S.A., which is distant about 6 miles. It is 40 miles by road south of Penticton, B.C. The deposit occurs in a flat depression known as Spotted lake, which is a partially dried up lake containing alternate circles of saturated brine and dried silt.

A small shipment was made from this lake in 1915, and it has been worked intermittently since that time. Approximately 1,600 tons of crude magnesium sulphate were removed from this deposit up to 1920, when operations apparently were abandoned. This material was hauled by auto truck to the Oroville plant of the Stewart Calvert Company, for treatment, where the crude salts were dissolved and recrystallized for sale to the drug and tanning industries.

Basque Chemical Co.

The Basque Chemical Company is operating a series of five lakes situated fifteen miles west of Ashcroft, B.C. From these lakes they are excavating crude magnesium sulphate (Epsom salt), which is shipped to Vancouver, where it is refined and sold as medicinal salts and to the tanning industry. Plans are now under way for greatly extending the development of this deposit.

Clinton, B.C.

There is a small lake one mile south of the town of Clinton, B.C., from which a small tonnage of magnesium sulphate was obtained a few years ago. This deposit was not operated during 1922.

Lillooet Soda Company

In the vicinity of Meadow lake, fifty miles north of Clinton, B.C., the Lillooet Soda Company is operating a sodium carbonate lake and shipping the product to Vancouver over the Pacific Great Eastern railway. This material is being disposed of at the present time to the soap manufacturers of the Pacific coast, but plans are under way to dry the material at the lake and increase the output.

This company also owns several other lakes of the same material which they propose to operate at some future date.

INDUSTRIAL USES OF GLAUBER'S SALT AND EPSOM SALT

In the chemical manufacturies, Glauber's salt and Epsom salt find a very extensive application, and the demand for these products is ever increasing. Since by far the greater part of the Canadian consumption is imported, it is of importance to analyse their different uses with a view to finding whether material from Canadian deposits cannot be utilized.

Sodium sulphate is used extensively in the pulp and paper, glass, dye and textile industries, and to a smaller extent for medicinal and tanning purposes. Magnesium sulphate is employed for tanning and dyeing, and for textile and medicinal use.

Pulp and Paper Industry

The manufacturers of kraft paper are very large consumers of salt cake, using annually over 50,000 tons. The principle upon which this process depends is the solvent power of caustic alkali on the non-cellulose constituents in the wood. Consequently sodium sulphate cannot be used directly, but has to be converted into caustic alkali and dissolved in water. This solution is termed white liquor and is composed mainly of sodium hydrate and sodium sulphide. To prepare this white liquor, the so-called black liquor, containing the dissolved non-cellulose substances, obtained from the process, is evaporated to 35° Be and put through a rotary furnace. At the discharge end of this furnace, enough sodium sulphate is added to replace the alkali lost in the treatment of the wood. It is then shovelled into smelting furnaces where the sodium sulphate is reduced to sodium sulphide and carbonate. From the smelting furnace the melt flows in a molten condition to dissolving tanks containing water or dilute washings from the sludge in the causticizing room. When the solution has reached the desired density it is discharged into the causticizing system and lime is added. The reaction with the lime is as follows:—



Magnesium sulphate is used in the paper industry for weighting paper.

Glass Industry

Manufacturers of glass bottles and other containers use comparatively small amounts of sodium sulphate or salt cake (Na_2SO_4), according to some manufacturers only about 40 lbs. per ton. Since it gives a more homogeneous batch than when soda ash is used, a very clear glass is obtained, therefore it can be advantageously used in window glass and where very clear and white glass is required. The window glass manufacturers require about 6-10 per cent sodium sulphate (Na_2SO_4) but foreign manufacturers often add as high as 25 per cent to their batch.

Tanning Industry

Sodium sulphate is not used in the tanning industry proper, but comparatively large amounts are used advantageously in curing hides, super-seeding salt. It is difficult to arrive at a figure of the requirements for that purpose. However, large amounts of sodium sulphide are used mixed with lime, or by itself. In practice, sodium sulphide is always obtained by the reduction of sodium sulphate. The immersion of hides in a solution of sodium sulphide removes the hair quickly, freshens the grain, and imparts great toughness to the hide. A tannery using sodium sulphide will require as high as 75 tons per year for an output of 180,000 hides.

Magnesium sulphate is used by the tanneries in manufacturing sole leather, the estimated annual requirement for Canada being about 1,000 tons. It is used in sole leather only, to get a clean, shiny cut; it also helps to retain the moisture in leather and increases its weight.

Dye Industry

The present estimated annual consumption of Glauber's salt by the dye works is from 1,300 to 1,500 tons. The dyers prefer the natural Glauber's salt to manufactured salt cake as it is free from nitrates and nitrites which readily oxidize the dye. Magnesium chloride tends to disassociate the colours.

The effect of Glauber's salt under the general theory of dyeing is, mechanically retarding the interaction between the colour-acid and the fibre, chemically retarding the liberation of the colour-acid from the dye salt, and in affecting the solubility of the dye stuff solution.

The general effect of the addition of sodium sulphate appears to be a more uniform distribution of the dye, since this substance has a slight solvent action on the dye taken up by the fibre, thus removing it from those places in which the dye may have been deposited in excess and generally retarding the operation of dyeing, thus obtaining a slow and even setting.

Epsom salt is also used in the dyeing industry but not to a very large extent. In some cases it is used in the after treatment in order to increase the fastness to washing. Sodium sulphide is extensively employed for the sulphur dyes.

Medicinal Use

For medical purposes Glauber's salt is employed as an aperient and is one of the safest and most innocent known. It is to some extent used in cattle food and especially for veterinary uses. Also, it has been employed in cooling mixtures. Magnesium sulphate has an extensive use in medicine and very large quantities are used for this purpose, estimated at about 500 tons per annum.

Textile Industry

Magnesium sulphate is extensively used in textile manufacture for various purposes. In bleaching wool where sodium peroxide is used, since caustic alkali attacks the wool, magnesium sulphate is added to destroy its corrosive effect. It is also used for weighting textile fabrics, especially silk. Printed cotton is always "finished," the finishing material consisting of a mixture of kaolin, gypsum, etc., and magnesium sulphate. Magnesium sulphate mixed with gypsum and ammonium sulphate is used for the manufacture of non-inflammable fabrics.

III

VOLCANIC ASH NEAR WALDECK, SASK.

LOCATION OF DEPOSIT

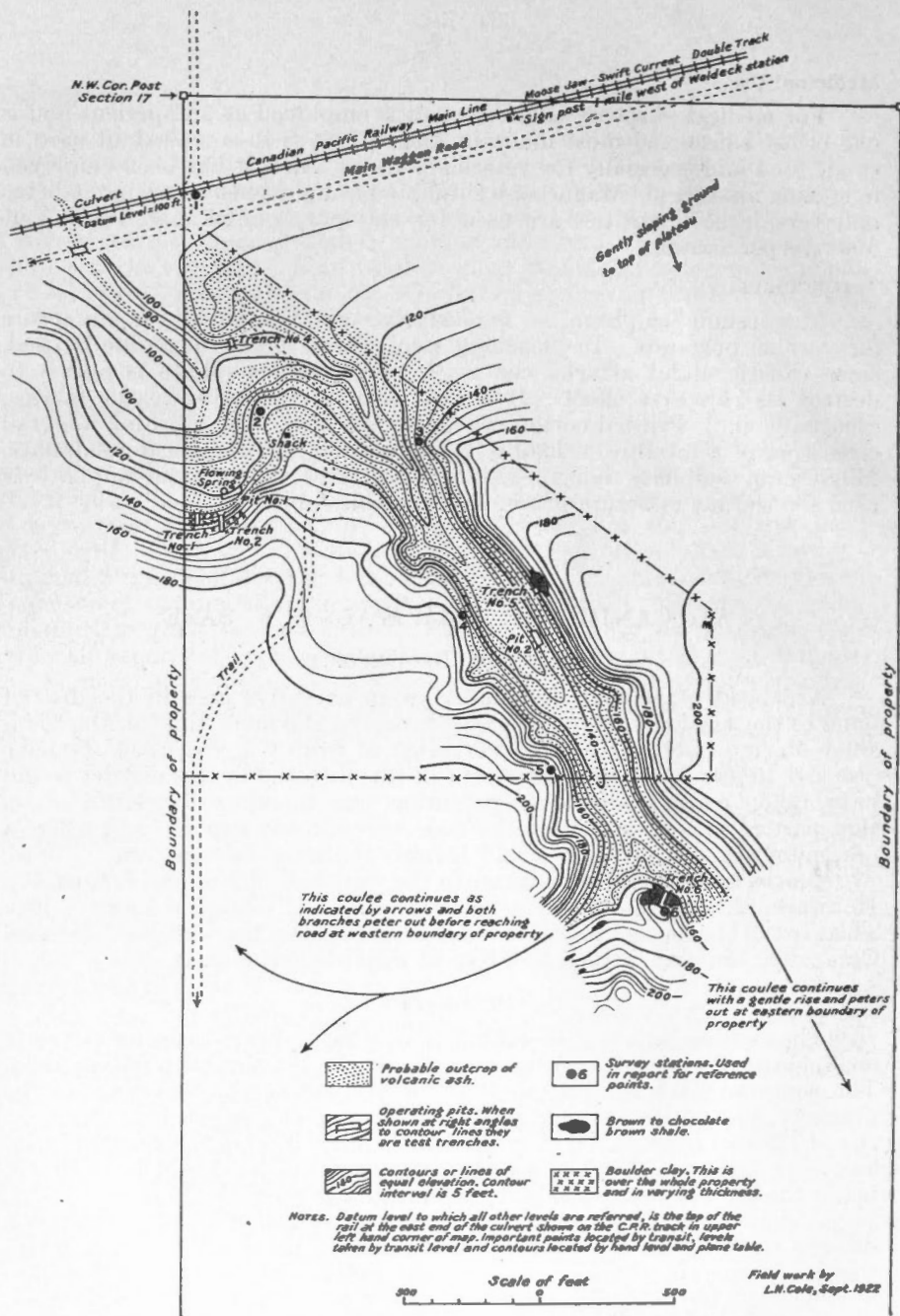
A deposit of volcanic ash underlies an extensive area in the district lying to the southwest of Waldeck, a station on the main line of the Canadian Pacific railway, 11 miles northeast of Swift Current, Sask. To have properly determined the exact extent of this material in this district would have taken considerable time; attention was therefore concentrated on that part of the deposit where the beds were already exposed and where a minimum amount of work would furnish the most information.

The examination was confined to the west half of section 17, township 16, range 12, west of the 3rd meridian, an area of 320 acres more or less. This part of the deposit is controlled and operated by the Van-Kel Chemical Company, Limited, with head office at Swift Current, Sask.

TOPOGRAPHY

The railway follows the south side of what appears to be an old river channel that has been cut below the general level of the surrounding plain. The southern bank of this old river crosses the northwest corner of the property, so that the ground rises gradually as one goes south. There is a rise of 125 feet from the track level to the general level of the original plain, and since there are places on the property where the level is at least 10 feet below the level of the track, there is a maximum relief of 135 feet.

A coulee, some 500 feet wide, and running in a southeasterly direction, dissects the plain on this property. It joins the main valley at the north-western corner of the half section and peters out at the southeastern boundary of the property 1,400 feet north of the southeast corner post. Approximately 3,000 feet southeast from the northwest corner post of the section another coulee branches off from the main coulee in a southwesterly direction and peters out near the western boundary.



Map of the property of the Van-Kel Chemical Co., Ltd
W 1/2 Sec. 17, Tp. 16, Range 12, west of the 3rd meridian
Saskatchewan

FIG.

With the exception of these two coulees and that portion of the old river channel already mentioned, the surface of the property is gently undulating, with a maximum relief of less than 20 feet. The main topographic features are shown on the accompanying map. (Fig. 1.)

The presence of these coulees and the old river valley have rendered the beds underlying the general mantle of boulder clay or till readily accessible, since they have cut through the drift material and portions of the underlying shale beds, leaving in many places only a thin veneer of covering on top of the ash beds.

GEOLOGY

It would be necessary to examine a considerable area of the surrounding country to determine whether the beds noted were continuous or only local, and whether the dips and strikes held good over the whole deposit. The time available did not permit of such detailed work, so that the data obtained can only be considered as applying to that part of the deposit examined.

The geological sequence as noted on this property was as follows:—

Boulder clay or till.....	Varying depths
Brownish grey shale.....	Thickness undetermined, 20 feet uncovered in one trench
Volcanic ash beds.....	Thickness of 37 feet in one place
Blue-grey shale?.....	Undetermined

Boulder Clay or Till

The boulder clay or till is the common type to be seen in the territory lying to the east of Swift Current. It consists of a heavy clay matrix in which numerous pebbles and boulders are embedded. Many of these boulders are badly disintegrated and readily crumble in the hand when pressure is put on them. This is especially true of many of the granite-gneiss pebbles contained in the clay. There are a number of remarkably well-rounded hard quartzite pebbles embedded in the boulder clay, especially at a definite horizon in the drift. The larger number of the pebbles and boulders are of Archean origin. The boulder clay is of varying thickness in different parts of the property. For example, trench No. 2 was cut in boulder clay horizontally into the hill for a distance of 14 feet and then sunk for a depth of 5 feet below this level, so that at the end of this trench there was a face of boulder clay of approximately 13 feet thick. In this trench, as well as in trench No. 1, the boulder clay was found resting directly on the ash beds and the brown shale was not encountered. It could not be definitely determined whether the top of the ash beds in these two trenches was the true top or whether some of the material had been eroded prior to the deposition of the boulder clay. At trenches Nos. 5 and 6 the overburden of boulder clay was less than one foot in thickness.

The boulder clay is very hard and compact and it would be difficult and expensive to do any extensive stripping where this material is three feet or more in thickness.

Brownish Grey Shale

In trench No. 6, beds of brownish grey shale were uncovered and a thickness of 20 feet exposed. The shales exposed in this trench have been highly weathered and carry some iron oxide, which gives it a chocolate brown colour when first exposed, but which afterwards turns to a brownish grey. These shales are highly arenaceous or sandy in texture and will probably prove suitable for a fair class of building brick, judging from preliminary tests made by Professor W. C. Worcester of the University of Saskatchewan. It is quite probable that this shale extends over a larger area and to a higher level than that exposed in the top of trench No. 6, since the material thrown out of badger and gopher holes shows similar shale all the way up the southwestern coulee nearly to the level of the general plain.

The contact between this shale and the underlying ash beds was encountered in trench No. 5. In this trench the materials gradually grade into one another so that it is difficult to determine the exact point at which the change occurs.

Volcanic Ash Beds

It is the material from these beds that is used in the manufacture of domestic cleansers and hand cleaners. The ash is a loosely compacted, finely divided material, and will vary, when dry, from a light buff colour to a pure white. The strike of the beds could not be determined with any degree of certainty, but it is approximately northeast, with a dip to the northwest of less than 10 degrees.

Two pits have been opened on the property and material has been used from both of them. Pit No. 1 was opened at the foot of the rise near the western boundary of the property and exposed very white material of fine texture. A strong flowing spring was encountered at this point which prevented the pit being operated to any depth without draining. A test hole, however, was sunk in the bottom of this pit, with an auger, to a depth of 10 feet and was still in the ash beds. The elevation of the bottom of this test hole was 110 feet,* and since in trench No. 2 the ash beds were encountered at an elevation of 131 feet, there is a thickness at this point of at least 21 feet.

In pit No. 2 the elevation of the bottom is approximately 130 feet. A test hole sunk in the bottom of this pit to a depth of 10 feet encountered the base of the ash beds. Trench No. 5 gave the contact of the ash beds and the brown shale at an elevation of approximately 157 feet, so that in this part of the deposit there is a thickness of 37 feet. The ash was not encountered in trench No. 6, but 50 feet north of this trench a shallow hole uncovered it at a few feet lower than the bottom of the trench. Trench No. 4 did not show the ash beds but exposed what appeared to be a bluish grey shale, but this could not be determined definitely. It was very similar in appearance to the material found in the bottom of the test hole sunk in the bottom of pit No. 2. Numerous badger and gopher holes also indicate the character of the underlying material.

*Datum level C.P.R. track at east end of culvert = 100 feet.

It is reasonably certain that the ash beds are continuous between the two pits and also over a considerable area in the district surrounding the property, since these beds are found at the foot of the old shore line one mile southwest of the property, and also in the bottom of a well at a depth of 20 feet on the next section west. Four miles directly south of the property material very similar in appearance is found, but the analysis shows that the material from the more southern locality carries a considerable amount of gypsum, which is not present in the deposit in question.

Material Available.—Assuming that the beds are continuous over the whole of the property, except on the area to the northwest where the ash is known to be absent, and assuming that the thickness holds nearly constant, there is a large tonnage of the volcanic ash present. The larger part is covered with an overburden of boulder clay and shale. There is, however, a large area with only a light covering, and this material will be sufficient to supply the company for many years. It is impossible to make an accurate determination of the tonnage available without further work in proving up the thickness of the material and the extent of the overburden, but taking the outcrop of the ash beds as shown on the map to be correct, and if the material were excavated to its full depth for an average width of 250 feet, there would be available approximately 200,000 tons in a strip 500 feet each way from pit No. 2 in the large coulee. From this it can readily be seen that by confining work to the outcrop of the ash beds alone, there is a large tonnage available with only a small amount of stripping.

Composition.—There has been a diversity of opinion regarding the composition of this material. Diatoms were reported by Andrews and Cruickshank, of Regina, Sask., in a sample they examined from pit No. 1, but in all the samples taken by the writer no diatoms were noted under the microscope. Five samples were submitted to Eugene Poitevin of the Mineralogical Division of the Geological Survey who reported on them as follows:—

The enclosed five specimens sent in for examination consist of semi-indurated volcanic ash composed essentially of glass particles with only minor proportions of comminuted crystals and microlites.

It is quite conceivable that where the spring comes out in pit No. 1, diatoms may be in process of deposition at the present time and therefore samples taken from this locality might easily contain occasional diatoms, but for all practical purposes the material can be considered volcanic ash.

The composition of the samples is shown by the following analyses:—

	1	2	3	4	5	6	7
SiO ₂	64.82	65.18	69.76	41.28	85.04	91.08	86.10
Fe ₂ O ₃ Al ₂ O ₃	21.64	19.70	15.58	9.10	4.04	0.96	4.90
CaO.....	2.25	2.15	2.20	17.25	0.67	0.36	1.30
MgO.....	2.77	1.99	0.90	4.18	0.66	0.29	0.80
SO ₃				10.34			
Loss on ignition.....	8.52	10.98	11.58	17.85	8.05	5.98	6.50
Totals.....	100.00	100.00	100.00	100.00	98.46	98.67	99.60

Localities from which samples were obtained:—

1. Buff material, Pit No. 2.
2. White material, Pit No. 2.
3. White material, Pit No. 1.
4. Outcrop of white material 4 miles south of Van-Kel property.
5. Analysis by Frank T. Shutt of material from same locality as sample No. 2.
6. Analysis by Frank T. Shutt of material from same locality as sample No. 3.
7. Analysis by Andrews and Cruickshank, Regina, Sask., of material from Van-Kel property, exact locality not stated.

Notes on Analyses.—First four samples were analysed by F. MacNiven, Mines Branch. Loss on ignition in first four samples obtained by difference; in sample No. 7 it includes moisture. In samples Nos. 5 and 6 amount under SiO_2 is "rock matter insoluble in acid." It is probable that in samples Nos. 5, 6, and 7, the fusion for silica was not made, hence the greater part of the iron and alumina is included in the silica figures, thus accounting for the high results.

An analysis of the water from the spring in pit No. 1 gave the following results:—

	Parts per million.
CaSO_4	290.0
MgSO_4	175.0
NaCl	27.5
Na_2SO_4	2,870.0

The ash is very fine in texture and has a high power of absorption. When first quarried it breaks up into powder very readily in the hand, but becomes slightly harder on exposure to the air. It does not appear to have a very strong bond. This quality of readily absorbing liquids, along with its abrading power, makes it a good material for making domestic cleansers. When burned at a comparatively low temperature, such as is employed when making the Little Wonder Fire Lighter bricks, the material still retains its high power of absorption, and it is this fact which is made use of in the application of the Fire Lighter.

The operating company hauls the material by wagon to Swift Current where they operate a small plant and turn out a line of cleansing products which seem to be finding a ready market in the prairie provinces. They have placed on the market the following lines.

Trade names:—

- Busy Bee Cleanser
- Busy Bee Hand Cleaner
- Busy Bee Odorizer
- Little Wonder Fire Lighter

All of these products have as a base the volcanic ash obtained from the company's property.

Very little has been done to determine the extent to which this material is suitable for commercial purposes, and it is possible that many other uses could be found for it besides those in which it has already been employed. The manufacture of bath brick, insulating brick, varying grades of metal polishes, and many other products are worthy of consideration.

CANADIAN FELDSPAR IN 1922

V. L. Eardley-Wilmot

Although the shipments of feldspar from the Dominion have been slightly less than in 1921, there has nevertheless been considerable activity in the industry, which appears to have gained further impetus during the latter part of the year.

In Table I will be found the shipments of feldspar by provinces during the last ten years.

Practically the whole of this material has been shipped crude to the United States grinding mills. Less than one per cent of the 1922 shipments were ground in the local mills at Kingston and Toronto. The products of these latter were used by the grinders or sold to Canadian manufacturers. The recent duty of 30 per cent on ground spar imported into the United States has doubtless been the cause of such a small amount of local ground material, but a probe into the European markets may reveal an outlet for the higher priced form of the product.

The average Canadian feldspar appears to be of better quality than that of the United States, which latter is mainly in the form of graphic granite.

Canadian feldspar is in much demand by various manufacturers in the ceramic industry in the United States for high grade pottery and porcelain purposes, for enamels and glazes, and in the electrical industry for insulators. The lower grade material is used in building materials such as stucco work and roofing, also for scouring soaps, opalescent glass, poultry grit, etc., etc.

In England feldspar is mainly used for enamelling of metal ware, the consumption, according to the Imperial Institute Mineral Resources Committee, being in the neighbourhood of 5,000 tons a year. The main source of supply is Scandinavia, the feldspar being delivered at an English port for about £2-15 per long ton. In the potteries china clay, china stone and mica clay, brought from Cornwall (England) are chiefly used.

In Table II will be found a general list of the feldspar grinders.

Many feldspar producers do not fully appreciate the difficulties of the manufacturers of pottery and porcelain. Certain formulae are calculated for the admixture of ingredients, and the temperature at which fusion has to take place (by the Orton cone) is carefully worked out for the particular grade of spar which they are using. If a batch of different grade of material is mixed in, it is liable to ruin the whole kiln run by either altering the fusion point or by contamination from discoloration and specking. A manufacturer cannot be continually altering his formulae and standard adjustments, and naturally prefers to buy from an experienced producer who has a large deposit of a regular grade. It is perhaps for this reason that the producer, or prospector, who has just begun feldspar mining often finds a difficulty in disposing of his product at a No. 1 price. It might pay him to develop his property and sell his first few carloads at a low figure to a grinder, or local buyer, and thus prove that he has a reasonably large deposit of good grade spar, or otherwise. When satisfied

that his property meets all requirements he should have no difficulty in getting a representative of one of the large grinding plants or manufacturers to come and see the deposit and make a contract for his output.

There is no doubt, however, that some kind of standard or guide is required to enable the producer to correctly grade his material, and it is hoped that some practical solution will be evolved. Although there has lately been a considerable amount of discussion devoted to this subject, which was also brought up before the recent ceramic meeting in Pittsburgh, so far no definite standard has been universally adopted.

QUEBEC

Buckingham District

During the year feldspar mining has been very active throughout the Buckingham district, from which the whole output for Quebec has been obtained. About a dozen deposits were worked by different individuals or companies, and approximately 12,500 tons of spar were shipped, about three-fifths of which came from the Derry mine owned by the O'Brien and Fowler Company, Ltd. Mahoney-Rich and the Pednaud quarries together shipped a little under 5,000 tons. A few hundred tons of dental spar and No. 2 material was shipped by Bush Winning, and the remainder came from five small producers.

The majority of the spar shipped from this district is very high grade and is of an almost pure white or buff colour. The deposits to the north of Buckingham occur as dikes, containing exceedingly large and pure crystals of feldspar and quartz which can easily be separated and sold as separate products. In the deposits worked by the principal producers the injurious ingredients such as mica, pyrites, hornblende and tourmaline are not usually intimately mixed, but when they occur are more or less concentrated at the edges of the dikes. Buff screenings from the Derry quarry are crushed and used for stucco work for ornamental building purposes. Practically all the deposits that are in the vicinity of Glen Almond, 8 miles north of Buckingham, occur as dikes carrying massive white or buff crystals of spar and of bull quartz, while farther south the spar appears to be of a pinker colour, not so massive, and carrying the quartz and impurities more intimately mixed.

The Derry mine on range I, lots 7 and 8 of Derry tp., operated by N. B. Davis for O'Brien and Fowler, has during the year shipped 50 per cent more spar than any other individual producer in Canada. It was originally staked by A. Parcher and R. J. Donaldson in 1917, and consists of a feldspathic dike about 100 feet wide with a well defined west wall of gneiss. This dike has now been quarried and stripped over a distance of about 400 feet along its strike. Operations were started in August, 1920, and the workings are at present confined to a level entry quarry on the northeast side of a gully. This quarry is some 300 feet long, 75 feet wide, and 40 feet deep at the north face, and is worked in bench fashion, and recently a bench has been started from below the track level. Crystals of pure spar 30 feet long and 15 feet wide are said to have been encountered.

Up-to-date methods are used for sorting and extracting the material, which is trammed out of the quarry over a high trestle alongside the road. The No. I spar is dumped into a loading bin, and the quartz, fines, and

waste material are dumped separately. The marketable materials are conveyed by wagon along the company made road to their own landing stage at Glen Almond on the Lievre river, from which they are loaded into 40-ton scows by a special dumping device, and conveyed by local steamer down to the railway siding at Buckingham. The quartz is sent to the Buckingham Chemical and Reduction works; the fines to the Company's crushing plant at Ottawa where it is further ground and sized for stucco and other purposes. In winter the material is hauled to Buckingham, 9 miles by snow road.

The No. 1 feldspar is shipped crude to grinding mills in the United States. The ground material is in high demand for the pottery trade and particularly for the manufacture of high tension insulators. It is stated that the quartz content of the Derry spar recently mined is only 1.5 per cent, with practically no sorting. An average analysis shows 13.0 per cent potash and 1.7 per cent soda.¹

The O'Brien and Fowler Co. also produce a clear semi-transparent spar from the centre of their deposit, which is sold for dental purposes under the trade name of Glen Almond spar.

About one mile farther north, on range II, lot 9, Mahoney and Rich of Ottawa, during the latter part of the year, took over the contract of Higginson and Parker and have been operating a property on top of a steep hill. The grade and quality of the dike are somewhat similar to the Derry mine, though the deposit does not appear to be as extensive, and mining operations have to be confined to open pit sinking and derrick hoisting. A pit about 85 feet long and 60 feet deep has been sunk on the dike. Steam power operates the derrick hoist and drills, and during the summer a 30-ton Holt caterpillar tractor hauled the material to a landing stage on the Lievre river, whence it was conveyed by scow to the Buckingham siding. Some very pure grade spar and quartz have been extracted from this deposit, which is the second largest producer in the province, approximately 3,500 tons having been shipped from the pit during the year. At the end of the year, however, owing mainly to trouble with water, Mahoney and Rich ceased operations and have moved their outfit to the McGivern property in Buckingham, range X, lot 5, about 8 miles to the southeast, which is owned by the New York Feldspar Corporation and upon which they have begun their 1923 operations.

One mile south of the Derry mine in Buckingham, range XII, lot 14, G. Pednaud operated his quarry throughout the greater part of the year. The workings consist of a series of level entry quarries one above the other over a vertical height of 300 feet. The deposit was originally worked for quartz, but the occurrence of large clean crystals of feldspar, particularly on the topmost workings, led to appreciable shipments of this material as well as quartz. Practically the whole spar output was taken by the O'Brien and Fowler Company.

In this area of about 4 square miles, which includes the above mentioned deposits, Messrs. Parcher, Whitmore and Louis Couture, have done some prospecting work on different deposits and have laid aside a few tons of spar and quartz which they intend to haul out by sleigh during the winter months. A little farther south J. J. Cameron sunk a pit on a dike

¹See description Can. Inst. of Min. & Met. Bull. 118, February, 1922, pp. 229-35. By N. B. Davis.

on the Gorman property, but abandoned the work after extracting about a car load of material. Operations have recently been begun on another part of the same dike by T. F. Foran.

Towards the end of the year A. J. McMillan did some prospecting on a large dike on his farm that has not been worked for over 20 years and on which there is evidence of local patches of fair grade pink spar. Practically all the output from the smaller producers has been taken by O'Brien and Fowler.

On Portland E., range IX, lot 3, Bush Winning has been operating the Villeneuve Extension quarry. This property is about one and a half miles due south of the well known Villeneuve mine, which years ago yielded dental spar and some of the highest grade spar ever mined in the Dominion. The appearance of the material on the Winning property is in many respects very similar and occurs in massive crystals of pure white spar and bull quartz. The quarry workings are on the side of a steep ridge, from which during the year several car loads of dental spar and No. 2 spar have been shipped. If it were not for the long haulage distances a considerably greater quantity of spar would be shipped from these more northerly deposits. In Table III will be found the dental spar shipments since 1910.

The majority of the feldspar operators in this district have shipped quartz to the chemical works at Buckingham.

St. Lawrence Feldspar Company, Quetachu Bay, North Shore of Gulf of St. Lawrence, Quebec

The feldspar found at Quetachu bay, opposite the centre of Anticosti island, occurs as a large batholith of pegmatite which covers an area of several square miles and which has irregularly intruded into black hornblende-biotite-gneiss, leaving many tongues and islands of the latter rock within its mass.

Generally speaking surface indications point to an intimate mixture with black mica and garnets, with smaller amounts of tourmaline, white mica and alteration products of all these minerals. The whole mass seems to be intermixed with smoky and white quartz, present either in graphic intergrowth with the feldspar or segregated as irregular nodules.

From an examination of the outcrops it would appear that the most valuable portion of this great batholith occurs within the 200 acres comprising the St. Lawrence Feldspar Company's property.

Recent attention has been turned to a promising looking area, which will be referred to later, but an account of the previous operations and conclusions thereby arrived at are as follows:—

Up to the end of 1918 prospecting work was confined to the southwestern end of the peninsula upon which this property is situated. Several hundred tons of material, which would be classed as Grade 3 spar, have been stock piled. A few tons of No. 1 spar have been cobbled out from the oldest stock piles, and a few more tons of the same material could be sorted out from the rock excavated in 1918. It is understood, however, that this excavated rock is now being used in the construction of the new wharf and piers. There is of course a possibility of finding a market for the lower grade material, such as for scouring soaps, provided that the excess of the intermixed quartz and garnets can be economically cobbled out.

As a result of this prospecting work and subsequent examination, which showed evidence of only small and scattered patches of higher grade material, it seems doubtful whether a good body of commercial spar for pottery purposes exists, either in this portion of the peninsula or in the islands. (An accurate description as applied to this area will be found in the report of H. S. Spence, "Feldspar in Canada," issued by the Mines Branch in 1916).

Consequently the idea of further prospecting for commercial pottery spar in this area has been temporarily abandoned, and attention has recently been turned towards the northeast, where appearances improve and the harmful impurities are not so intimately mixed. Several local belts of clean high grade spar, and indications of a large area of good graphic granite, were noticed here on the surface, but practically no prospecting work has as yet been done to prove these more promising looking showings.

The Company is building a wharf and has laid down a tram line connecting it with the face of a steep bluff, on the top of which the last mentioned showings of commercial spar are exposed. It is understood that the Company propose to develop this body in the near future. By cutting into this bluff a good working face will be exposed, by means of which such commercial spar as may be opened up can be economically quarried and then sorted and trammed to the wharf. It is proposed to devote the winter's operations to constructional work, further development of the new showings and possibly a little prospecting.

All the No. 1 spar and graphic granite mined will have to be carefully hand sorted, and with efficient cobbing it should be possible to obtain a considerable tonnage of good material.

Some of the purer patches contain individual crystals of as high grade a spar as the writer has seen in the Dominion.

In many places deep water extends to the deposit, with good anchorages which are said to be well protected from storms, so that the loading of the mineral into ships should present no difficulties.

The feldspar output for Quebec in 1922 constitutes a record for the province, being about 3,000 tons higher than the previous record in 1921. It is of interest to note that for the first time the value of the Quebec shipments has slightly exceeded that of Ontario though the actual tonnage is less. Feldspar was, however, shipped from Quebec ten or twelve years previous to Ontario, which commenced in 1900. Most of those old Quebec shipments, which reached a maximum of 3,000 tons in 1899, came from Templeton township and were valued at \$2.50 per ton, which was considered high compared to the early Ontario shipments at \$1.25 per ton.

ONTARIO

There has been a slight falling off in the Ontario feldspar shipments for the last two years when the maximum shipments of 37,000 tons was reached in 1920. This is mainly due to the inactivities of the larger Verona quarries, including the Richardson quarry, which for a period of 15 years, had an average annual output of over 10,000 tons. It is stated, however, that there are now thousands of tons of commercial spar that have been picked over from the dumps and are ready for shipment.

During the year the greatest production came from the Perth district.

Perth Area

In southwest Lanark feldspar mining has been active throughout the year. A series of dikes, having a general northeast-southwest strike, yielding commercial spar have been mined in Bathurst, con. IX, lots 20 and 21, about 8 miles northwest of Perth.

Practically the whole output of some 6,000 tons came from this small area, over three-fourths of which was shipped by the Rock Products Company, the second largest producer in Canada during the year.

The workings of this Company, which are alongside the road, consist of a pit about 75 feet long by 45 feet wide and 55 feet deep, and during the latter part of the year the Company drove a tunnel from the bottom of the northeast face. The best spar is of a very dark pink colour, and although the run-of-mine ore carries appreciable impurities, the deposit does not appear to be extensive and contains local patches of soda spar; nevertheless by means of a practical system of cobbing by experienced men, an excellent grade of No. 1 spar is separated and shipped to the Company's grinding plant at Toledo, Ohio. The mine is equipped with up-to-date hoisting machinery, including a substantial lattice steel derrick.

About a quarter of a mile to the east S. H. Orser has been working a deposit of spar from which he shipped a few car lots. The material is, however, somewhat low grade and requires considerable hand cobbing, so that work was abandoned during the late fall.

To the west of the Rock Products, and on the same lot, A. M. Campbell has taken an option on a feldspathic dike of considerable size. The outcrop, which is on top of a ridge, is some 800 feet long and 300 feet across, in which occur a few lenses of gneiss. Surface showings indicate a certain amount of impurities and admixed quartz, but recent work at the east end of the body has shown improvements. The dike is of sufficient size to allow of there being several local workings, any one of which would constitute a small shipper in itself. The spar is of the usual pink variety, but a dike of almost white spar, not unlike the north Buckingham mineral, has been exposed. Work was started during the summer, and a derrick operated by horse and drum was erected, but this has now been duplicated. Almost 1,000 tons are believed to have been shipped which have been classed as No. 2 grade, but as a result of the most recent operations some of the surface stained material has been cleaned off and the owner expects to be shipping No. 1 spar during 1923.

During December a few cars of spar were shipped by S. H. Orser from one of R. McConnell's properties known as the Kirkham quarry. The dike appears to carry a fairly large proportion of impurities so that considerable cobbing is necessary to obtain clean spar. A small crushing plant was erected by Orser on the Burns property, where the railway cut has exposed a dike north of Christie lake, and a few car lots of crushed quartz and stucco material were shipped during the summer.

Prospecting work has been done on two or three other deposits in the district but no shipments have yet been made.

Bancroft Area

Mining and prospecting have been conducted during the year on about half a dozen spar properties in Monteagle township in the vicinity of Hybla station, some 8 miles north of Bancroft, and approximately 5,000 tons of spar have been shipped. About half this output came from the quarry of the Feldspar Mines Corporation, a subsidiary of the Pennsylvania Pulverizing Company.

The workings consist of a quarry some 200 feet long by 60 feet wide and 20 feet deep at the southwest face. This dike, although containing several belts of impurities and admixed quartz masses, yields a considerable quantity of clean spar, particularly at the southwest face, where the present workings are conducted. Several patches of pure green spar, known as amazonstone, have been mined, a carload of which has been shipped. The Company has an up-to-date steam hoisting and drilling plant.

On the adjoining lot the Verona Mining Company, which was a subsidiary of the Pennsylvania Feldspar Company, made considerable shipments of spar from the McDonald property, leased to them by W. A. Hawley of Toronto in 1919, since when about 15,000 tons have been shipped. The Company has now gone into liquidation, and the property was taken over at the end of the year by the Genesee Feldspar Company, who have re-started operations and have erected derricks and installed machinery. The spar body, which is on the top of a hill, appears to be of large extent, and although locally carrying the usual impurities and aggregates of smoky quartz, nevertheless contains large crystals of pure spar. The level entry quarry is some 400 feet long and in places 80 feet wide, but in the wider portions the country rock of black gneiss, which caps over part of the dike, has been considerably broken into.

A short distance from the above the Monteagle Feldspar Company operated the Watson property, but during the summer, after shipping a few car lots, the Company went out of business and was taken over by the Cleveland Feldspar and Products Company.

The spar body consists of a narrow dike running into the side of a valley. From the face of a small quarry a tunnel, some 120 feet in length has been driven, from which the spar was trammed out and dumped into a loading bin above the roadway that runs along the valley. A few prospect pits have been opened up on the top of the hill, exposing a fair grade of spar, which, however, would require careful sorting.

In all the above deposits crystals of the radium bearing mineral euxenite were found, particularly in the last mentioned dike.

Work has recently been started on a likely looking spar body on the farm of J. Thompson, a little to the north of the Feldspar Mines Corporation property.

Verona District

There are a large number of feldspar quarries in southern Frontenac county, particularly in the Verona district, from which at one time practically the whole Canadian output of the mineral was obtained. The Feldspar Quarries, Ltd., a subsidiary of the Dominion Feldspar Corporation, and the Gardner property, leased during the latter part of the year to W. G.

Treadwell, were the only two producers of any importance, both of which are situated in the north of Loughborough township. Approximately 3,700 tons of spar were shipped from the district during the year. A small portion of this consisted of material sorted out from old dumps. During the summer the former Company leased the property from W. A. Dillon and T. Craig who had previously shipped several hundred tons of spar.

Although the Feldspars, Limited, have shipped practically no ore from any of their properties, including the well known Richardson mine, nevertheless parts of the huge dumps have been sorted over, and some six or seven thousand tons are stated to be ready for shipment as soon as the railway transportation facilities, now under way, are completed. Preparations are also being made to sink on the extensions of the Richardson lens.

During the summer W. Gardner operated a small crushing and screening plant on his property and has shipped, besides crude spar, several hundred tons of stucco and chicken grit material.

The Frontenac Floor and Wall Tile Company, whose plant is at Kingston, has recently installed a feldspar grinding unit of about 1,200 tons a year capacity. The majority of the material that they grind, all of which comes from the Verona district, is used in the manufacture of their own tiles, which have proved very satisfactory and durable.

The Feldspar Milling Company have also ground some of the Verona spar as well as some from Buckingham. The Company's mill, which is situated in Toronto, consists of a chaser mill, screens and two 8 ft. x 6 ft. pebble mills. The power is supplied by electric motors.

Other Localities

The Canadian Non-Metallic Minerals, Ltd., has been operating a property at Ayles Lake, near Opeongo in Dickens tp., con. III, lot 12.

The work done consists of a level entry quarry leading from the railway track. The cutting is some 100 feet long and 40 feet wide with a 20-ft. high face. A spur track runs into the quarry, which enables direct loading into the cars. Several hundred tons of a dark pink spar have recently been shipped.

About two miles to the east another feldspar dike was operated by the company during 1921 and upon which machinery consisting of a compressor, hoist, boiler and dynamo, etc., is installed.

The Industrials Minerals Corporation, whose president is H. E. Harcourt of Toronto, have been shipping feldspar from quarries in Monmouth tp., and also in Dryden tp., in the Sudbury district. The former is of low grade, consisting almost entirely of graphic granite. The latter, leased from the McPhee Brothers, is in con. II, lot 9, near Coniston. The first shipment, which was made by the Corporation at the end of the year, consisted of high grade flesh pink spar, showing very few impurities.

The Wheeling Feldspar Company did a little work in their quarry on the north shore of Cecebe lake in Parry Sound county, Chapman tp., con. II, lot 26. This property was operated two years ago and the spar is now treated by means of a grinding and screening plant and then sold in the United States as stucco. The crushed material is shipped down the lake in a scow, thence to Burks Falls station, 9 miles to the east.

TABLE I

Canadian Feldspar Shipments During Last Ten Years ¹

Year	Quebec			Ontario			Dominion		
	Tons shipped	Value	Average price per ton F.O.B. cars	Tons shipped	Value	Average price per ton F.O.B. cars	Tons shipped	Value	Average price per ton F.O.B. cars
1913.....	74	\$ 1,554	\$ 21 00 ²	16,716	\$ 59,241	\$ 3 54	16,790	\$ 60,795	\$ 3 62
1914.....	98	2,156	22 50	17,962	68,668	3 82	18,060	70,824	3 92
1915.....	572	2,005	3 50	13,987	55,796	3 98.	14,559	57,801	3 97
1916.....	4,610	18,075	3 82	14,878	53,332	3 57	19,488	71,407	3 66
1917.....	1,188	8,204	6 87	18,274	81,622	4 47	19,462	89,826	4 62
1918.....	191	4,279	22 40 ²	18,591	108,449	5 80	18,782	112,728	6 06
1919.....	925	13,073	14 15 ²	13,754	73,158	5 32	14,679	86,231	5 85
1920.....	649	10,052	15 50 ²	37,224	270,843	7 28	37,873	280,895	7 45
1921.....	9,737	80,180	8 58	20,115	150,457	7 43	29,868	230,754 ³	7 73
1922 ⁴	12,672	114,235	9 00	15,800	113,850	7 20	28,472	228,085	8 00
Total....	30,698	253,013	.....	187,301	1,035,416	.....	217,952	1,289,346	.....

¹ From the "Mineral Production of Canada."² High price due to shipments of dental spar.³ Includes 16 tons valued at \$117 from Nova Scotia.⁴ Approximate; final statistics not yet published.

TABLE II

Feldspar Grinding Plants in Canada and in United States

Canada

Name of Company.

Feldspar Milling Co., 33 Richmond St. W., Toronto, Ont.

Frontenac Floor and Wall Tile Co., Kingston, Ont.

United States

Bedford Mining Co., Bedford, N.Y. Operating two mills at Bedford, N.Y., and grinding potash and soda feldspar from Westchester county, N.Y., exclusively.

Carolina Feldspar Co., Asheville, N.C. Operating a mill at Erwin, Tenn., and grinding North Carolina feldspar.

The Cleveland Feldspar and Products Company (late Monteagle Feldspar Corp.), 327 Union Bldg., Cleveland, Ohio. Operating their own mine in Canada and grind Canadian spar in Cleveland.

Climchfield Products Corporation, Erwin, Tenn. North Carolina spar.

Dominion Feldspar Corporation, Rochester, N.Y. Operating a mill at Genesee Dock, N.Y., and grinding Canadian feldspar exclusively. They also operate their own mine near Verona, Ont., under name of Feldspar Quarries, Ltd.

Erwin Feldspar Corporation, Erwin, Tenn. Operating a mill at Erwin, Tenn., and grinding North Carolina feldspar.

Eureka Flint and Spar Company, Trenton, N.J. Operating a mill at Trenton, N.J., and grinding Connecticut, New York, Canadian and North Carolina feldspar, both pure and blended.

Genesee Feldspar Co., Inc. (late Pennsylvania Feldspar Co.), Rochester, N.Y. Operating a mill at Genesee Docks, N.Y., which grinds Canadian spar, and a mill at Toughkenamon, Pa., which grinds Pennsylvania feldspar exclusively.

Golding Sons Company, Trenton, N.J. Operating mills at Trenton, N.J., Wilmington, Del., and East Liverpool, Ohio, and grinding Maine, Maryland, North Carolina and Canadian feldspar, both pure and blended.

Golding-Keene Company, Keene, N.H. Grinding New Hampshire spar.

TABLE II—*Concluded*Feldspar Grinding Plants in Canada and in United States—*Concluded*United States—*Concluded**Name of Company—Concluded*

- Howe, L. W., South Glastonbury, Conn. Operating mill at South Glastonbury, Conn., and grinding Connecticut feldspar exclusively.
- Maine Feldspar Company, Brunswick, Me. Operating mills at Topsham and Auburn, Me., and grinding Maine spars exclusively.
- The Maryland Flint and Feldspar Company, Bel Air, Md.
- Newell Mining and Pulverizing Company, Newell, W. Va.
- Product Sales Company, 306 Equitable Bldg., Baltimore, Md. Operating a mill at Baltimore and grinding Maryland feldspar.
- Potters Mining and Milling Company, East Liverpool, Ohio. Operating a mill at Loughlin, Ohio, and grinding Canadian and North Carolina feldspar.
- Pennsylvania Pulverizing Company (New York Feldspar Corp.), Rochester, N.Y. One of the largest grinders of Canadian feldspar.
- Rock Products Company, Nicholas Bldg., Toledo, Ohio. Operating a mill at Toledo and grinding feldspar from their own mine in Canada.
- Southern Spar and Mica Company, 322 Haywood Bldg., Asheville, N.C.
- Tidewater Feldspar Company, Middletown, Conn.
- Trenton Flint and Spar Company, Brunswick, Me. Operating a mill at Cathance, Me., and grinding Maine feldspar exclusively.
- Trenton Fireclay and Porcelain Company, Trenton, N.J.
- United States Feldspar Company, East Liverpool, Ohio.
- Wheeling Pulverizing Company, Wheeling, Va. Operating mill at Wheeling and used to grind Canadian spar.
- Williams, Jr., Carl, Erwin, Tenn.

TABLE III

Dental Spar Shipments Since 1910

Year	Tons shipped	Value	Average per ton
1910.....	90	\$ 1,800	20 00
1911.....	12	240	20 00
1912.....	100	2,000	20 00
1913.....	74	1,554	21 00
1914.....	98	2,156	22 50
1915.....	32	640	20 00
1916.....	145	2,900	20 00
1917.....	220	5,300	24 09
1918.....	136	4,004	29 40
1919.....	352	10,203	29 00
1920.....	176	6,670	37 90
1921.....	64	2,080	32 50
1922.....	180	3,946	21 90
Total.....	1,679	43,498	26 00

Up to 1917 the output was obtained from the Villeneuve mine, Labelle county, Villeneuve tp., I, 30, Quebec.

1917 to date, the output was obtained from Villeneuve Extension, Labelle county, Portland E. tp. IX, 3, Quebec, and Glen Almond spar from the Derry quarry.

TABLE IV
Canadian Feldspar Shippers (over 50 tons), 1922
QUEBEC

Shipper	Address	Name of Mine	Location of Property			Local Office	Representative, Superintendent or Manager, etc.
			County	Township	Concession or Range Lot		
O'Brien and Fowler.....	Ottawa, 114 Wellington	Derry.....	Labelle.....	Derry.....	I, 7	Glen Almond	N. B. Davis, Mgr.
Mahoney and Rich.....	Ottawa, 88 Bank St.....		"	"	II, 9	"	E. Brewer, Mine Supt.
Buckingham Feldspar Co.							
G. Pednaud.....	Buckingham.....	Villeneuve Extension	"	Buckingham..	XII, S $\frac{1}{2}$ 14	"	G. Pednaud
Bush-Winning.....	N.D. de la Salette.....			Portland E..	IX, E $\frac{1}{2}$ 3			N.D. de la Salette	Bush-Winning
ONTARIO							
S. H. Orser.....	Perth.....	Kirkham.....	Lanark.....	Bathurst.....	VII, 3	Perth.....	S. H. Orser
Rock Products.....	Toledo, Ohio, U.S.A....	W. J. Keays..	"	"	IX, 20, 21	"	V. M. Gettins, Supt. A. G. Minehart, Mgr.
A. M. Campbell.....	Perth, Box 30.....	H. Keays.....	"	"	IX, W $\frac{1}{2}$ 20	"	M. P. Powers, Supt. A. M. Campbell, Mgr.
S. H. Orser.....	"		"	"	IX, 20, N $\frac{1}{2}$ 21	"	S. H. Orser
Monteagle Feldspar Co..	Cleveland, Ohio, U.S.A.	Watson.....	Hastings.....	Monteagle...	VI, 22, 23	Hybla.....	C. C. Burket, Secy.
Cleveland Feldspar and Products Co.							
Verona Mining Co.....	Rochester, N. Y., U.S.A.	McDonald....	"	"	VII, 18	"	G. E. Worth, Mgr.
Genesee Feldspar Co.....	Lewistown, Pa., U.S.A.	Woodcox.....	"	"	VIII, 16, 17	"	R. H. Thompson, Mine Supt. E. O. Banker, Gen. Supt.
Feldspar Mines Corp.....							
Federal Feldspar, Ltd....	Ottawa, 46 Elgin St....		Frontenac...	Bedford.....	III, 25	Tichborne...	J. O'Toole, Supt. S. Fisher, Secy.
T. Craig.....	Verona.....		"	Portland.....	X, 3	Verona.....	T. Craig
Gardner and Treadwell..	Hartington.....	Holleford....	"	Loughborough	XI, 1	"	W. G. Gardner
Feldspar Quarries, Ltd...	Toronto, 60 Front St. E.	Imperial.....	"	"	XII, 1	"	W. H. Despard, Pres.
Can. Non-Metallic Minerals, Ltd.	Montreal, 207 St. James St.	Aylen Lake...	Nipissing....	Dickens.....	III, N $\frac{1}{2}$ 12, 13	Aylen Lake...	W. Johnson
Industrial Minerals Corp..	Toronto, Bank of Hamilton Bldg.		Haliburton...	Monmouth...	XIV, 29	Monmouth...	H. E. Harcourt
Industrial Minerals Corp..	Toronto, Bank of Hamilton Bldg.		Sudbury.....	Dryden.....	II, 9	Coniston....	H. E. Harcourt
Wheeling Feldspar Co....	Wheeling, Va., U.S.A....	Ceece Lake..	Parry Sound..	Chapman.....	II, 26	Burks Falls...	W. B. Woods

V

FLUORSPAR IN 1922

V. L. Eardley-Wilmot

During the year Canadian fluorspar production amounted to 4,503 tons, valued at \$102,138. In recent years practically all the fluorspar mined in Canada has come from the Rock Candy mine in British Columbia. In 1922 only 284 tons came from the Madoc district in Hastings county, Ontario, from which district in 1918 almost the entire Canadian output of 7,362 tons was won from some of the thirty, now dormant, mines.

Outside British Columbia the only two mines from which production was reported were the Wallbridge and McIllroy properties, and shipments from stock from the Perry mine, all in the Madoc district.

The Madoc fluorspar deposits mainly occur in veins occupying fault fissures in flat-lying beds of finely banded limestone and sandstone, and consist of pale green or yellow fluorspar, barite and calcite, intermixed in various proportions. The vein filling often occurs as a sand or gravel spar and a considerable proportion of the shipments during the year were in this form.

On the Wallbridge property in Madoc township, con. I, lot 1, the ore is very friable and is hoisted up a shaft which at the time of closing down was 55 feet deep. A platform has been erected at the shaft head upon which the ore is dumped, screened and hand picked. The larger lumps, after being washed by water in order to reveal the spar, are cobbled and further sorted. The fines go to waste.

The McIllroy mine in con. IV, lot 2, was operated for a few weeks by Mineral Products, Ltd. The old shaft was opened up, and material, mostly in the form of gravel spar, was shipped from the underground workings.

The Perry mine in Huntingdon township, con. VIII, lot 11, which is managed by Wm. Cross of Madoc, consists of extensive underground workings as well as several shafts along the strike of the vein for a distance of about 1,000 feet. The vein was first discovered in 1912 when the Grand Trunk railway was built, which exposed an outcrop, but little notice was taken of it at the time. No ore was mined during the year, but a few car loads were shipped from stocks.

The Madoc spar is used within the Dominion as a special flux for electric steel furnaces. The prices range from \$13 to \$15 per ton f.o.b. cars.

The Mines Branch at Ottawa has devoted considerable attention to the concentration of the Madoc fluorspar. Experiments in direct tabling, jigging, decrepitation, etc., were tried and rejected, and finally it was found that the best results were obtained by first calcining to slack the lime, and then tabling off the heavier barite. By this means a 95 per cent CaF_2 concentrate was produced.

The Rock Candy mine, owned by the Consolidated Mining and Smelting Company of Canada, is situated on Kennedy creek, a tributary of the north fork of the Kettle river, British Columbia. The nearest shipping point is Lynch Creek station, about 2 miles south of the concentrator.

The ore body, which outcrops on the side of a ravine, occurs on the almost vertical contact of an alkali syenite and a porphyry. The width of the deposit is very variable, being in some cases 140 feet wide, carrying veins of high grade fluorspar of a pale green colour. The vein matter consists mainly of quartz, while the occurrences of iron and copper sulphides are only in small segregations.

Mining has been carried out over a vertical distance of about 200 feet by means of three levels, which have been connected by raises and stopes. The most recent work consists of a series of drifts in the lower tunnel, the ore body being split by tongues of alkali syenite which have been utilized as pillars.

The mine is connected to the mill by an aerial tram of approximately two miles in length.

In concentrating the ore, advantage is taken of the fact that fluorspar when it is decrepitated splits up into minute fragments, while quartz is not so affected, so that after the heat treatment the products are merely screened to separate the fluorspar from its silica contents.

The Rock Candy mill flow sheet is as follows:—The ore is crushed in Blake crushers, screened over $\frac{1}{2}$ inch mesh, after which it passes through two sets of rolls and is then dried in a rotary dryer. The dried product passes over a series of impact screens from 8 to 15 mesh. The three sizes so produced are decrepitated in three separate 14 ft. x 3 ft. rotary kilns which make three revolutions per minute, at 1200° F. The 8-mesh products gives the best result, being under 2 per cent silica. The minus 15 is not decrepitated but regarded as a middlings product that passes over three vibrating tables in order to eliminate as much of the silica as possible. These table concentrates are dumped into the hot decrepitated products from the first two kilns in order to evaporate the moisture before screening. The decrepitated products are then separately screened. The combined smalls from the three kilns are sent to the shipping bins, while the oversize is rejected. These concentrates average 85 per cent CaF_2 and 6 per cent silica.

Although the mill was only operated for about four months during the year, 6,313 tons of ore were treated, and some of the rejects were put through the flotation plant at Trail. A total of 4,219 tons of high grade concentrates was produced, valued at \$22 to \$25 per ton. The material treated at Trail was converted into hydro-fluo-silicic acid used by the company in the process for the recovery of zinc.

H. E. Harcourt of Toronto has recently opened up a promising looking vein of deep purple fluorite in Haliburton county, Cardiff tp., con. XXI, lot 18, about 3 miles east of Wilberforce. No shipments have yet been made.

In the United States the main sources of supply come from Illinois and Kentucky. The new tariff of Sept. 1922 called for a duty of \$5.60 per ton into the States.

The main use of the mineral is in the steel industry, mainly as a neutralizing agent and to increase the fluidity of basic open-hearth slags. The main demand is for a washed gravel of 85 per cent CaF_2 not exceeding 5 per cent silica free from sulphides of lead, zinc and barium. High silica means adding more limestone to the charge thereby increasing the duration of the time of heat and consequent reduction of tonnage.

The average consumption of fluorspar is roughly 8 to 10 pounds per ton of steel.

Next to the steel industry, the greatest use for fluorspar is in the ceramic, glass and enameling trades, where the highest grade hand picked and ground spar is used. The mineral is somewhat extensively used in electrolytic lead, antimony, etc., smelters. Its use in foundries is once more increasing. As sodium fluoride it is used for preserving wood.

In the United States the proportionate consumption of fluorspar is approximately as follows:—

Steel ingots and castings 80 to 85 per cent; Glass and enameling 7 to 10 per cent; Hydrofluoric acid 5 to 6 per cent; Foundries 1 to 2 per cent; Miscellaneous 2 per cent.

The steel industry in the United States has been steadily improving throughout the past year and this has been reciprocated in Canada, so that the future prospect for the Canadian fluorspar industry should be considerably brighter than in the past.

Canadian Fluorspar Statistics During Last Five Years

	1918		1919		1920		1921		1922	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
<i>Production—</i>		\$		\$		\$		\$		\$
Ontario.....	7,187	150,779	3,425	59,281	3,758	68,475	116	1,744	284	3,905
British Columbia.....	175	5,250	1,638	38,556	7,477	171,971	5,403	134,523	4,219	98,233
Total.....	7,362	156,029	5,063	97,837	11,233	240,446	5,519	136,267	4,503	102,138
<i>Exports.....</i>			(a) 697	9,616	6,900	109,683	4,625	51,470	2,944	32,914
<i>Imports—</i>										
Hydro-fluosilicic acid.....	0.5	80	2.8	747	1.2	409	1.05	212	0.06	15
Fluorspar.....			(a) 8,273	84,702	6,812	113,818	3,867	43,752	4,980	73,343

(a) Last nine months.

VI

GRAPHITE IN CANADA, 1922

V. L. Eardley-Wilmot

The production of Canadian graphite experienced a marked decrease in 1918, due to the general reaction of business and an over-production during war years. The 1922 production of 650 tons is the lowest since 1908. Practically the whole of this output was produced by the Black Donald Graphite Co., Ltd., at Calabogie, Renfrew county, Ontario. During the year no ore was mined by that company, due to accumulated stocks of ore mined in 1919. Shipments of refined products since that date were the result of the treatment of these previously accumulated stocks of ore. Mining operations were conducted on a small scale by the Standard Graphite Company, at Guenette, Que., who mined and treated approximately 100 tons of ore, but made no shipments.

The Quebec Graphite Company, at Buckingham, Que., made some shipments of flake and manufactured products from stocks.

The Canadian market for flake graphite during the year was abnormally quiet. The ruling prices were extremely low, particularly for No. 1 and the lower grades, but the worst of the depression appears to have been reached about August, since which time there has been a gradual hardening in demand and a corresponding improvement in prices, which still continues.

The markets are to a certain extent governed by the productions from Ceylon and Madagascar. These countries have for the past few years been clearing up their enormous stocks produced during the war.

There was an increase in the Ceylon exports, but the stocks on January 1, 1923, amounted to about 15,000 tons, which shows a considerable reduction over the previous years, and prices have already stiffened up.

A continued demand for this material will necessitate the resumption of mining operations on the island, which have practically been at a standstill since 1918, due to over-production and lack of demand, which has caused extremely low selling prices that meant a heavy loss to the miners and producers. Ceylon importers are of the opinion that there will be a lapse of time before the mines are again operated on a large scale, and it is most likely that the graphite so produced will be marketed at a higher price than the after-war stocks that have mostly been sold at any price obtainable and much below the actual cost of production.

There was practically no production from Madagascar, but for the last three years about 6,000 tons annually have been exported from stocks. Madagascar flake is extensively used by the crucible makers in Great Britain, but in the United States it has not met with the same measure of popularity; hence comparatively little business was done in Madagascar graphite by the latter country, as crucible producers prefer Ceylon graphite.

There was a marked increase in the exports from Chosen, over 90 per cent of which was amorphous. Practically the whole of this latter material was shipped to Japan and was mostly re-exported from that country in the form of manufactured articles, particularly in the lead pencil industry.

About 35 per cent of the world's 1922 production came from Germany, this comparatively large output being mainly due to the depreciation of the mark which protected that country from strong foreign competition.

In the United States there was a slight increase in production, mainly due to the new tariff. There are practically no stocks of the domestic flake on hand at the mines, and during the year crystalline flake graphite was mined by three producers in Alabama, one in California, and one in Texas, while amorphous was mined by one company in Rhode Island and one in Nevada.

The following table gives the world's production of natural graphite for the last four years:¹

World's Production of Natural Graphite, 1919-1922

(In metric tons)

	1919	1920	1921	1922
United States (a)—				
Amorphous.....	3,065	4,258	1,671	(f) 1,996
Crystalline.....	3,668	4,369	540	(f) 839
Canada (a) (g).....	1,199	1,987	361	(f) 590
Mexico (c).....	4,995	3,319	3,088	1,993
Austria.....	8,265	11,543	13,280	(b) 11,650
Czechoslovakia.....	31,234	(b) 15,000	(b) 12,000	(b) 13,000
Germany.....	30,525	20,639	(b) 30,000	(b) 35,000
Italy.....	7,626	5,398	(f) 5,750	(f) 7,300
Spain.....	1,958	6,315	2,772	(d)
Ceylon (c).....	6,778	9,352	4,419	10,190
Japan.....	1,954	1,135	(e) 842	(b) 1,000
Chosen (c).....	12,945	18,259	8,015	13,352
Madagascar.....	4,983	4,000	Negligible	Negligible
Other countries.....	8,442	1,574	(d)	(d)
	127,637	107,058	(b) 85,000	(d) 102,000

(a) Shipments. (b) Estimated. (c) Exports. (d) No data. (e) Unofficial. (f) Preliminary. (g) See Dominion Bureau of Statistics, p. 39.

The average price quotations during the last half of 1922 were steady as follows, f.o.b., New York:—

Ceylon, per pound			Madagascar, per ton				Mexican and Korean per ton		American flake per pound
Lump, 1st grade	Chip	Dust	Amorphous			Flake 85%	Crude amorphous	Higher grades	F.O.B. mines
			75-78%	80%	81-84%				
cts. 3-8	cts. 4-4½	cts. 3½-3¾	\$ 39	\$ 46	\$ 50	\$ 50	\$ 15-35	\$ 45-50	cts. 4-6

At the beginning of the new year the quotations for Ceylon lump and chip each rose one cent.

To the above quotations should be added the recently passed tariff on graphite going into the United States, which is 20 per cent on crystalline (Ceylon and Canadian), 10 per cent on amorphous (Mexican, Korean and Canadian) and 1½ cents per pound on flake (Madagascar, Canadian, etc.).

CANADIAN GRAPHITE OPERATORS

The deposit owned by the Black Donald Graphite Co., Ltd., occurs on Whitefish Lake near Calabogie, con. III, lots 17 and 18, Brougham tp., Renfrew county, Ontario, and constitutes the richest graphite ore body on the North American continent.

¹"Eng. and Mg. Jour-Press," p. 976, June 2, 1923, by A. H. Redfield, U.S. Geol. Surv.

The country rock consists of a coarse limestone in which are interlaced bands of hornblende schist. The ore body itself has been subjected to extreme deformation and folding which in places assumes the nature of a blanket vein. This graphite ore is of a dense micro-crystalline structure, some parts of which are classed as amorphous, while other portions of the ore body are made up of scattered particles of crystalline.

The vein has been followed by inclined shafts and extensive workings under the lake for several hundred feet at a depth of 200 feet.

During the year no mining was done, but the supply of crude ore was drawn from large reserve stocks mined and accumulated soon after the cessation of the war. R. F. Bunting, the president, states that he has planned to commence mining operations in the spring of 1923 on the blanket vein which outcrops behind the mill and thus avoid having to dewater the main workings under the lake.

Seventeen hundred tons of crude ore from yard stocks were milled in the up-to-date concentrator at the plant, which consists of stamps, Callow oil flotation units, screens, settling tanks and dryers. The finishing department consists of buhr stones and screens whereby the material is finally classified into seven different products. The highest grade, No. 1, analyses 97 to 99 per cent graphitic carbon, and the lowest grade dust about 65 per cent. The mill feed varies between 55 and 65 per cent. The main output is in the form of dusts or plumbago, which are extensively used for foundry facings. Although the proportion of No. 1 is small, it is, on account of the quantity produced, quite considerable. It takes about 400 H.P. to operate the whole plant, which is obtained from the company's power house on the Madawaska river.

The property of the Standard Graphite Company, of Montreal, is located on ranges VI and VII, lots 27-30, Boyer tp., Labelle county, Quebec, two miles east of Guenette station, which is 143 miles north of Montreal. A spur line runs through the property.

The rocks consist of biotite gneiss, which shows the nearby influence of limestone, and are occasionally intersected by soda bearing pegmatite dikes. The whole region is somewhat distorted and metamorphosed. The ore zone itself has a considerable areal distribution, in which the graphite occurs as more or less continuous series of lenses of varying width which follow the general strike and contortions of the rocks in which they occur. Both the rocks and the type of graphite are typical of the majority of graphite deposits in the Buckingham district.

The main ore zone, to which the present workings are confined, shows a surface width of 8 feet of good ore, and outcrops along its strike for at least 200 feet. Besides this there are in the immediate vicinity a number of approximately parallel and narrow ore shoots of one to three feet in width. The main ore body has been stripped and quarried over about 100 feet.

The graphite, which carries an appreciable amount of mica, has in places penetrated several feet into the footwall, but is of low grade. The higher grade milling ore runs about 20 per cent graphitic carbon, which, with the exception of the Black Donald deposit, is considerably above the average of the Canadian graphite ores.

A concentrator has been erected on the property close to the railway spur, about a quarter of a mile from the workings, and consists of a Spearman film flotation unit which was run for a period of two months in the summer, when 100 tons were treated. Changes of management have, however, recently taken place, and the mill flow sheet is being altered and Callow oil flotation units are being installed. It was originally intended to obtain motive power from a lake 500 yards distant, but construction work on this has been temporarily abandoned.

The property is now being worked by E. L. Goyette, of the Finance and Industries, Ltd., Montreal, by an arrangement with the Standard Graphite Company.

In the Buckingham district no ore was mined or milled by the Quebec Graphite Company during the year, but material in the form of flake, foundry facings and lubricating graphite in tins was sold from stocks.

The old North American Graphite Co., Ltd., whose property is located eight miles west of Buckingham, has been reorganized. H. P. H. Brumell states that he intends to remodel the old concentrator (which was erected in 1895) and install a Callow oil flotation system using flat shallow cells. The mill feed runs between 10 and 12 per cent graphite.

Early in the year the Consolidated Graphite Company's property, seven miles north of Buckingham, was bought by J. H. Cameron of that town. The property includes the mine, concentrator with machinery, and several hundred tons of mixed concentrates.

The outlook for the domestic industry appears much brighter than in the past, more particularly for high grade dusts, or plumbago, rather than for flake and lower grades. It should nevertheless be borne in mind that an increase in the demand and price of graphite is liable to lead to increased production of both foreign and domestic material, and thus cause further competition.

Canadian Graphite Statistics for Last Three Years¹

	1920		1921		1922	
	Tons	Value	Tons	Value	Tons	Value
		\$		\$		\$
<i>Refined graphite shipments—</i>						
Flake.....	421	68,954	149	29,187	95	16,170
Dusts.....	1,769	96,663	788	36,675	555	19,454
Total.....	2,190	165,617	937	65,862	650	35,624
<i>Exports—</i>						
Concentrates—Plumbago and flake.	2,142	159,817	614	40,809	452	16,619
<i>Imports—</i>						
Plumbago—crucibles.....		(a)176,717		23,786		36,961
Plumbago—not ground or manufactured.....		4,352		4,141		1,007
Plumbago—ground and manufactured.....		102,568		47,463		47,095
Total imports.....		283,637		75,390		85,063

(a) Includes clay crucibles.

¹ Dominion Bureau of Statistics.

VII

TALC AND SOAPSTONE IN CANADA, 1922

V. L. Eardley-Wilmot

During the year there was a slight increase of talc production over 1921, but the output is still considerably below the normal. There were seven companies that reported activity, four of which were shippers. Seventy-five per cent of the 14,500 tons of talc mined in 1922 was mined by the Henderson Mines, Ltd., at Madoc, in Huntingdon tp., XIV, lot 14.

This mine has been in operation since 1899 and constitutes one of the world's important producers of superfine white foliated talc. The deposit occurs in a quartzose crystalline limestone of Grenville age, and has a width of 25 to 40 feet and is in the form of a flat horseshoe, due to the strata having been folded. The extent of the deposit is undetermined. The workings consist of a large open-cut and about 2,000 feet of driftings and cross-cuts, mainly on the 150 and 200 foot levels. During the year the new shaft was completed and connected by a cross-cut to the 200 foot level, also considerable drifting was done in an easterly direction from the end of the same level.

All the ore is hauled one mile by teams to the mill at Madoc station owned by Geo. H. Gillespie. The material goes through a series of grindings and screenings whereby three grades are produced, which are valued at \$9 to \$22 per ton according to grade.

The greater part of the remainder of the Canadian talc output was produced by the Asbestos Pulp Company, whose property, known as the Connolly mine, is on the adjacent lot east (lot 15) of the Henderson mine, and is a continuation of the same ore body.

The workings consist of about 1,500 feet of drifts and cross-cuts on four levels. During the year a new shaft 110 feet in depth was sunk at the east end of the workings and connected with an intermediate level, from which some cross-cutting to the north has been conducted in the nature of prospecting work. Considerable cross-cutting and drifting has also been carried out in a southerly direction from the west of the main shaft at the 185-foot level.

A mill was built on the property about six years ago by the Anglo-American Talc Corporation, and consists of the usual grinding and screening units, with the addition of an air float chamber lined with canvas.

The highest grade of refined talc from the Madoc district is used as talcum powder, while the other grades are used as fillers for the paper and rubber industries.

About a car lot of talc was mined by H. H. Wood at Mine Centre in the Rainy River district, Ontario. Crayons for metal workers and heat resisting and electrical insulators were manufactured by means of a sawing, lathing and baking process.

The Wabigoon Soapstone Company has opened up a deposit in Zealand township in the district of Kenora, Ontario.

The Megantic Mining Company did a little prospecting work at New Ireland, Megantic county, Quebec, and preparations are being made to install machinery during 1923.

It is of interest to note that some of the material from the soapstone deposits of the asbestos district is now being quarried and cut into bricks, which are being used as a lining for alkali recovery furnaces in paper-pulp mills. Although the production of these bricks so far has been very small, there is, nevertheless, an important consumption of the imported product, which may in future be supplied from within the Dominion.

In British Columbia two companies mined and shipped a few hundred tons of talc. The Canadian Talc and Silver Company did some development work during the late fall and commenced erecting a mill at Keefers P.O., in township XII, range 26.

A few car lots of ground talc were shipped to Vancouver and Victoria by the Eagle Talc and Mining Company, Ltd., from their deposit at Wolf creek, Victoria mining division, B.C.

Canadian Talc Statistics for the Last Five Years

	1918		1919		1920		1921 ¹		1922 ²	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
<i>Production—</i>		\$		\$		\$		\$		\$
Crude.....	12,772	47,494	12,243	49,074	11,820	48,939	}			
Refined.....	5,397	71,703	6,399	67,221	9,851	117,995				
Total.....	18,169	119,197	18,642	116,295	21,671	166,934	10,134	144,565	13,558	185,197
<i>Exports—</i>										
Crude.....		} 208,301		} 210,150		10,653	71	437	Nil	Nil
Refined.....						14,909	253,055	7,008	112,053	9,854	143,938
Total refined sold ²	15,903	222,167	15,927	235,000	19,610	303,738	10,063	144,128	13,058	182,697

¹Practically all refined talc.

²Product Canadian plants.

VIII

THE MOLYBDENUM SITUATION IN CANADA, 1922

V. L. Eardley-Wilmot

War requirements greatly stimulated the demand for molybdenite, and in Canada the maximum output was reached in 1918, when 34,000 tons of the ore were mined from which concentrates containing 189 tons of pure molybdenite were produced. The price of concentrates was controlled at \$1.09 per pound at Ottawa.

Although there has been no actual molybdenite production in Canada for the last three years, in 1922 the following companies reported a certain amount of activity in the way of further prospecting and constructional work, and are preparing for production in the near future:—

The Molybdenite Reduction Company, known as the Benjamin mine, in the Abitibi district, Quebec, L. N. Benjamin, Managing Director, 108 Laurier Ave. W., Montreal, Que.

St. Maurice Mines Company, on the Indian peninsula, Kewagama lake, in the same district as above, P. Geddes Grant, Director, 342 Madison Ave., New York city.

The United Molybdenum Corporation, known as the Joiner mine, at Wilberforce, Haliburton county, Ontario, W. E. Joiner, Director, 76 Sun Life Bldg., Toronto.

American Molybdenites, Ltd., three miles west of Joiner mine, W. J. L. McKay, Managing Director, 42 Yonge St. Arcade, Toronto.

The Indian Lake property, known as the Bain mine, west of the Gatineau, in Masham township, Quebec, H. H. Claudet, Manager, 363 Sparks St., Ottawa, Ont.

It is felt that one cause of the inactivity in the molybdenum industry is that the steel maker or consumer of the metal hesitates to make contracts until he is assured of his supply of the raw material, and the producer will not commence mining operations until he is assured of the disposal of his output and at a price satisfactory to him.

As compared to most other minerals, molybdenite deposits are scattered and of low grade, generally between one-half and one per cent, so that production costs per pound of high grade concentrates (85 to 90 per cent MoS_2) are high. The nominal market quotations of the mineral, particularly in Europe, are so low that the miner is not assured of profits and hesitates to commence producing. There are, however, a number of deposits in Canada from which a very considerable quantity of the mineral can be produced as soon as the demand and market prices improve.

In the recent United States tariff revision the following amendment was passed by the 67th Congress, in August 1922. The clauses of this tariff affecting molybdenum and molybdenum products are as follows:—

Molybdenum ore or concentrates, 35 cents per pound on the metallic molybdenum contained therein.

Ferro-molybdenum, metallic molybdenum, molybdenum powder, calcium molybdate and all other compounds and alloys of molybdenum, 50 cents per pound on the molybdenum contained therein and 15 per centum ad valorem.

The duty on an 85 per cent MoS_2 concentrate is, therefore, approximately 18 cents per pound.

The most recent New York quotations are 65 to 75 cents per pound of MoS_2 in an 85 per cent MoS_2 concentrate, including duty.

In the United States this alloy is produced by at least a dozen different firms.

Small quantities of molybdic acid have been produced by J. W. Evans, manager of the Tivani Electric Steel Company, in his laboratories at Belleville, Ont. This company during the war produced considerable quantities of ferro-molybdenum, and it is understood that they are ready to continue the manufacture of this alloy as soon as the demand arises.

A number of automobile firms in the United States are using molybdenum in parts of their cars, and recently a molybdenum steel shovel and molybdenum rolls have been put on the market for which highly satisfactory results are claimed.

The present day uses are mainly for what are known as low molybdenum alloy steels for structural and engineering purposes, in which only one-quarter of one per cent of molybdenum is used in combination with other alloying metals.

Several Canadian producers of the mineral realize the future possibilities and are making preparations for production, but for the reasons already stated they require further stimulation from the consumers.

IX

BITUMINOUS SANDS OF NORTHERN ALBERTA

S. C. Ellis

An extensive deposit of bituminous sand—commonly though incorrectly referred to as "tar sand"—outcrops at frequent intervals along the Athabaska river and its tributaries through an aggregate distance of approximately 200 miles, in the district centering about McMurray. Unfortunately a great deal of misconception regarding the character and extent of this deposit has arisen through exaggerated and otherwise incorrect statements by uninformed people.

The bituminous sand of Alberta is at present attracting the attention of responsible persons. This may be attributed, in part, to the recent completion of the Alberta and Great Waterways railway to the provisional head of navigation at Waterways, and, in part, to legitimate publicity given the deposit through the Mines Branch.

The area represented by outcrops, and presumably underlain by bituminous sand, may be arbitrarily defined as lying between W. long. 110° and 113° and between N. lat. 56° and 58°. All exposures within this area lie within a radius of 60 miles of McMurray. Upwards of 250 exposures, all of which represent portions of one continuous deposit, have been examined and measured. The direct distance in a north and south direction through which outcrops have been noted is approximately 110 miles, and that from east to west approximately 80 miles.

Certain of the above outcrops represent portions of a deposit that, with reasonably favourable market and transportation conditions, will eventually prove commercially valuable. But it is also true that a large portion of the area underlain by bituminous sand must be considered as of very doubtful economic value. This statement is based on a consideration of controlling factors such as thickness, character, and possibility of disposing of overburden, transportation, percentage of associated bitumen and uniformity of material. Each of these factors should be given careful and detailed study in considering commercial development in any portion of the McMurray district. Other important, though subsidiary factors, are fuel, labour, water supply, and climatic conditions.

Associated with the bituminous sand are occasional small seepages of bitumen, which originate in the richer beds, and are locally known as tar springs. None of these is of sufficient extent to be considered of economic importance, nor can they be considered as indicating the probable presence of a petroleum pool within the area under consideration.

The outstanding features presented by the McMurray deposit may be briefly stated as follows:—

(a) That the deposit represents the largest known occurrence of solid asphaltic material.

(b) That the deposit is, as yet, totally undeveloped.

(c) That at the present time practically all asphaltic materials used in Canada are imported from foreign countries.

Three possible lines along which the bituminous sand may be commercially developed are suggested:—

1. That the crude material may be used in the surfacing of streets and highways. In 1915, in order to demonstrate the merits of the material, the writer designed and laid in Edmonton, Alberta, areas of standard sheet asphalt, bitulithic and bituminous concrete. This effort marked the first attempt to commercially utilize the bituminous sand as a paving material, and the result was entirely satisfactory. The extent to which the crude material may be used for such purposes will be largely determined by freight charges. In competition with imported asphalts and under existing freight rates the permissible freight haul for crude bituminous sand will probably be limited to about 625 miles.

2. That the bitumen, which is of a high grade, be separated from the sand aggregate, and utilized for a number of recognized purposes for which such material is well adapted.

The results of the writer's research work, in 1916, in connection with the separation problem, although encouraging, are as yet not conclusive. This work included separation by means of various solvents, by the use of centrifuges, by the use of water heated under pressures ranging up to 92 lbs. per sq. inch, followed by filtration, and by the use of flotation cells. Results from the use of flotation, using heated water to which certain reagents had been added, appeared to give the most favourable results.

3. That the crude bituminous sand be retorted with a recovery of crude petroleum. Such a distillation was made by the writer in 1915, using a retort with a capacity of 25 pounds crude bituminous sand. The crude petroleum derived in this manner was then fractionally distilled and

the various distillates refined. Possibilities of such distillation on a commercial scale have yet to be determined, but there are strong indications that the associated hydrocarbons can be successfully recovered from the bituminous sand in this manner.

It has been recognized for many years that large commercial development of the bituminous sand will depend on the successful recovery—either by separation or distillation—of the associated hydrocarbons. Such a recovery presents a problem which is apparently not more difficult than many metallurgical problems which have already been successfully solved. The problem will be solved only by those methods which have been successfully applied in metallurgical work—intelligent research, mechanically sound design, and careful, correlated experimentation.

Successful commercial development will depend on making no false moves during initial stages of development, and in having no "lost motion" in subsequent operations. Consequently, as a preliminary step every effort should be made to secure the most complete information possible regarding the deposits.

CHEMICAL DIVISION

I

SOME CANADIAN FOSSIL RESINS

R. T. Elworthy

Fossil resins have been known to exist in certain districts in western Canada since the earliest explorations of prospectors and geologists. Results of the examination of samples from the north Saskatchewan river, from Peace river and from the Nechako river south of Fort Fraser, B.C., were recorded in the report of the Geological Survey for 1876-77, by Dr. Harrington. Other localities where such fossil resins have been found, usually associated with lignites, are the Queen Charlotte Islands, B.C., in Saskatchewan, the Francis river in the Yukon, and in many parts of British Columbia.

Recently a considerable quantity of fossil resin, which was thought to be amber, was recognized in the waste dumps at Coalmont collieries, Coalmont, B.C. In view of the possibilities if it proved to be amber, an investigation of the material and of methods of separation from the coal was carried out in the Mines Department.

This report describes the results of the work undertaken in the Chemical Division, on the physical and chemical properties of this resin, in which the writer was ably assisted by R. J. Offord, Sr. Lab. Asst. Methods of separation from the coal are described in the Ore Dressing Division report.

A sample of fossil resin from Cedar lake, Manitoba, was also examined. This came from the same locality as that reported on by Dr. Harrington in 1901, and proved to vary little from the material studied at that time.¹

Tests were also made to determine the possibility of their industrial utilization.

For purposes of comparison a short account of amber and its properties precedes the description of the laboratory investigation.

AMBER AND ITS PROPERTIES

Amber is a hard fossil resin, varying in colour from lemon yellow to deep brown, sometimes transparent but usually translucent or opaque. It was prized among the ancients as a material for making personal ornaments and was of interest to the early philosophers on account of its property of becoming electrified by rubbing, which gave it the power of electrical attraction. The oil obtained by the destructive distillation of amber was valued as a perfume. The chief source of the world's supply of amber has been the shores of the Baltic, especially from mines along the coast of East Prussia.

The mineral occurs in nodules disseminated in clay of the Cretaceous formation or associated with lignite, and when liberated by the action of the waves, is washed up on the sea shores, where it is collected by hand. Later developments led to the digging of mines, some even under the sea, and to the installation of dredging and washing machinery. The

¹ Harrington, Am. Jour. Sc., 1831, Vol. 42.

production of the material is now a government monopoly and thousands of pounds were produced annually before the war. The chief use was in the manufacture of beads and ornaments and for pipe stems and cigarette holders. Years ago it was highly prized as the basis of varnishes, but it has been displaced by the cheaper eastern copals.

Other varieties of fossil resins have been found in Germany, Austria, Russia, Poland, India, Burma, Japan and Canada. Mineralogists have endeavoured to classify these separate occurrences. Succinite, retinite, gedanite, glessite, stantienite, backerite, chemawinite, etc., are a few of the species described. It is the usual practice to apply the name amber to the particular variety succinite, which is the chief material obtained in Prussia. It differs from the other varieties in its higher yield of succinic acid when it is destructively distilled. In view of the complex nature of these fossil substances, which have been formed from balsams and resins subjected to age-long processes of condensation and volatilization, constancy of composition and identity of properties such as is found in the mineral kingdom cannot be expected.

Although the physical properties and analytical constants have been determined for many of the fossil resins, comparatively little work has been done in the investigation of the chemical nature of the compounds composing them. The outstanding investigator is Prof. A. Tschirch¹, who has shown that the chief components of Prussian amber are free succinoabietic acid, esters of this acid and succino-resene, a substance of unknown constitution. The difficulties of separating, identifying and determining the constituents of these resins are considerable.

THE COALMONT FOSSIL RESIN

Occurrence.—The material subjected to examination in the laboratories of the Mines Branch came from the Coalmont collieries, Coalmont, B.C., where it occurs associated with the lower grade coal close to the slate contact of the coal seams. It was first observed in the waste dumps. The material is found in the coal in thin seams about a quarter of an inch thick, or as isolated fragments. Pieces larger in diameter than one-fourth of an inch are seldom present. For complete separation the coal has to be crushed considerably smaller than this mesh. The small size of the resin particles thus obtained is one of the handicaps in its commercial utilization.

The material used for the following tests was the product recovered by separation from four hundred pounds of the coal in the Ore Dressing Laboratories during the progress of concentration tests carried out by the division in their experiments.

THE CEDAR LAKE RESIN

This material was provided by Messrs. J. T. Donald Co., of Montreal, and was part of a sample obtained from Saskatchewan by Mr. J. Kemp of Montreal. It was collected from the shores of Cedar lake on the main Saskatchewan river, and like the earlier occurrences reported contained much debris and fragments of wood.²

¹ A. Tschirch. *Harze und Harsebehalter*. Leipsig. 1906.
² J. B. Tyrell, G.S.C., 1890-91, Part E.

EXAMINATION OF PHYSICAL PROPERTIES

Appearance.—The pieces of Coalmont resin, separated from the coal, are irregular in shape with no marked cleavage lines. The material is brittle and breaks with a conchoidal fracture. The colour varies from light lemon yellow through all shades of brown to dark green and even black. Most pieces are transparent to translucent; the darker pieces are opaque. A light green fluorescence is often noticeable.

The Cedar Lake material is brown and more uniform in colour. The particles vary in size from one-tenth to one-half inch in diameter, and having been subjected to the action of the waves and weather are more rounded and regular in shape.

Hardness.—The hardness of pieces of Coalmont resin varies between two and three. Most fragments will scratch gypsum (hardness 2) but not calcite (hardness 3). The Cedar Lake specimens gave similar results.

The hardness of amber is given as 2 to 2.5.

Specific Gravity.—Determinations were made by weighing and by ascertaining the densities of solutions in which pieces just floated. The results for different pieces of Coalmont resin varied considerably. The limits were 1.031 to 1.168. The Cedar Lake material gave similar results. This variation is due chiefly to occluded gas bubbles and is common to substances of this nature. The specific gravity of Prussian amber is given by Dana (Descriptive Mineralogy, p. 1002) as 1.050 to 1.096.

Similar tests on pieces of the coal from which the Coalmont resin had been separated gave 1.308 to 1.313, showing much less difference between individual fragments.

TESTS ON THE WASTE COAL FROM COALMONT WHICH CONTAINED
THE FOSSIL RESIN

It was necessary to find the amount of resin in the coal and to determine the size to which it would be necessary to crush it in order to free the greater part of the resin from adhering coal.

METHODS OF ANALYSIS

Two methods were tried to determine the amounts of resin and coal in the samples at different stages of treatment.

Counting Method

The first method used was to count the number of pieces of resin and of coal in a representative sample of uniformly sized particles, under the microscope.

A portion of the sample was spread on a slide on which had been engraved with a diamond a checker board of small squares. Using a combination of objective and eyepiece, which gave a magnification of 25, with transmitted light, the particles of coal and resin were sharply differentiated, and if not spread too thickly could be readily counted.

Two slides were used, one with 25 squares, each one-tenth inch size, best for particles between 28 and 100 mesh, and one with 15 squares, each of 5 mm. size for particles 10 to 28 mesh.

The following example shows the method of working:—

Counts	Resin	Coal	Per cent by volume		Per cent by weight	
			Resin	Coal	Resin	Coal
(1.) 20 squares.....	205	53	79.5	20.5	76.4	23.6
(2.) 20 ".....	143	37	79.5	20.5	76.4	23.6
(3.) 20 ".....	263	91	74.3	25.7	70.6	29.4
(4.) 20 ".....	200	56	78.2	21.8	74.9	25.1
Mean.....			77.9	22.1	74.5	25.5

The weights were calculated by assuming the particles counted to be of equal volume and by multiplying respectively by 1.08 sp. gr. of resin and 1.30 sp. gr. of coal. This mixture was artificially made up of 78.5 gm. amber and 21.5 gm. coal. The agreement is fair.

Other tests were made on mixtures containing less resin, both by counting and by actually separating the amber and coal mechanically and weighing the portions thus separated.

	-20 and +28 mesh		-28 and +35 mesh	
	Coal	Amber	Coal	Amber
By separation and weighing.....	98.1	1.9	98.5	1.5
By counting.....	97.7	2.3	97.4	2.6

The method is only suitable for particles between about 20 and 65 mesh.

Flotation Method

Experiments with solutions of salts such as sodium chloride and calcium chloride of specific gravity about 1.10 to 1.20 showed that clean separation of the coal and resin could be made by shaking up known weight of the mixtures with such solutions, allowing them to stand and then removing the floating resin or the sunken coal.

For samples smaller than 20 mesh a separatory funnel served well. Five to fifty grams of the mixture was placed in the funnel, and 50-100 c.c. calcium chloride solution, sp. gr. 1.20 added. The funnel was well shaken for several minutes to remove all air bubbles on the particles, and then left from one to five hours for the coal particles to settle, the time depending on the size of the particles. The coal was then run off through the stop cock, and usually more solution added to the residue and the mixture again shaken up and left. Two or three such treatments gave almost complete separations. The two portions were then filtered, well washed, dried and weighed and the proportions calculated.

For larger mesh samples, a pear shaped glass vessel closed at the end by a rubber tube and clip made it easy to run off the larger pieces. This method is more accurate, though not quite as rapid, as the counting method.

ESTIMATION OF AMOUNT OF RESIN IN HEAD SAMPLE

A representative 100 gm. sample of the coal was taken and the amount of resin determined by the methods just described. The weight of resin separated was 1.72 gm.

The screen analysis, described in the next section, gives the range sizes of the pieces in this sample.

To determine the effect of crushing to a smaller size some of the sample was ground to pass 100 mesh, but not 150, and the resin content then determined. Separation by floating in calcium chloride solution was not readily attained, and a number of treatments were necessary to obtain a good product. From 25 gms. 0.493 gm. was recovered equal to 1.96 per cent. Crushing to this small size would not be practical in a commercial separation process.

SCREEN ANALYSIS OF HEAD SAMPLE

Two hundred grams of the head sample as received from the ore dressing plant and as used in flotation experiments was shaken in a series of Tyler standard screens in a mechanical shaker with the following results:

Screen scale ratio, 1.414.

Openings			Diameter wire inches	Weights		
Inches	Millimeters	Mesh		Sample weights	Per cent	Per cent cumulative weights
0.065	1.651	10	0.035	79.85	39.92	39.92
0.046	1.168	14	0.025	20.70	10.35	50.27
0.0328	0.833	20	0.0172	19.20	9.60	59.87
0.0232	0.589	28	0.0125	17.85	8.92	68.79
0.0164	0.417	35	0.0122	13.65	6.82	75.61
0.0116	0.295	48	0.0092	12.90	6.45	82.06
0.0082	0.208	65	0.0072	8.95	4.48	86.54
0.0058	0.147	100	0.0042	8.35	4.18	91.72
0.0041	0.104	150	0.0026	2.75	1.37	92.09
0.0029	0.074	200	0.0021	6.50	3.25	95.34
0.0029	0.074	200	0.0021	8.40	4.20	99.54

ESTIMATE OF RESIN IN EACH SCREEN SIZE OBTAINED IN THE SCREEN ANALYSIS

The eleven fractions of the 200 gm. head sample used on the screen analysis were then analysed for their content of resin. The fractions staying on 10 and 14 mesh were analysed by mechanical separation of the resin and weighing. The estimation of the resin content of the finer mesh samples was carried out by the flotation method.

The following results were obtained:—

Mesh	Opening millimeters	Sample weight	Per cent	Weight	Per cent
10.....	1.651	79.85	39.92	0.73	0.91
14.....	1.168	20.70	10.35	0.16	0.77
20.....	0.833	19.20	9.60	0.36	1.50
28.....	0.589	17.85	8.92	0.27	1.51
35.....	0.417	13.65	6.82	0.34	2.5
48.....	0.295	12.90	6.45	0.24	1.9
65.....	0.208	8.95	4.48	0.33	3.7
100.....	0.147	8.35	4.18	0.40	4.8
150.....	0.104	2.75	1.37	0.09	3.9
200.....	0.074	6.50	3.25	0.24	3.7
200.....	0.074	8.40	4.20	0.08	1.0
		199.10		3.24	

=1.63 per cent

This checks well with the results obtained by straight flotation 1.72 per cent.

As might be expected more resin is found in the smaller mesh samples as there is more chance of a greater number of pieces being present, free from attached coal when they will float.

THE GRADING OF THE RESIN BY MEANS OF SOLUTIONS OF
VARIOUS DENSITIES

On account of the considerable range of specific gravity of the resin it seemed of interest to see what the result would be from treating a quantity of the pure product with solutions of different densities. For this purpose 20 gms. of resin free from coal and varying in size from 20 mesh to 65 mesh was treated with the following solutions and that which floated was separated and weighed. The table shows the percentage floating in each solution and the cumulative percentage:—

	Weight	Per cent	Total floating per cent
(a) Floats on distilled water sp. gr. 1.00.....	0.0396	0.19	0.19
(b) " solution " " 1.03.....	0.7868	3.93	4.12
(c) " " " " 1.05.....	7.1304	35.65	29.77
(d) " " " " 1.08.....	3.9357	19.68	59.45
(e) " " " " 1.10.....	2.1193	10.60	70.05
(f) " " " " 1.15.....	3.0232	15.10	85.15
(g) " " " " 1.20.....	0.8345	4.16	89.31
(h) Residue sinks " " 1.20.....	0.7842	3.92	
Lost in separations.....	1.3493	6.77	
	20.0000	100.00	

These figures well illustrate the variation in specific gravity of the resin. When the separate portions *b*, *c*, *d*, etc., were compared a very satisfactory gradation in colour was noted. Although *b* was not wholly free from dark particles the general colour was light brown. Portion *d* was perceptibly darker than *c* and lighter than *e*. There was little difference between *e*, *f* and *g*.

Larger quantities of the resin have been separated into three grades in this way:—

Grade 1. Floats on solution sp. gr. 1.03.

Grade 2. Floats on sp. gr. 1.09 and sinks in sp. gr. 1.03.

Grade 3. Sinks in sp. gr. 1.09.

The difference in colour and transparency is very marked. It is evident that this would serve as a commercial means of grading the product. With narrower limits of density even better classification would be possible.

SOLUTIONS FOR FLOTATION AND GRADING

The following table gives the specific gravities of various strength solutions of some common soluble salts:—

Grams substance in 100 gm. solution.

—	2	4	6	8	10	12	14	16	18	20	22	24	26	35	45
Sodium chloride.....	.011	.025	.039	.053	.068	.083	.099	.114	.130	.146	.164	.181	.197*		
Sodium sulphate.....	.016	.035	.053	.072	.091	.110	.130	.145*	.....	.....	.....	.....	.....
Magnesium sulphate..	.018	.039	.060	.081	.103	.125	.148	.170	.194	.217	.242	.266	.292*		
Calcium chloride.....	.014	.031	.048	.065	.082	.100	.118	.137	.166	.175	.196	.214	.235	.329	.442*

*Saturation point at 20° C.

These figures are the decimal part of the value for the specific gravity. The deposits of alkali salts now under investigation in the west might prove a cheap source of sodium and magnesium sulphates for local use.

Although there is not a very great difference between the specific gravity of the same percentage solution of sodium chloride and calcium chloride, the percentage of saturation is very much less in the case of the calcium chloride on account of its greater solubility.

The practical advantage of this is that solutions of 10-15 per cent of calcium chloride when spilt or splashed will crystallize less readily than 10-15 per cent sodium chloride and would be cleaner to work with. On the other hand sodium chloride is cheaper (\$10-15 per ton) than calcium chloride (\$20-25 per ton).

CHEMICAL PROPERTIES

In the following paragraphs the results of the determinations of the various analytical constants are reported, especially with a view to comparing the fossil resins with amber. No separations of the constituents or attempts to determine the constitution have yet been made.

Softening and Melting Points

Prussian amber begins to soften at about 150° C. at atmospheric pressure. Various figures have been reported for the melting point.

Authority	Reference	Melting point °C.
Thorpe.....	Dictionary of Applied Chemistry, page 183, Vol. I, 1921.....	350-375
M. B. Blackler.....	Allen's Commercial Organic Analysis, page 19, Vol. IV, 1915.....	287
Livache and McIntosh.....	The Manufacture of Varnish and Kindred Industries, page 134, Vol. II, 1920.....	250-300
Morrell and de Waele.....	Rubber, Resins, Paints and Varnishes, page 86, 1921.	280-315

The following table gives the results obtained with the Coalmont resin:—

Weight	Size	Softens °C.	Melting point °C.	Oil distilled per cent by weight
(a) 5 gm.....	10 mesh	180	250-270	76
(b) 25 ".....	8-35 "	200	270-297	60

A sample of Prussian amber, treated in the same way, gave:—

(c) 10 gm.....		160	260	
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The results of a similar test on the Cedar Lake resin were:—

(d) 25 gm.....	3-10 mesh	120	230-240	23.6
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The Products of Distillation

A number of specimens of different samples of amber, obtained from various sources, as well as the Cedar Lake and Coalmont resins, were subjected to destructive distillation.

In the case of amber the initial products are water and a light lemon yellow coloured oil. As the temperature rises the oily distillate becomes darker in colour. The vapours have a characteristic odour.

The Coalmont and the Cedar Lake resins gave very similar results though less water was collected. The oils closely resembled amber oil. The Coalmont resin oil had a specific gravity of 0.939 at 20°C. It was readily soluble in ether, chloroform and carbon tetrachloride, but only partially soluble in absolute alcohol. It decolorized a solution of bromine in carbon tetrachloride, showing it to be unsaturated.

It formed an oily nitro compound on nitrating in the usual way. Alkalies darkened and resinified it. On redistillation of the crude distillate three fractions, 140-180°C., 280-310°C., and 350-370°C., were obtained, the first light yellow, the second pale green, and the third brown in colour. All the distillates darkened slowly on standing in closed vessels and very much more rapidly when exposed to the air. A dark brown resinous residue forming 20 per cent of the original oil remained after distillation. It was soluble in turpentine and in gasoline.

When distillation was carried to completion, the residue was a black tarry substance only slightly soluble in turpentine and linseed oil. Distillation yielded about 70 per cent of the resin as oil. On the other hand heated to about 300°C., when it is well molten as it would be in the process of varnish manufacture, the resin lost about 12 per cent of its weight. This figure agrees¹ with the usual loss noted in running ordinary varnish gums such as Kauri and Zanzibar.

¹ H. A. Gardiner. Fume control in the varnish industry. Chap. II, Papers on Paint and Varnish. Washington, 1920.

The Succinic Acid Content of the Resin

A sample of 50 grams of amber was heated in a distillation flask and the products of reaction collected. The water was separated from the oil by filtration, and, on evaporating, a mass of crystals remained. These were purified by recrystallization from absolute alcohol and weighed 2.1 gm., equal to 4.2 per cent of the amber. Tests confirmed that the material was succinic acid.

Several samples of the Coalmont resin were treated similarly. The aqueous portion of the distillate had an acid reaction and gave faint indications of succinic acid, but on evaporating only a resinous material remained there not being sufficient succinic acid to determine quantitatively. The Cedar Lake resin gave similar results.

The Action of Solvents

Most fossil resins are only slightly soluble in the usual solvents, and the Coalmont and Cedar Lake resins are no exception to this.

The method used to determine solubility was as follows:

A known weight of resin powdered to pass 100 mesh screen was placed in a gooch crucible previously prepared with a mat of filter paper and weighed. The crucible was suspended in the wide neck of a special flask fitted with a reflux condenser and containing 50 c.c. solvent. The flask was placed on a sand bath and the resin subjected to the boiling solvent for several hours. The crucible was then dried and weighed, and the loss in weight calculated. The solvent was also evaporated to dryness and the residue thus obtained weighed. The two results gave fairly coincident figures.

The following are the results obtained:—

Solvent	Per cent soluble		
	Coalmont resin	Cedar Lake ¹ resin	Prussian amber
	Per cent	Per cent	Per cent
Absolute alcohol.....	8.7	21.0	14.3
Ether.....	5.0	24.8	18.8
Acetone.....	10.8	.....	23.3
Chloroform.....	38.4	.....	17.3
Carbon tetrachloride.....	7.3	.....	11.5
Benzene.....	38.4	.....	21.2
Petroleum ether.....	5.1	.....	.....
Pyridine.....	51.8	.....	.....
Selenium oxychloride.....	partly soluble	.....	.....

As in the case of amber and the varnish copals, the Canadian resins were only completely soluble in solvents after they had been melted and had lost about 25 per cent of their weight. Both varnishes were soluble in linseed oil and turpentine after being heated to 300°C., as amber is.

¹Harrington. Amer. Jour. Sci. 1891, Vol. 42, p. 332.

Saponification Value

Samples of the Coalmont resin were boiled with 0.5 N alcoholic potash in a flask fitted with reflux condenser, and the amount of alkali required to saponify the esters present ascertained.

It was found that 1 gm. of the resin took 75 mgm. potassium hydroxide for saponification. Similar figures¹ for Prussian amber are 86.8, 74.5, 91.1 and 115.

Iodine Value

The iodine value, a measure of unsaturation of the material, was determined by Hubl's process.² Owing to the incomplete solubility of the resin in chloroform the results were not altogether satisfactory. The mean of several experiments gave an iodine value of 41.3 (gms. iodine required to combine with 100 gm. resin).

The corresponding value for Prussian amber² is 69.4.

Ultimate Analysis

Neither sulphur nor nitrogen could be detected in the Coalmont fossil resin, although the associated coal contained both elements. Sulphur was present in the Cedar Lake sample.

A trace of this substance is reported in most specimens of amber.

The following table gives the results obtained from combustion analyses of the Coalmont resin and includes figures for other varieties of fossil resins:—

Material	Carbon	Hydrogen	Oxygen	Ash	Ratio C : H
Coalmont fossil resin—					
(a) Air dried sample, average grade.....					
(I).....	76.40	10.19	10.66	2.75	7.17
(II).....	76.60	11.02	7.78	4.60	6.95
(b) Selected clear pieces, average.....					
(I).....	80.01	10.44	7.95	0.80	7.82
(II).....	79.80	10.11	9.13	0.96	7.89
Cedar Lake ³ material dried over H ₂ SO ₄ in vacuo.....					
(I).....	80.01	10.37	9.53	0.09	7.71
(II).....	79.91	10.55	9.45	0.09	7.57
Prussian amber.....	78.82	10.23	10.95	.....	7.71

These results show the Coalmont fossil resin and the Cedar Lake material to have a very similar composition to Prussian amber.

Analysis of the coal associated with the Coalmont resin gave the following results:—

Carbon	Hydrogen	Oxygen	Sulphur	Nitrogen	Ash
59.00	4.55	23.11	1.82	1.07	10.45 per cent

The proximate analysis was:—

Moisture	Ash	Volatile	Fixed carbon
3.48	10.45	35.06	51.01

¹ K. Diesterich. Analysis of Resins, Balsams and Gum Resins, pp. 139-140. Scott Greenwood, London, 1920.

² Loc. cit.

³ Analyses by Dr. Harrington. Amer. Jour. Sci. 1891, Vol. 42, p. 332.

THE POSSIBLE INDUSTRIAL USES OF THE RESINS

For Varnish Manufacture

Several samples of varnish were made up in the laboratory according to prescribed recipes by melting samples of each of the resins, adding hot boiled linseed oil and small quantities of litharge as a drier, and thinning with spirits of turpentine. After filtering and leaving for some time these were tested and compared with some typical commercial varnishes. They gave very satisfactory results, drying in the usual time, and resulting in lustrous and hard surfaces. The chief disadvantage was the rather dark colour. Samples of the graded resins have been submitted to various varnish manufacturers, though unfortunately not in sufficient quantity for plant tests to be made. Their opinions have been without exception, that although they would undoubtedly make good varnishes, they could not compete with the large sized and much paler copals such as Zanzibar, Kauri, Manila and Congo gums. One has only to see these resins contrasted with the Canadian samples to be equally convinced. The disadvantages are their small size and their comparatively dark colour, especially evident when they are heated.

The greatest demand is for pale varnishes and the highest price is obtained for large sized, pale and clear resins. For the cheaper and dark varnishes Kauri scrapings and dust can be obtained for a few cents per lb. and much rosin is also used. It is only with these materials that the Coalmont and the Cedar Lake resins could compete, and even then it would be difficult to convince the varnish makers that the harder Canadian resins are superior.

The Oil obtained by Distillation

There is very little use for amber oil. Similarly it would be difficult to find uses for the oil obtained by distillation of the Coalmont and the Cedar Lake resins. Its property of darkening on exposure to light and air make it unsuitable for most purposes. It might be used to add to cements, artificial resins, and plastics, but its hardening and waterproofing properties are doubtful.

Amber oil is quoted at 75 cts. to \$1 a pound on the New York market. Coalmont resin oil is very similar in its properties to amber oil.

Moulding Processes

Large sized blocks of amber are formed from chippings and waste by the action of heat and pressure. According to one process the material is heated to 200-250°C. and 400 atmospheres pressure is applied. Experiments made compressing Coalmont resin have not yet been successful.

However, the synthetic resins such as Bakelite, Redmanol and Condensite are rapidly supplanting compressed amber and it is improbable that there is any use for the resins in this way.

It therefore seems difficult to find satisfactory industrial uses for these materials unless they can be obtained in considerable quantity and sold cheaply enough to compete with the darker varnish resins.

II

A FIELD METHOD AND APPARATUS FOR THE DETERMINATION BY MEANS OF ELECTRICAL CONDUCTIVITY MEASUREMENTS, OF THE CHARACTER OF WATERS LEAKING INTO OIL AND GAS WELLS.

R. T. Elworthy

The development of the apparatus, its calibration and preliminary testing as hereunder described were carried out for and at the request of the Northwest Territories and Yukon branch of the Department of the Interior. One of the functions of that branch is the supervision and inspection of oil and gas wells in the western provinces, especially in relation to drilling operations. An important part of this work is the safeguarding and protection of the oil and gas sands from encroachment by water. Drillings in progress must be prevented from flooding. Such water may come from the lower levels of the oil or gas bearing formation, when it is usually known as bottom water, or it may infiltrate from one or more of the water bearing strata that have been penetrated in boring. In the latter case the water is more probable to be a lightly mineralized water, originally a surface water which has gained soluble constituents in its passage through the earth. Although mixtures of bottom waters and top waters are often met with, it can be generally stated that they are distinctly different in character, in that the bottom waters are much more strongly mineralized, having sodium chloride as the predominating constituent. They are usually considered to be remnants of the original sea in which the sediments were laid down. Greater difficulty exists, however, in distinguishing between various top waters.

It has been proposed that samples of waters from various known horizons and from representative wells in any particular oil or gas field be collected and chemically analyzed. From such data information can be afterwards obtained of the source of water leaking into new or unexamined wells in that field, when samples of these waters are analyzed.

Valuable investigations of this nature have been carried out in the United States.¹

It was proposed that such a survey should be made in the various gas fields of Alberta, but it was not possible to carry out this investigation on account of the lack of facilities and of staff. It was therefore thought that a determination of the electrical conductivity of the waters would give much information in less time. This examination would be made at first on a series of waters whose origin and general character was known, and then using the measurements obtained as standards. It would be applied to waters of unknown character and origin encountered in new drillings.

This report describes the apparatus that was chosen for the purpose and some of the preliminary results obtained.

¹G. S. Rogers. "The chemical relations of the oil field waters in the San Joaquin Valley." U.S. Geol. Survey, Bull. 653, 1917. R. O. Neal. "Petroleum Hydrology applied to the Mid Continent field." Bull. Amer. Inst. Min. Met. Bull. No. 145, pp. 1-8, 1919 and No. 147, pp. 603.

Electrical Conductivity Measurements in Water Analysis

There has been a considerable development of the use of conductivity measurements in industrial processes¹ during the last few years. Although the physical laws underlying the conduction of electricity by concentrated aqueous solutions of salts are still subjects of scientific research, the methods employed can be made to give results far above the accuracy required in industrial operations. Such measurements have been used in checking the composition of boiler feed water, in following electrolytic separations of metals, in the washing of wood pulp in the sulphate process, and in many similar operations. In water analysis the method has been applied to determine² the mutual influence of various salts on their dissociation in aqueous solution, and for the study of the relation between salt content of natural waters and conductivity.³ Similar measurements afford a rapid means of determining the total solids in a water sample.

The results of analysis of several waters typical of those met with in the western gas and oil fields showed that sodium chloride was the main constituent, and therefore the method resolved itself into one that would best give by simple manipulation the conductivity of solutions of sodium chloride.

Analysis of Typical Waters from Alberta Gas Fields

The following table gives the results of analysis of five waters, the first of a series to be collected as typical of those encountered in drilling for oil and gas in Alberta.

(For Table—see page 60.)

The following particulars of the geological relations of the strata from which the samples came were supplied by Mr. S. E. Slipper, petroleum engineer of the Northwest Territories and Yukon Branch.

No. 1.—The water horizon was 55 feet below the Cretaceous and thought to be in the upper Devonian. Fresh waters occurred at 224 feet, 440 feet and 500 feet, but no leakage from there was reported. This is confirmed by the analysis which shows the water to be strongly mineralized. It is probably a connate or fossil sea water.

No. 2.—This water is probably a mixture of meteoric and connate water, although it is believed to issue from an horizon 150 feet deep in the Cretaceous formation.

No. 3.—The source of this sample was from the Ribstone Creek beds of the Belly River formation, 350-430 feet in depth.

No. 4.—This water comes from a series of sandstone beds below the Loon River shales. It is highly charged with natural gas and occasional globules of heavy oil come up with the water. This water occurs stratigraphically higher than No. 5.

No. 5.—This sample issues from several sandstone beds in the base of the Cretaceous. It is ejected from the wells with considerable force and often forms geysers rising to forty feet in the air. Large quantities of gas occur with the water. When closed, the pressure varies from 230 to 180

¹ E. A. Keeler, Chem. and Met. Eng. Vol. 23, p. 721, 1920.

² Chem. Weekblad 15, pp. 1160-83, 1918.

Chem. Abs. 13, p. 624, 1919.

³ Chem. Weekblad 8, pp. 977-82.

Sources	Czar Monitor Misty Hills field, Tit Hills well No. 1		Czar Monitor Misty Hills field, North West Oil and Exploration Co., No. 1		Birch Lake field, Birch Lake well No. 1		Peace River field, Peace River Petroleum Co.'s well No. 1		Peace River field, Peace River Oil Co. well No. 3	
Number.....	1		2		3		4		5	
Depth of water, horizon ft.....	3,295		150		350-430		1137-1148		1003-1282	
Specific gravity at 15° C.....	1.052		1.004		1.001		1.004		1.020	
Constituents.....	P.P.M.	R.V.%	P.P.M.	R.V.%	P.P.M.	R.V.%	P.P.M.	R.V.%	P.P.M.	R.V.%
Carbonic acid (CO ₂).....										
Bicarbonic acid (HCO ₃).....	324.0	0.2	693.0	27.98	481.0	7.9	2,051.0	5.1	3,331.0	6.48
Sulphuric acid (SO ₄).....	13.0		78.7	4.02	17.0	0.4	9.0		127.8	0.30
Chlorine (Cl).....	42,395.0	49.8	258.9	18.00	1,470.0	41.7	10,355.0	44.9	12,549.0	42.20
Sodium (Na).....	24,943.0	45.4	414.8	44.43	1,033.0	45.2	6,829.0	45.6	9,263.0	48.51
Potassium (K).....	883.0	0.9	31.4	1.97	75.0	1.9	21.0	0.1	168.0	0.50
Calcium (Ca).....	898.0	1.8	19.9	2.44	35.0	1.8	189.0	1.4	28.8	0.18
Magnesium (Mg).....	580.0	1.9	5.8	1.16	13.5	1.1	230.0	2.9	82.8	0.81
Iron oxide and alumina.....	85.5		5.9		38.0		17.7		17.6	
Silica (SiO ₂).....	0.9		5.9		35.7		11.2		44.1	
Total.....	70,122.4	100.0	1,514.3	100.0	3,198.2	100.0	19,712.9	100.0	25,965.0	100.0
Hypothetical combinations—	P.P.M.	%	P.P.M.	%	P.P.M.	%	P.P.M.	%	P.P.M.	%
Sodium chloride (NaCl).....	63,455.0	90.7	380.0	25.1	2,311.0	72.4	17,043.0	85.6	20,440.0	78.8
Potassium chloride (KCl).....	1,684.0	2.4	60.3	4.0	143.0	4.4	37.2	0.2	313.0	1.2
Sodium sulphate (Na ₂ SO ₄).....			115.6	7.6	24.8	0.7	14.2	0.1	184.5	0.7
Magnesium chloride (MgCl ₂).....	2,270.0	3.2								
Magnesium sulphate (MgSO ₄).....	20.0									
Sodium carbonate (Na ₂ CO ₃).....									16.0	0.3
Sodium bicarbonate (NaHCO ₃).....	421.0	0.5	832.0	54.9	422.5	13.3	445.0	2.2	4,589.0	17.6
Magnesium bicarbonate Mg (HCO ₂).....			34.4	2.2	81.5	2.5	1,375.0	6.9	288.0	7.1
Calcium bicarbonate Ca (HCO ₂).....			80.2	5.3	141.7	4.4	769.0	3.8	75.0	0.3
Calcium chloride (CaCl ₂).....	2,186.0	3.1								
Ferric oxide and alumina.....	85.5	0.1	5.9	0.4	38.0	1.1	17.7	0.1	17.6	
Silica (SiO ₂).....	0.9		5.9	0.4	35.7	1.1	11.2	0.1	44.1	0.2
Total.....	70,122.4	100.0	1,514.3	100.0	3,198.2	100.0	19,712.9	100.0	25,965.2	100.0
Properties of reaction in per cent—										
Primary salinity.....	92.6		44.04		84.2		89.8		85.00	
Secondary salinity.....	7.0									
Primary alkalinity.....			48.76		86.2		1.6		13.02	
Secondary alkalinity.....	0.4		7.20		9.6		8.6		1.98	

pounds per square inch, but is probably a gas pressure over and above the pressure of the water column in the well. There is a distinct odour of hydrogen sulphide from the flow of water and gas, and the water deposits a coating on material over which it flows. Heavy oil and tar sand beds are interlayered with the water sands in the well. The sandstones are overlain by impervious shales and beneath them are the Palæozoic limestones.

Conductivity Measurements

It will be seen from the results of analyses of these waters that the chief constituent is sodium chloride, usually forming more than 75 per cent of the total solids. Preliminary conductivity measurements made with the usual set up of a Wheatstone's bridge, induction coil and telephone gave encouraging results.

For such measurements to be carried out in the field, a reliable and simple form of apparatus had to be selected.

Three types of instrument were therefore tested.

The first was an instrument, made by Messrs. Leeds and Northrup of Philadelphia, designed especially for measurements of conductivity in industrial processes. This apparatus gave very satisfactory results in many ways, and was well built and rugged in construction; but it required an alternating current of 110 volts to operate it. This rendered it of no value for field use.

The second instrument was the Dionic water tester, made by Messrs. Evershed and Vignoles, of Chiswick, London. It is intended for the detection and measurement of impurities in town water supplies, boiler waters, river waters, and washing waters in all types of industrial processes. The electric current is generated by a small dynamo worked by hand, and the conductivity of a sample of water, contained in a special cell, is read off directly on the scale of a galvanometer of the pointer type. The instrument at our disposal however was intended for very lightly mineralized waters, and even when a cell with greater distance between the electrodes was substituted, it did not give a sufficiently wide range of readings. Otherwise the apparatus would be ideal for field use.

The third instrument, and the one finally adopted, was the conductivity bridge¹ designed for the measurement of soluble salts in soils by the Bureau of Soils, U.S. Department of Agriculture. It was purchased from the Bryan Instrument Co., Washington.

This is of the regular Wheatstone bridge type, and measurements are made by adjusting the position of a slider on a resistance wire till there is a minimum of sound in the telephone.

The conductivity cell supplied with the instrument was unsuitable for testing strong saline solutions and a more suitable cell was therefore designed.

¹ U.S. Dept. of Agriculture. Bureau of Soils, Bull. No. 61, 1910. The electrical bridge for the determination of soluble salts in soils, by R. O. E. Davis and H. Bryan.

Conductivity Cell

Fig. 2 and Plate I show the design of this cell. It consists of a glass cylinder, $1\frac{1}{4}$ inch in diameter, and 7 inches long, closed at the top with a rubber stopper carrying the supports for the two electrodes. These are circular platinum discs, 9 mm. diameter, welded to platinum wires sealed into glass tubes serving as supports, and carrying the copper wires making connection with the bridge.

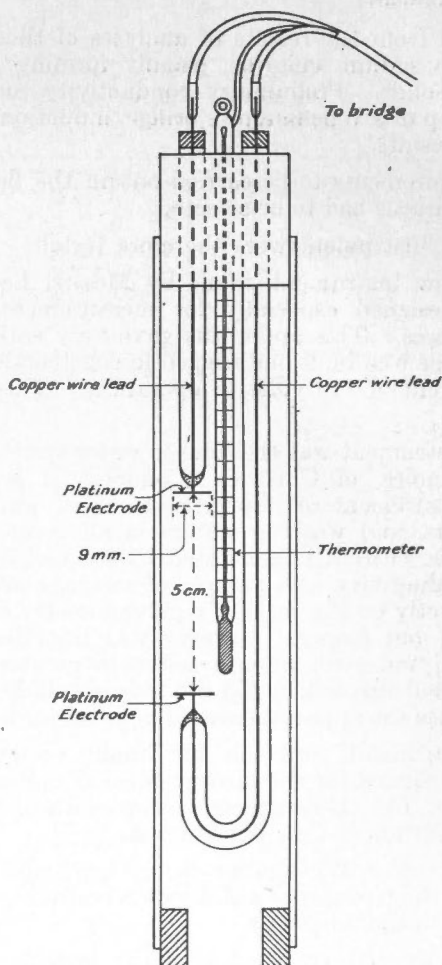
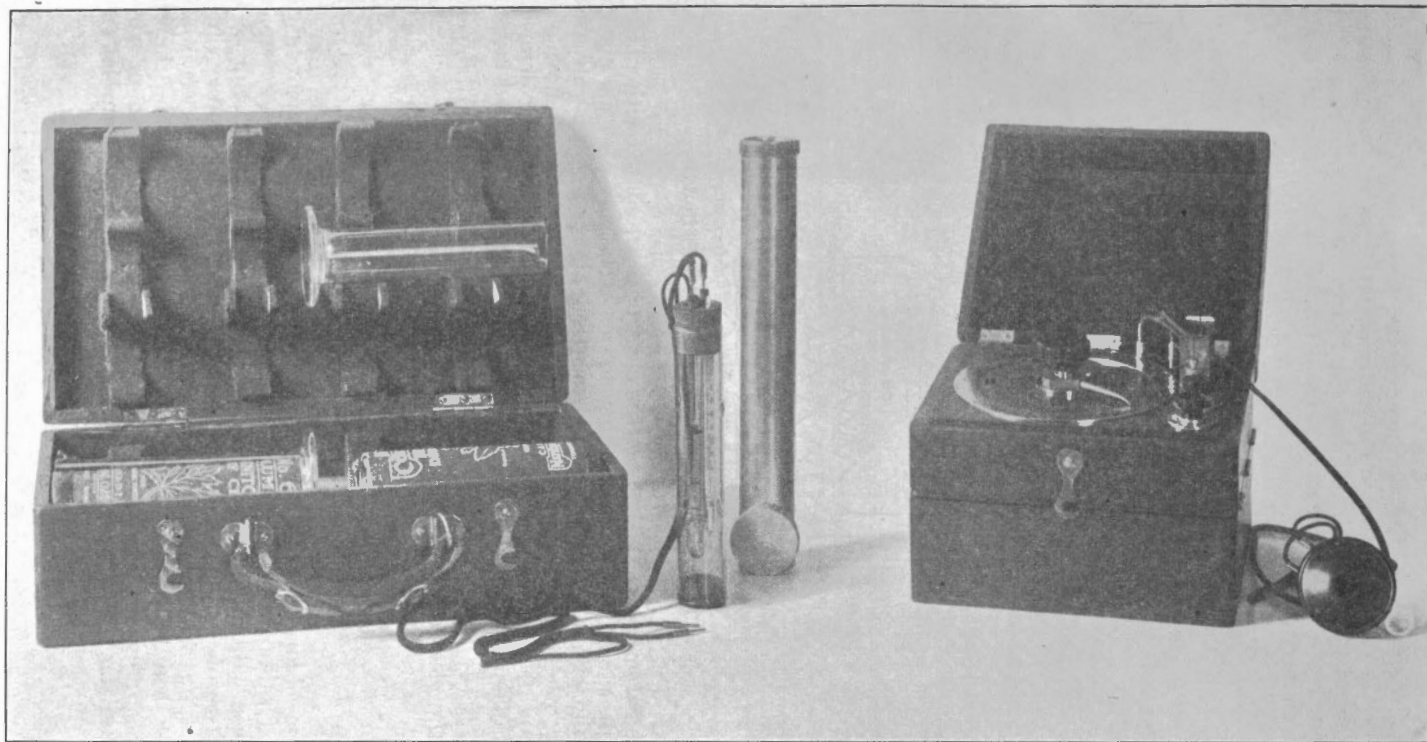


FIG. 2. Conductivity cell.

Fig. 3 shows the wiring of the circuits (see Bull. 61, pp. 10-13). The temperature of the solution at which the measurements are made is read on the thermometer in the cell. Holes in the glass tube and the stopper



Conductivity bridge, cell and carrying case.

allow the escape of air when the cell is immersed in the solution to be measured. A rubber ring in the lower end of the tube serves as a cushion when the cell is lowered into a vessel containing the water. The electrodes are fitted exactly 5 cm. apart, and as the resistance depends on the length of the column of solution between the electrodes, it is important that the distance be not altered if the electrodes are removed for any purpose.

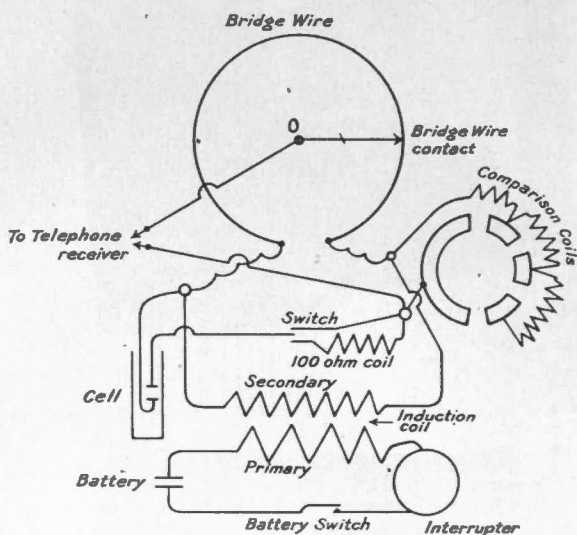


FIG. 3. Diagram of interior connections for field bridge.

For sharp setting of the balance the electrodes are coated with platinum black. This can be easily done by putting the cell into a 5 per cent platinum chloride solution and connecting the leads from the cell to a 6-volt storage battery or other source of direct current. The direction of flow of the current should be reversed every minute until a black velvety deposit on both electrodes is obtained. The cell is then washed in distilled water.

It is essential that the cell be kept clean and free from salts crystallizing on the electrodes or walls. After use it should be very well rinsed in distilled or rain water and left to drain. On no account should the electrodes be dried with a cloth, or even touched.

Calibration

Sodium chloride is by far the most important constituent of the majority of saline waters found in oil and gas wells, and, therefore, the cell has been calibrated by means of solutions of sodium chloride. The conductivities of equivalent solutions of different salts of course vary to some extent, but with such salts as are found in mineral waters, e.g. sodium bicarbonate, sodium sulphate, magnesium and calcium chloride, the error made in assuming the sodium chloride to be the sole constituent will be easily within the limits of accuracy of measurement and manipulation.

Temperature Effect

The electrical conductivity of a solution has a large temperature coefficient, being approximately 2 per cent per degree centigrade. This is greater than the errors of measurement, and therefore must be allowed for in the calculations. The actual value for a 5 per cent sodium chloride solution at 18°C. is 0.0198.¹ Measurements made at three different temperatures, 20°, 25° and 30°C., recorded in the table following, give approximately 2 per cent difference per degree.

The conductivity of a solution increases with increase of temperature, and vice versa, and, therefore, the resistance which is the reciprocal of conductivity, decreases with increase in temperature. For example, a salt solution at 20° had a resistance of 103, at 25° it was 94, and at 30°, 87. To bring the results to 25°C. therefore, the resistance found at temperatures above 25° must be increased by 2 per cent per degree, and those measured below 25° must be reduced by 2 per cent per degree.

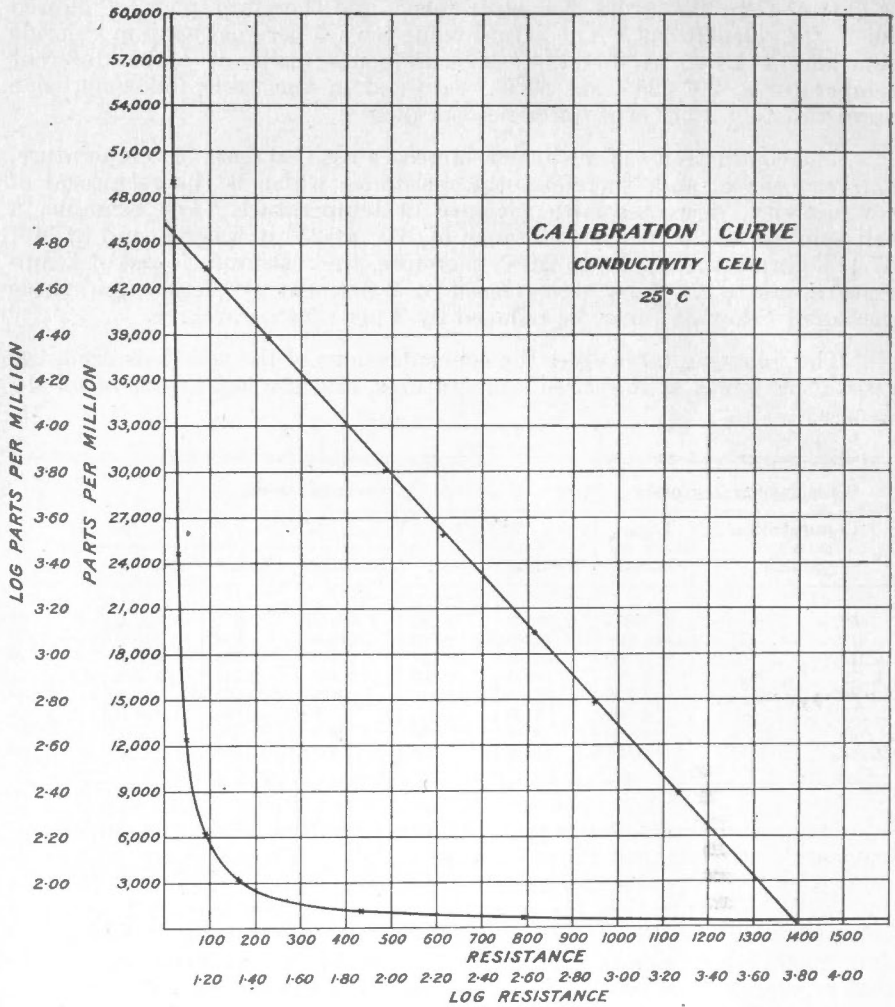
The following table gives the concentrations of the solutions used, the resistances found at the three temperatures, and the logarithms of all the figures:—

Sodium chloride solution		Resistances					
Concentration parts per million	Logarithm concentration	20° C.		25° C.		30° C.	
		Reading	Log.	Reading	Log.	Reading	Log.
250.....	2.398	2,202.0	3.342	1,840.0	2.265	1,620.0	2.209
614.....	2.788	893.0	2.950	790.0	2.898	740.0	2.869
1,228.....	3.089	465.0	2.667	425.0	2.628	380.0	2.580
3,275.....	3.515	186.0	2.269	165.0	2.217	150.0	2.176
6,140.....	3.788	103.0	2.013	94.0	1.973	87.0	1.939
12,338.....	4.091	53.0	1.724	48.0	1.681	44.0	1.643
24,550.....	4.390	30.4	1.483	28.0	1.447	25.5	1.406
49,110.....	4.691	16.9	1.228	15.3	1.184	14.0	1.146

Diagram I shows the hyperbolic curve resulting when the concentrations are plotted against the resistances at 25°C. From this curve the concentration of any water can be found if the resistance is known. But the change in concentration for a small change in resistances between zero and 100 is great. Similarly a large variation in resistance between 500 and 1,500 corresponds to a very small difference in concentration, and for that reason it is difficult to take readings from the hyperbolic curve. If, however, the logarithms of the concentration, carried to three places of decimals, be plotted against the logarithms of the corresponding resistances, a straight line results when the points are joined, also shown in Diagram I. It is much easier to take readings from this straight line, and for use in the field the logarithmic curves for the temperatures 20°, 25° and 30°C. were plotted.

¹ Landolt, Bornstein and Roth. *Physikalische Tabellen*, Berlin, 4th edition, p. 1092

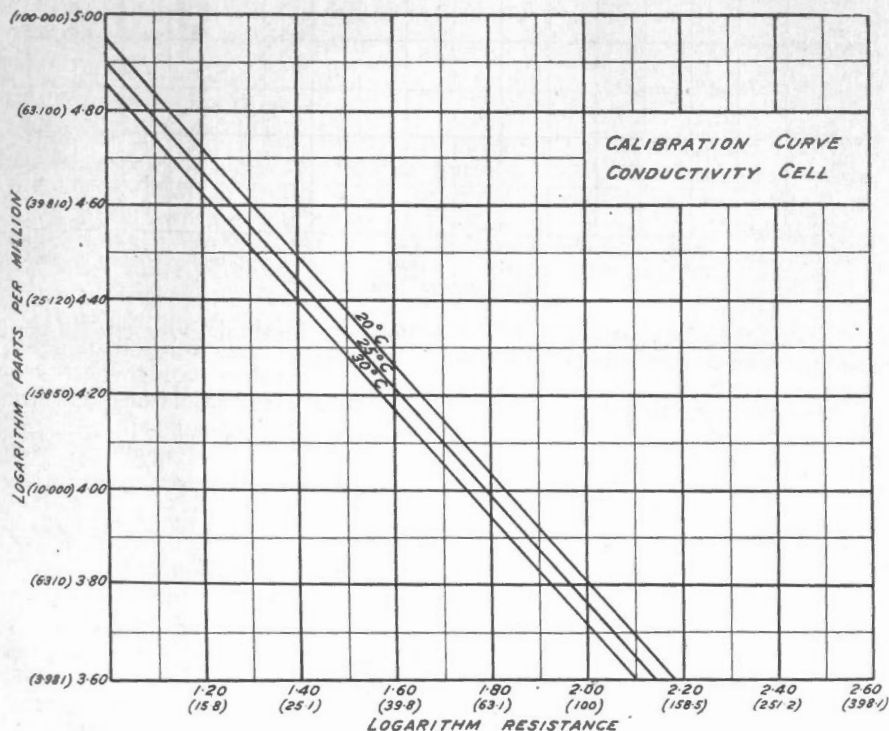
DIAGRAM I

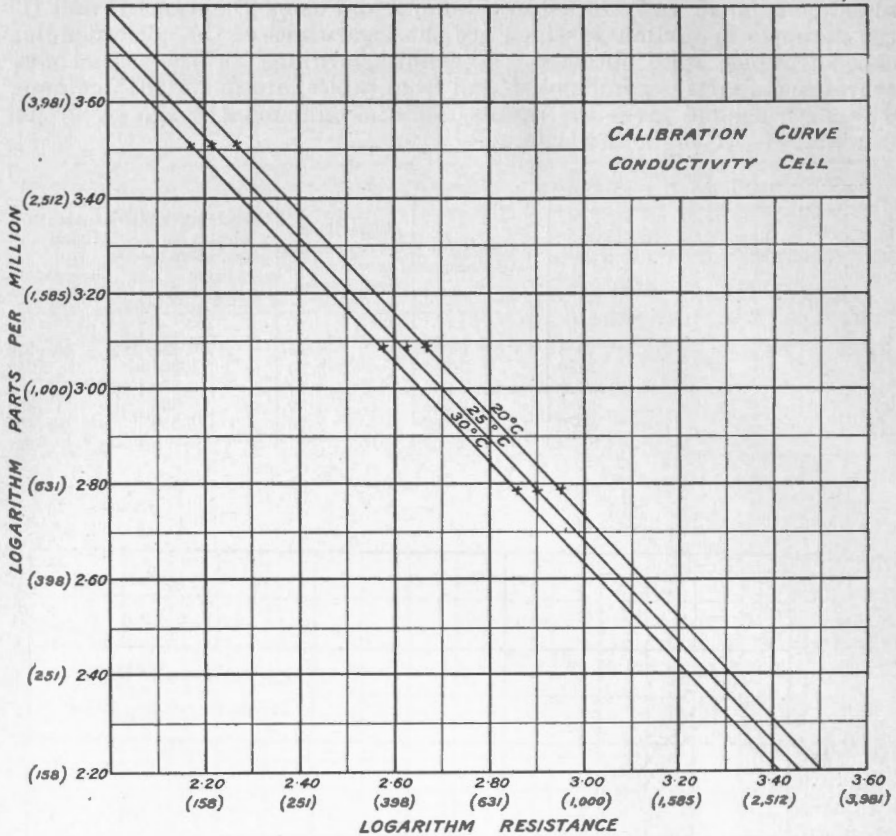


Application.—The five samples of water, the analyses of which have just been given, were tested by the conductivity method. Taking the resistances found as recorded in column 2 and using Diagrams II and III the numbers in column 4, which are the logarithms of the corresponding concentrations, were obtained. The antilogarithms, or the actual concentrations (parts per million), found from tables, are in the fifth column. The sixth column gives the results found several months ago by actual evaporation, drying and weighing:—

Sample No.	Resistance found at 25° C.	Logarithm resistance	Logarithm corresponding concentration from curves.	Concentration looking up figs. of last column in antilog. tables	Concentration found by actual analysis
I.....	10.8	1.033	4.85	70,790	68,080
II.....	432.0	2.635	3.10	1,259	955
III.....	224.0	2.350	3.42	2,630	2,371
IV.....	34.5	1.538	4.29	19,500	19,360
V.....	28.0	1.447	2.39	24,550	25,120

DIAGRAM II





These results show that the conductivity method gives substantial agreement with the ordinary method of analysis.

Another example, illustrating the temperature correction, is as follows:

Suppose a bridge reading of 58 is obtained at 18°C. At 25° this would be $58 - \frac{(58 \times 2 \times 7)}{100} = 58 - 8.1 = 49.9$, $\log 49.9 = 1.698$, 1.698 corresponds to 4.10 from Diagram II, antilog 4.10 = 12.590.

Therefore, the water contains 12,590 parts per million.

Cell Constant

The conductivity of a cube of solution having sides 1 cm. long, is known as the specific conductivity, and this number for solutions of different concentrations of inorganic salts is recorded in most chemical and physical tables.

The usual type of conductivity cell on account of its large dimensions gives a number greater than the specific conductivity, but the following relation holds:—

Specific conductivity (c) = conductivity (C) \times cell constant (K). To find the cell constant of the conductivity cell described in this report, the following measurements were carried out:—

Two solutions of potassium chloride were made up, one 0.1N. (7.46 grams per litre) and the other, 0.02 N. (1.492 grams per litre). The 0.1N. solution gave a reading on the bridge at 24°C. of 91.5 ohms; the 0.02 solution gave 420. This corresponds to a conductivity of

$$\frac{1}{91.5} = 0.01092 \text{ and of } \frac{1}{420} = 0.00238.$$

The specific conductivity of 0.1N potassium chloride solution at 24°C. is 0.01264.¹ Applying the relation, we have

$$0.01264 = 0.01092 \times K$$

$$\text{or } K = 1.155$$

Taking this value and the conductivity found in the case of the 0.02N potassium chloride solution, the specific conductivity of this solution at 24°C. is:—

$$c = 1.155 \times 0.00238 \\ = 0.00275$$

The value given in the tables¹ is 0.00271.

This shows that the bridge and cell give reliable and accurate measurements.

Field Tests of the Instrument

To see how the conductivity bridge operated under actual field conditions, a trip was made to Carlsbad Springs, about 11 miles from Ottawa, where there exists a group of five saline springs of varied concentration. These springs were examined in 1914 (Mineral Springs of Canada, Mines Branch bulletin No. 20, 1918, pp. 33-43) for their radioactive and chemical properties and, therefore, the results obtained with the bridge could be compared with those found by careful analysis.

It is not probable that the composition of the waters had changed appreciably in the eight years interval, with the possible exception of the most concentrated water, as the analyses made in 1914 agreed well with those carried out by Dr. G. C. Hoffmann, of the Geological Survey, in 1875.

The following results were obtained with very little manipulation in about one hour:—

Spring	Bridge reading	Corrected to 25° C.	Log. corrected reading	Log. concentration from curves	Concentration parts per million	
					From last column	From report
Gas.....	275 at 14° C.	214.5	2.331	3.39	2,455	.....
White sulphur.....	260 at 11° C.	187.2	2.272	3.45	2,818	2,964
Lithia.....	171 at 10° C.	119.7	2.078	3.66	4,624	4,550
Soda.....	650 at 12° C.	481.0	2.682	3.02	1,047	1,170
Magic.....	59 at 11° C.	42.5	1.628	4.18	15,140	22,140

¹ Physical and chemical constants, Kaye and Laby, p. 86, published by Longmans, Green and Co., 1919.

Considering that the instrument was calibrated with sodium chloride solutions, and that considerable temperature corrections have been made, these results are very satisfactory. The discrepancy in the case of the Magic Spring may be perhaps due to a decline in concentration, especially as this was found to have occurred between 1875 and 1914.

The waters were afterwards tested in the laboratory at 25°C. with the following results:—

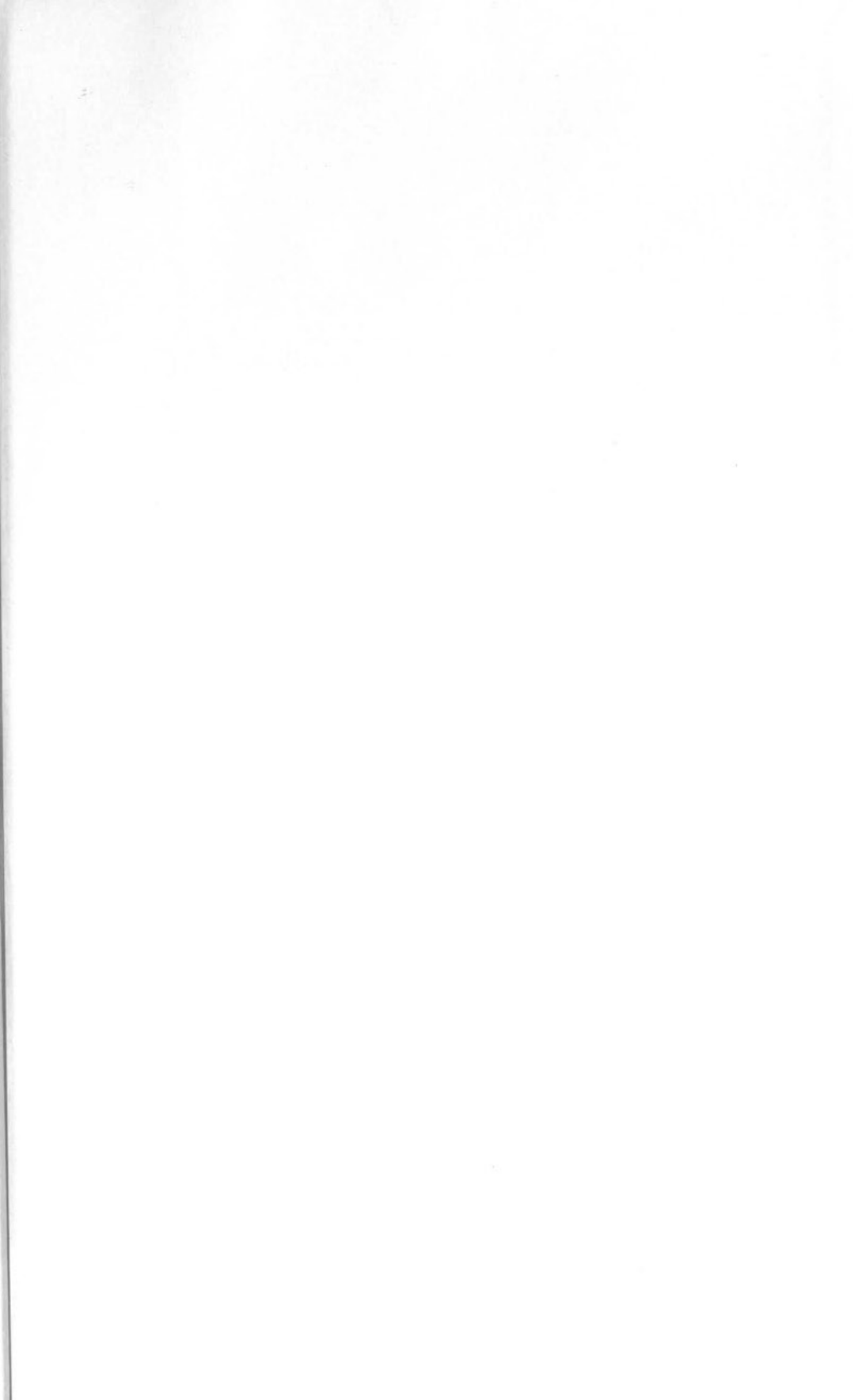
—	Gas	White sulphur	Lithia	Soda	Magic
Found.....	210.0	190.0	120.0	520	43.0
Calculated.....	214.5	187.5	119.7	481	42.3

The percentage of sodium chloride of the total inorganic matter in solution in these waters was, according to the analyses in 1914:—

—	White sulphur	Lithia	Soda	Magic
Sodium chloride (NaCl) per cent.....	69.30	77.11	44.05	73.50
Sodium bicarbonate (NaHCO ₃) per cent.....	21.49	9.51	48.40	.....

The instrument has now been sent out for field use in western Canada, where it is being tested on a number of waters from known horizons, so that a series of standards can be set up.

The determination of total solids by this means seems to afford a method sufficiently accurate for the purpose required.





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Canada Mines Branch.

Report no. 607

