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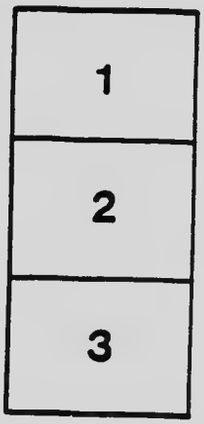

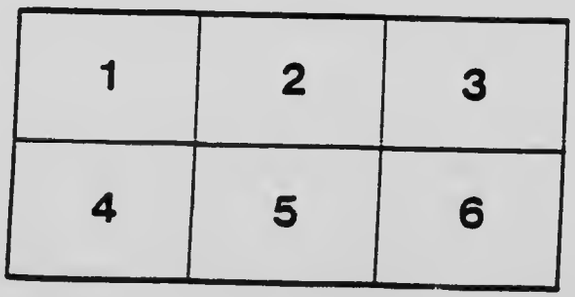

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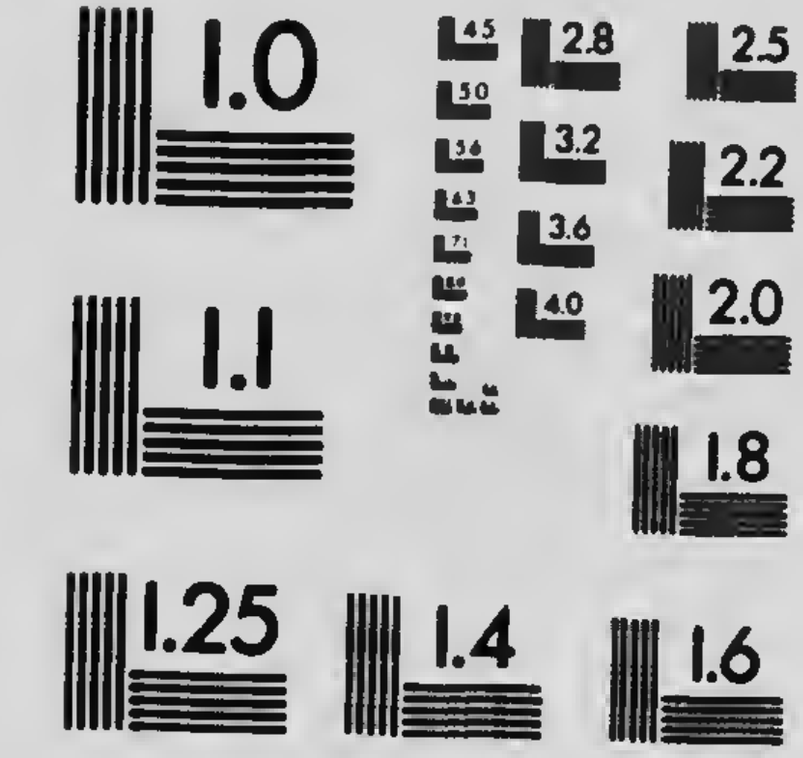

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GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc. (CANTAB.), LL.D., F.R.S.

SECTION OF MINES

MINERAL RESOURCES OF CANADA

BULLETIN No. 1

PLATINUM

ELFRIC DREW INGALL, M.E.

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GEOLOGICAL SURVEY OF CANADA,
OTTAWA, March 27, 1903.

ROBERT BELL, M.D., LL.D., F.R.S.,
Acting Deputy Head and Director.

SIR,—I beg herewith to submit a pamphlet dealing with platinum.

It represents a reprint with additions of the article with that title forming a portion of the Annual Report of the Section for 1901 (Part S, Vol. XIV) Annual Report of the Geological Survey Department, The material has been collected and prepared by Mr Theo. Denis, B.Sc.

Pursuant to a policy suggested some years ago and now carried out with your permission, this pamphlet is intended to be the first of a series giving, in condensed and popular form, information regarding the mineral resources and possibilities of the country, together with any data regarding similar occurrences in other countries which may be of use to prospectors and operators in Canada.

I am, Sir,
Your obedient servant,

ELFRIC DREW INGALL.

PLATINUM

So far the production of this metal is altogether derived from the placer working on the Similkameen river district of British Columbia. As will be seen on inspection of the figures in Table 1 below, the yield has been generally falling off for some years past. The amount is now insignificant. Production.

Table 1.

Platinum.

Annual Production of Platinum.

Calendar Year.	Value.
1887	$ 5,600
1888	6,000
1889	3,500
1890	4,500
1891	10,000
1892	3,500
1893	1,800
1894	950
1895	3,800
1896	750
1897	1,600
1898	1,500
1899	825
1900	Nil.
1901	457
1902	190

PLATINUM.

Production.

As articles of platinum are not manufactured in Canada, there is no home market for the crude metal and the imports, as shown in Table 2, represent only the finished articles.

TABLE 2.

PLATINUM.

Imports.

IMPORTS OF PLATINUM.

Fiscal Year.	Value.
1883	$ 113
1884	576
1885	792
1886	1,154
1887	1,422
1888	13,475
1889	3,167
1890	5,215
1891	4,055
1892	1,952
1893	14,082
1894	7,151
1895	3,937
1896	6,185
1897	9,031
1898	9,781
1899	9,671
1900	57,910
1901*	20,263

*Platinum wire and platinum in bars, strips, sheets or plates; platinum retorts, pans, condensers, tubing and pipe, imported by manufacturers of sulphuric acid for use in their works. Duty free.

It is to be hoped that the increasing demand for this valuable metal may stimulate prospecting and lead to the discovery of other workable deposits. With this in view Mr. Theo. Denis, B. Sc., of the Staff of the Mines Section has prepared the following article on the subject, giving in condensed form, information inaccessible to the ordinary reader on account of its being scattered throughout a number of technical publications. Descriptive matter relating to the mode of occurrence and methods of working deposits in other countries has been included as suggestive of points likely to be of use to the prospector and miner in Canada.

OCCURRENCES OF PLATINUM IN CANADA.

Occurrences.

Although the first reference to the occurrence of platinum in Canada was made as early as 1852, by Dr. T. Sterry Hunt, yet, the production

so far, as may be seen by the table given above, has been very small and moreover the figures show great irregularity from year to year. This is due to the fact that in Canada this metal is obtained as a by-product only, mainly in the working of some auriferous placers in British Columbia, and in many cases the black platiniferous sand which is held back in the riffles of the sluiceboxes, is overlooked and thrown away owing to the ignorance, on the part of the miners, of its value or of the mode of further treatment. Even as late as 1899, the Provincial Mineralogist for British Columbia in his report for the year says that 'It appears that many of the placer miners do not know its value and throw it away as so much black sand.' This may have been due to the fact that until a few years ago the demand for platinum was somewhat limited and the market price accordingly comparatively low; but at present, owing to its extended uses, the price has risen, so that it now rivals that of gold, the market price for ingot platinum during 1901, ranging from $18.00 to $22.00 per ounce. PLATINUM. Occurrences.

Platinum was first noticed in Canada in 1852, as mentioned in the Geology of Canada of 1863. It was found on Rivière-du-Loup, province of Quebec, near its junction with the Chaudière, in the course of washing sand for gold. Associated with this native platinum were plates of a hard steel gray metal resembling iridosmine. There is also another record of platinum having been found under similar conditions in Riviere des Plantes, Beauce county, in the province of Quebec. The quantity was very small and these finds possess at present only a historical interest. If, however, placer mining should be more vigorously prosecuted in this region it is not impossible that platinum might become a valuable by-product of the operation.

The recorded Canadian production of platinum comes from British Columbia, where the metal is obtained mainly in connection with the working of the auriferous deposits of the Similkameen and Tulameen rivers.

It is rather difficult to ascertain when platinum was first discovered in British Columbia. In his 'Mines and Minerals of Economic value of British Columbia,' (Geol. Surv. Rep. 76-77), the late Dr. G. M. Dawson mentioned finds of platinum on the Similkameen, Tranquille and Fraser rivers. But as some of those placers were first worked as far back as 1858 it is very probable that the black platiniferous sand must have come to the notice of gold miners a good many years before.

However, the first record of its having been saved is found in the report of the gold commissioner of the Similkameen division for 1886 in which he says: 'Mixed with the gold found in this district, and pos-

PLATINUM. Occurrences.

sessed of a greater specific gravity, is a whitish metal which at first was thrown away under the impression that it was worthless. For considerable time no definite idea could be procured as to its value. Mr. Jenson, of Granite City, who forwarded a sample to a cousin of his at Manchester, England, for analysis has kindly supplied me with the desired information. The metal is principally platinum, containing small quantities of iridium, osmium, and palladium. Its value depends on the percentage of platinum, which varies in quantity and may be considered as worth about $2.50 per ounce. The selling price at Granite City was 50 cents per ounce; so the purchasers will reap a handsome return for their investment.' The following year he estimates the production to have reached some 2,000 ounces, which commanded from $2.60 to $3.00 per ounce.

Platinum has been found in many places in British Columbia in association with gold, in alluvial deposits, an annotated list of localities being given below, but the region of the Similkameen and Tulameen rivers (north fork of Similkameen) is by far the most important.

The origin of the platinum found in the placers of the district, has not been definitely ascertained; Dr. Dawson in his report on the Mineral Wealth of British Columbia expresses himself as follows: The metal (platinum) occurs in notable quantity in the region of the upper Similkameen and Tulameen, in minute scales where the gold is "fine" but increasing in coarseness to small pellets and nuggets in places where "coarse" gold is found. Coarse grains and pellets of platinum have so far been found only on Granite, Cedar and Slate creeks, all entering the Tulameen on the south side. In certain claims in these creeks, the platinum has been found to equal half the weight of gold obtained ..... Though above referred to as platinum, the metal so named is alloyed with several other metals of the same class, of which osmiridium is the most abundant. Specimens of the native platinum from Granite creek have been subjected to careful examination and analysis by Dr. Hoffmann, who states that the material "having the composition of the ore here in question would, at the present time, be worth, from $2.90 to $3.65 per ounce troy in the English market." Osmiridium is employed, on account of its great hardness, for tipping the nibs of gold pens. "For this purpose it is necessary that it should be in the form of natural grains, and these are very carefully selected, the requirements being that they should be solid, compact and the proper size and shape.' This was not however found to be the case with the grains present in the platinum from Granite creek.

Platinum has very rarely been discovered in veins or otherwise in its original matrix In Russia, whence the greatest quantities are obtained, it is almost always found as in the cases above cited in association with gold-bearing alluvions, although it has been noted in a few places with little or no accompanying gold. It appears to be derived from rocks consisting of serpentine and peridotite with talcose and chloritic schists and chromite. While there is a notable abundance of greenish chloritic and hornblendic schists and diabase rocks (resulting from the metamorphism of old volcanic rocks) in the Tulameen and upper Similkameen region of British Columbia, and chromite and magnetite are here found in the workings in association with the platinum and gold, no peridotite or serpentine is actually known to occur. The circumstances in connection with the occurrence of the 'coarse' platinum appear to point to the vicinity of an important mass of intrusive diorite as its point of origin. A great part of the associated magnetite is certainly derived from veins in this rock and it seems not improbable that the platinum, and possibly also a great part of the gold of this district, may occur in scattered grains in this intrusive mass. Very little vein-stuff occurs in the gravels with which the platinum and gold of this region are associated. (Geol. Surv. Rep. 87-88 part R.) PLATINUM. Occurrences.

Later investigations however have led to a modification of the views expressed as above by Dr. Dawson in 1888.

The following statement by Mr. R. W. Brock was published in the Summary Report of the Geological Survey of Canada for 1901 p. 67: "It (platinum) has been found in the Similkameen district and is known to occur at many points in the western United States. When found in place it has generally been confined to serpentine, and when found in sands it is usually in the neighborhood of serpentine. Consequently streams draining masses of serpentine in particular should be prospected for platinum. Serpentine, as above noted, occurs at a number of points in the district examined this summer, as on July creek, Hardy mountain and Central Camp. It also occurs on the range east of the Cascade."

A very interesting investigation on a sample of platinum from Granite creek was conducted by Dr. G. C. Hoffmann of the Geological Survey. The original sample weighed 18.266 grams, of which .372 consisted of rock matter, pyrite and gold. The sample was submitted to magnetic separation, and divided into two parts, which on analysis gave the following results:

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	Non Magnetic.	Magnetic.
Weight	11·115 grams.	6·779 grams.
Platinum	69·19 °/₀	78·43 °/₀
Palladium	0·26	0·09
Rhodium	3·10	1·70
Iridium	1·21	1.04
Osmium	...	....
Copper	3·09	3·89
Iron	7·87	9·78
Osmiridium	14·62	3·77
Gangue	1·95	1·27
	100·29	99·97

This determination shows, therefore, a proportion of 72·07°/₀ of platinum in the 17·894 grams of material analyzed. For the purpose of comparison, platinum contents of samples of platinum bearing material from different parts of the world are given: The analyses are by Messrs. Deville and Debray; Oregon, 51·45 °/₀; Australia, 61·40; California, 85·50; Choco, Columbia, 86·20; Nischne Tagilsk, Urals, 76·40.

The following is a list of Canadian localities at which the occurrence of platinum has been noticed. With the exception of that at Sudbury, Ont., all the finds have been made in the alluvial deposits, usually while working for gold.

Rivière du Loup, and Rivière des Plantes, province of Quebec. (See note above.)

Sudbury, Ontario.—This occurrence is one of the very few in the world where platinum is found "in situ."—In this case the metal is found in combination with arsenic and associated with the nickeliferous pyrrhotite deposits. The arsenical platinum mineral was named sperrylite by H. A. Wells who described it, and found it to consist on analysis of: Platinum 52. 57 per cent; Rhodium 0.72; Antimony 0.50; Arsenic 40.98; Iron 0.07; Tin oxide 4.62.

At Sudbury the ore bodies consist of chalcopyrite and nickeliferous pyrrhotite, which are primarily worked for their nickel and copper contents, and yield a large proportion of the world's supply of nickel. The ore undergoes a first treatment at the mines, where it is smelted, the low grade matte first made containing approximately 15 per cent of nickel and about the same proportion of copper and the Bessemerized matte from 35 to 40 p.c. of nickel. This is shipped to the refinery in New

Jersey where it is finally treated. According to a reliable authority this matte holds 1.25 oz. of the platinum metals per ton of nickel contents of the matte, and of this some 80 per cent is extracted. In 1900 the matte shipped from Sudbury, contained approximately 4,594 tons of nickel. The platinum metals would therefore, on that basis have amounted to 5,742 oz. This however is not included in the table of production, as returns of platinum from this source are not sent in to the Mines Section.

North Saskatchewan, N.W.T. Native platinum has been found in association with gold on the bars in the North Saskatchewan river, in the neighborhood of Edmonton, district of Alberta. A sample of the material from this locality received from Mr. Pearce consisted of exceedingly minute rounded and flattened grains of native platinum, the largest not exceeding one fourth of a millimeter in diameter, with intermixed, equally minute scales of native gold. (Geol. Surv. Rep. 90-91 part R).

Yukon river and tributaries, Y. T. Platinum was reported to have been found in small quantities along all or nearly all tributaries of the Yukon in association with river-bar gold (Geol. Surv. Rep. 87-88). but these reports have not been verified by fuller investigation and it is still uncertain whether this metal has been discovered or not on the Yukon river.

It has been reported lately that comparatively large quantities of platinum were bought at low prices from placer miners in the Yukon, who were ignorant of its value, and sold again at a large profit in Vancouver.

Teslin (Hootalinqua river), Y.T.—A discovery of platiniferous sand was made in 1898, at the mouth of the Hootalinqua river and on Thirty Mile (Lewis) river. A company was said to have been subsequently organized to work these alluvions for the gold and platinum, by means of dredges.

Upper Similkameen and Tulameen rivers, British Columbia, especially on Granite, Cedar and Slate Creeks. (See note above.)

Tranquille river, B. C. This river which flows into Kamloops lake, was worked before 1862 by gold miners; later the work was taken up by Chinamen. Gold is found for a distance of eight miles from the mouth. The metal is scaly and mixed with it are particles of platinum, similar in shape and size to those of gold.

(Geol. Surv. Rep. 1877-1878 part B.)

PLATINUM. Occurrences.

Fraser river, British Columbia. Found in small quantities in fine scales, with gold, particularly at a place ten miles below Lillooet. (Geol. Surv. Rep. 87-88).

A sample of crude platinum sand from washings in the Fraser river gave the following result :—

Base metals	6·48
Platinum group	81·30
Osmiridium	12·20

Rock creek, Camp McKinney, Yale district, B.C. A sample of heavy black sand taken from the riffles of sluice-boxes at Camp McKinney, Rock creek, a tributary of Kettle river which contained in addition to gold a large proportion of native platinum, gave on analysis the following results :

Native platinum	44·7
Gold	1·8
Magnetite	47·4
Quartzose sand	6·1

The platinum was in the form of exceedingly minute to moderately coarse irregularly shaped grains, the largest of which measured four millimeters in diameter. (Geol. Surv. Rep. 92-93).

North Thompson and Clearwater rivers, B.C. The discovery of platinum in the North Thompson and Clearwater rivers has created some interest, as its existence was not formerly suspected. It is found associated with the alluvial gold but the extent and condition of the finds are not yet fully determined. (Rep. Minister of Mines, B.C., 1900).

SOURCES OF THE WORLD'S SUPPLY. OCCURRENCE AND TREATMENT.

Although platinum is known to occur in situ in several places, it is in such small quantities, that nowhere are these occurrences worked for the metal. These deposits have therefore at present no direct economic value although the study may eventually throw light on the origin of this metal which is not well understood. Platinum has been found in place (in contradistinction to alluvial deposits) in the following countries, a short description being given in each case.

Columbia.—In Columbia the platinum deposits may be divided into two main classes, the more recent alluvial deposits and the "caliche" beds. These last are deposits which consist of clay, sand

and boulders indiscriminately mixed and which show no stratification. Those deposits are probably of glacial origin, and are the oldest platiniferous deposits of El Choco. They frequently contain diorite boulders, and it seems possible that the platinum will eventually be found disseminated in this rock. The true gravel deposits of El Choco are newer than the "caliche" beds and in part derived from them. The largest deposits of the kind are situated along the Tamana, Iro, and San Juan rivers. These are from 6 to 20 feet deep and have been extensively worked by the natives. (Min. Ind. Vol. I.) Although the "caliche" beds cannot be said to contain platinum in situ, yet the occurrence differs from the ordinary alluvial deposits. The annual production of Columbia has varied for the last few years between 10,000 and 12,000 oz. PLATINUM Occurrences.

New South Wales.—In New South Wales platinum is said to have been detected in felsite and granite at Broken Hill. It is, of course, very sparsely disseminated. It has also been found in small quantities in washings for gold at several places, and since 1894 there is a production recorded, which is very irregular and varies between 500 and 2,000 ozs. annually.

Brazil.—In Brazil platinum is found associated with gold in quartz lenses intercalated in gneiss and schists.

United States.—As to the United States, Mr. David T. Day in a paper read before the American Institute of Mining Engineers in February 1900 makes the following statement:

"Messrs. William E. Hidden and J. H. Pratt have found sperrylite-platinum arsenide in placers at several points in the Cowee valley of North Carolina. The conditions favour the belief that the source of this mineral is a ledge of impure rhodonite and biotite, containing much disseminated iron sulphides, conditions much like those at Sudbury, Canada.

"There have been unsubstantiated reports of the occurrence of platinum in place in certain localities of the Catskills in New York. in granite near Philadelphia, and again near Port Deposit, Maryland."

As to alluvion deposits he says:

"Platinum has been found at many places on the Pacific beach, from as far south as San Bernardino county, northward to the mouth of the Columbia. Indefinite reports have been made of its occurrence further north on the Washington beach; but its amount is certainly not great. The principal beaches where platinum has been reported, beginning at the south, are: Santa Barbara, Lampoc, the beaches of San Luis,

PLATINUM. Occurrences.

Obispo county ; Santa Cruz, and occasionally between Santa Cruz and the Golden Gate. In accordance with Blake's statement, the richest beaches are further north, in Humboldt and Del Norte Counties. The beach mines of Gold Bluff north of Arcata, Big Lagoon, Stone Lagoon, Little River, Crescent City, Cal., and Gold Beach and Port Orford, in Curry county Oregon, have all yielded platinum in commercially appreciable quantities. Still further north, platinum is found at Yaquina beach, Oregon, but the sands there are poor."

Russia.—The metal is found in the Ural mountains sparsely disseminated in peridotite and serpentine masses. The platiniferous alluvial deposits are also characterized by the presence of boulders of olivinite and serpentine, which both contain chromite. Thus the source may be said to have been placed, the matrix being beyond doubt the serpentintized olivinite. It is even reported that a streak or zone of this rock some six feet wide in a massive olivinite, was actually worked for some time for its contents of platinum, but at a depth of about 35 feet it was no longer workable. It does not seem certain that platinum has been found in the perfectly fresh igneous rock which had not yet undergone serpentinization, hence there is a possibility that the same agencies that brought about the conversion of the olivine into serpentine also introduced the platinum into the rock. (Min. Ind. Vol. VI. Abstract.)

Over 90 per cent of the world's production of platinum is derived from the placer deposits of the Urals in Russia. The whole of the platinum producing portion of these mountains is contained within a length of 100 miles along the 60° meridian E. of Greenwich, between latitudes 57.30' and 59° and is all included within the government of Perm. Within this area there are two chief districts, Goroblagodatsk in the north and Nishni Tagilsk in the south. The platinum placers occupy the valley bottoms of a number of streamlets and their branches, the alluvions of the larger streams being rarely rich enough for working. In the Goroblagodatsk district, which lies wholly on the Asiatic side of the Urals, the placers are found on the river system of the Iss and its tributaries which, in its turn, discharges into the Tourna. The total length of the Iss and its affluents is about 60 miles.

In the southern district the main producing area lies on the European side of the Ural watershed in the river systems of the Vissine and the Martian. On these 18 placers are being worked. On the Asiatic side there are three fields of operation on the Chornaia and its tributary, the Chonge.

The platiniferous alluvion is very variable in thickness and in richness, but always shallow, the placers being undoubtedly of quaternary age. These placers carry gold in addition to the platinum, but these metals did not occur together in primary deposits, and their presence together is due to the fact that the stream which formed the alluvial deposit, received the product of disintegration of rocks containing gold and of rocks containing platinum, the source of gold being traceable to quartz veins or to rocks of an acid type, whereas the platinum is derived from basic rocks. PLATINUM. Occurrences.

The thicknesses of the respective layers of overburden and platiniferous alluvion are also recorded, and are as follows: Overburden average 16 feet (maximum 63 feet, minimum 2½ feet), pay gravel, average 3½ feet (maximum 6 feet, minimum 1 foot). The average richness of these pay-sands being at present about 2 dwt., crude, to the ton. The yield of platinum to the ton of gravel washed was at first much higher, but has decreased considerably within recent years. According to private records the sands of the Gorablagodatsk district in 1870 yielded 1 oz per ton, in 1882 this fell to 9 dwt., in 1886 to 4½ dwt. and in 1895 it was 1½ dwt. In the Nishni Tagilsk district, the same decrease is noticeable. This progressive impoverishment is due to the fact that at first only the small shallow and rich placers at the headwaters of the smaller streams were worked; and as these were exhausted, gradually poorer and poorer deposits further down stream had to be attacked, till now there is nothing left but the more extensive low grade placers in the large valleys and the tailings of earlier washings.

Crude platinum, as obtained by washing of the gravels, is in the form of fine particles, grains and scales, of about the size of the finest gunpowder; its colour varying from light to very dark grey. Nuggets are occasionally met with, the largest found in the Gorablagodatsk district was 72½ ozs, and in the Nishni Tagilsk 310 ozs.

Methods of Working.—The method of working the placer gravels is almost everywhere identical. There are two different labour systems in force in all the alluvial workings of Russia. The men are either day labourers receiving regular wages, or they are 'starateli' or free labourers. These latter are what the Cornish miner would call 'tributers'; they are allowed to work certain portions, in some cases the whole of a placer, practically as they please, and are in turn bound to sell the platinum they produce, to the individual or company owning the placer, at a fixed price, which is usually less than half its value. These men are said to be able to work gravels too poor to be worked by day wages.

PLATINUM. Occurrences.

The method of working adopted by the 'starateli' is simple in the extreme; they establish a short sluice-box or 'tom' in some position where they can run a stream of water into the head of the box. One of the most usual types of sluice used in the Urals consists of a box about 2 feet wide, into which the gravel is dropped, and through which a current of water is run. The stream of gravel and water is carried into the sluice proper, which consists of a box, some two feet wide by 30 feet long, inclined at a low angle (about 5°). The far end is opened and terminates in a chute under which a cart can stand to receive the boulders and large pebbles. On the bottom of this sluice, at intervals of about 7 feet, there are three openings which are 9 inches by two feet (the width of the box). These openings are grated with bars of iron set $\frac{1}{4}$ inch apart, and through these, practically all the finer sand and water drop, whereas the larger stones continue on to the chute. Beneath each grating runs a transverse box to receive the sand and water which drop through the gratings. These boxes are also inclined at a low angle and deliver into a trough which lies at a steeper angle; this trough carries the sands, which are now considered worthless, into a settling box, whereas the water runs off into the ditch. The sands are shovelled from the settling box into carts for removal. The bottoms of the main sluice of the transverse boxes, and of part of the trough are covered with riffles and coarse matting, forming interstices for catching the heavy sand. As will be seen, this sluice is really the hydraulic miners sluice, undercurrent and grizzly in miniature. In some places this sluice is combined with a simple machine for disintegrating clayey gravels. When the work is done on an extended scale either by a large company of starateli or by mine owners, washing machines are built and the pay gravels are brought to them in small carts drawn by one horse. The machines are usually driven by steam. One type of washing machine consists of a cylindrical tub, the bottom of which is a circular cast iron pan 15 inches deep, pierced with $\frac{5}{8}$ inch holes; around the top of the pan runs an annular cast iron pipe, perforated so as to allow water in small jets to play into the pan. In the centre is a vertical shaft carrying a six-armed spider, from each of the arms of which hang a couple of iron bars that almost touch the bottom of the pan. The shaft is revolved at about 25 revolutions per minute, and the gravel is fed in continuously. The large stones which remain after the disintegration are removed from time to time, while the sands and clayey matter suspended in water pass through the perforated bottom and fall upon a sloping board covered with stout sheet iron which discharges into a large box, the front of which is closed by a strong wooden grating kept always padlocked

while the machine is in operation. The bottom of the box is inclined at an angle of about 15°. It is eight feet wide and the bottom is covered by stout bass mats, which are held in place by stout pieces of wood about 3 inches deep, which are kept in their places by wedges, and act as riffles. The sands drop through the grating into a transverse shallow trough, then over a table some 18 feet long and furnished with wooden riffles and one or two more troughs. At the bottom of the table the sands drop into a wooden chute which is at such a height above the ground that these sands can be carried by the stream of water to a low dump, some 100 yards away from the machine.

It is evident that any coarse pieces of platinum or nuggets which are the most liable to be stolen, will be retained in the padlocked section of the table, while most of the finer platinum sands are also caught in the mats; the lower table is said to catch very little, but this however is no proof that the tailings are clean, for all the arrangements now in use are obviously unsuitable for catching flour platinum. The machine referred to above can treat about 100 tons in 12 hours, the volume of water required being from 5 to 10 times that of the gravel. The clean-up of the different appliances usually takes place every 12 hours at 5 p.m. and 5 a.m. The sands resulting from the clean-up are then further concentrated in another very simple sluice, consisting of an upper portion in the shape of a box lined with sheet iron and a lower portion which consists of a narrow box about 15 feet long which is laid with well washed peats forming shallow riffles. The sands are thrown in small quantities into the box and then worked about with a hoe or a narrow shovel in a carefully regulated current of water; the bulk of the platinum is retained in the box, the rest being caught in the riffles and most of the lighter material is carried away. The rich concentrates thus obtained, seem to consist of crude platinum, chromite and a few of the heavier minerals. They are finally cleaned on a small flat table or wash-board. This consists of two tables separated by a drop of two inches. Above the upper one is a small box which delivers a regular shallow stream of water over the whole breadth of the table, the force of the current being just sufficient to move the average-size particles of platinum. The breadth of the board is about 3 feet. The concentrated sands from the sluice are thrown on the upper table and are continually pushed upward against the current by means of a little wooden hoe. On this table the concentration is finished; the sands are worked with the hoe until fairly clean and are then allowed to be carried by the stream of water to the lower table, where the washing is completed. The clean platinum sands are then collected off both tables and stirred up with suffi-

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olent mercury to dissolve any gold that may be present. The platinum left behind is now ready for the market. In its crude state it usually contains from 75 to 85 per cent of pure metal. It is then ready to be sold to the refineries. The bulk of the produce of Russia is exported in the crude state.

In *Colombia*, which is the platinum producer next in importance to Russia, the metal is also recovered by very simple methods. The greater proportion is obtained from the working of the "caliche" beds which are usually ground-sluiced. River bars and beds are worked in even a more primitive way; women diving for the black sand and washing it in pans.

Since the foregoing notes were compiled and printed in the Report of the Section of Mines for 1901, a bulletin on 'Geological Relations and distribution of platinum and associated metals,' by Prof. J. F. Kemp, of Columbia University, New York, has been published by the United States Geological Survey and treats the subject very exhaustively. Owing to the importance which the question of the supply of platinum is assuming, it is thought that abstracts of some parts of this bulletin could very appropriately be appended to this article and special attention drawn to the bearing which some of the observations mentioned in the bulletin may have on certain rocks in Canada which might be found on careful search to be platiniferous. Some results have also been given of the analyses of serpentine rocks collected by R. W. Brock in British Columbia and assayed by Donald Locke, both of the Geological Survey of Canada.

Source and associated minerals.

In connection with platinum deposits, many observers have endeavored to trace back to the rock *in situ* the source of the metal found in placers. Minerals associated with the nuggets in the alluvial deposits are therefore important to consider, especially those minerals which are found to actually form part of the nuggets and which are therefore derived from the same source, such as the following, viz: chromite, olivine, serpentine, pyroxene, mica and gold. As to minerals which are present merely as components of the gravels they offer less interest; they are, as a rule, minerals of high specific gravity, and on panning, one may expect to find among them gold, silver, copper, metals of the platinum group, chromite, magnetite, garnet, &c.

Chromite.—Chromite is by far the commonest of foreign minerals found attached to the nuggets. The two minerals seem to have crystalized simultaneously, for they are, as a rule, intergrown so that

Source and associated minerals.

either of them may be found including the other. In British Columbia, nuggets have been observed to have a crumbly appearance, as if the grains of chromite were bound together by the platinum, and it may be surmised that such nuggets could not have travelled very far. Platinum nuggets with chromite attached to them have been reported from Columbia, Russia, British Columbia, and also one from Plattsburg, in New York State. This last is discussed further on, as it is of special interest. It is of interest to note that chromite suggests a basic igneous rock as the source of chromitiferous platinum nuggets.

Olivine.—In some British Columbia nuggets, olivine acts as an envelope to the core of platinum. This would point to a peridotite as the mother rock of these platinum nuggets. Russian nuggets have been found with serpentine attached, which certainly was derived from olivine.

Pyroxene.—In British Columbia, some nuggets have been found with attached crystals of augite, near occurrences of pyroxenite, suggesting this rock as the probable source.

The Russian platinum mines of Tagilsk are located along rivers which rise in the mountains of Soloviev, and this suggested the advisability of searching in the mountains for the original source. The country rock is a fine grained variety of peridotite consisting of colourless olivine, which predominates, bound together by serpentine in which is disseminated chromic iron; the serpentine being probably an alteration of the olivine. At a place where an excavation had been made, probably in search of platinum, a sort of pocket, a foot or so in diameter, was observed in the country rock. It consisted principally of angular grains of chromic iron, and in the interstices were serpentine and a little dolomite acting as a cement. An assay of this rock gave 0.0107 per cent of platinum or about 3 ounces per ton.

Platinum has been observed to be a constituent of some copper ores, in tetrahedrite and bournonite, at Val du Drac in France, at Guadalcanal in Spain, in the latter case in a vein; and at the Rambler mine in Wyoming; in this last occurrence it is found as sperrylite, (the arsenide of platinum,) in covellite. Two assays, by Baker & Co., of the matte in car load lots produced from the Rambler mine furnace gave the following results:

	I.	II.	
Gold	0·45	0·16	oz. per ton.
Silver	7·40	3·80	"
Platinum	1·05	0·74	"
Palladium	3·15	1·80	"

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The mines of Commern and Mechernich in Germany, where nodules of galena and cerrusite occur in Triassic sandstone, yield silver which contains some platinum. These deposits also hold copper carbonate in small quantities, so it is uncertain whether the platinum is associated with the lead or the copper.

Discoveries of platinum in traces in veins, more especially associated with copper show that the metal is not necessarily confined to olivine rocks, or even to igneous rocks. However, in all cases of the discovery of the metal *in situ*, the amount is commercially very small.

The finds of platinum in gravels in the Chaudiere River district, province of Quebec, Canada, have been mentioned in another part of this article. In connection with this, however, it is very interesting to note that some years ago a platinum nugget was found in glacial drift near Plattsburg, N.Y. This nugget weighed 104 grains, of which 46 p. c. was metallic platinum and 54 p. c. chromite. As it was found in the drift it had undoubtedly been brought from the north, very probably from the great areas of serpentine which occur in the province of Quebec, parts of which are worked for chromite.

There seems to be no doubt that this nugget has been derived from this source, although no platinum in place has yet been reported from the serpentine region. The presence of the metal in the sands of the Chaudiere seems to confirm the surmise. These two occurrences were not probably derived from the same source *in situ*; for the 'belt' of igneous rocks in which areas of serpentine occur, extends from the boundary of Vermont to the Shickshock mountains in Gaspé, and in connection with the serpentines at many points, are found deposits of chromite more or less extensive. This therefore suggests a wide field awaiting careful search for the source of the platinum.

A great many of the serpentine occurrences of this belt are described in the reports of Dr. R. W. Ells, on the geology of the Eastern Townships, and these may be consulted with advantage by any one interested in this subject. They are Vol. II., 1886, part J; Vol. III., 1887-88, part K; Vol. VII., 1894, part J; Vol. XI., 1898, part J, of the Reports of the Geological Survey of Canada.

In his report on the copper ores of Ontario (Report of Ontario Bureau of Mines, Vol. IX) Dr. A. P. Coleman mentions that on lot 15, Con. IV. of McConkey Tp., Parry Sound, to the north of Lake Cariboo, there are large areas of rusty diabase. At one point where an excavation some six feet deep, has been made, the loosened rocks show some iron and copper pyrites, and pyrrhotite. The sulphides

show in seams and stringers, but no well defined vein is exposed. It is said that Mr. Hays of Toronto found on assaying some of the selected ore 1·55 p. c. copper, 1·20 p. c. nickel and 1 oz. 3 dwt. 8 grs. of platinum per ton. However, a sample from this occurrence collected by Dr. Coleman gave some nickel and gold, but neither copper nor platinum. PLATINUM. Source and associated minerals.

The British Columbia sources of platinum, have so far been the most productive in North America and these have been the subject of special personal study on the part of Professor Kemp.

He states that the platinum bearing area of chief interest in this region is in the valley of Slate creek and along the Tulameen river below Eagle creek. A great dyke of peridotite which is flanked on both sides by areas of pyroxenite crosses the Tulameen river at its junction with Eagle creek. As far as could be ascertained this peridotite is of the dunite variety and contains no chief mineral constituents other than olivine, chromite and some secondary serpentine. The pyroxenite is a coarsely crystalline rock made up mainly of common augite and it is of later date than the peridotite which it penetrates in places in tongued dykes. Both olivine and pyroxene have been observed adhering to the nuggets found in the Tulameen, and as the peridotite contains no pyroxene it is therefore probable that the platinum has been derived from both the peridotite and the pyroxenite.

In the endeavour to trace the platinum back to its original location, tests were made of serpentine veins rich in chromite and of dykes of pyroxenite in the peridotite. Assays of the serpentine gave amounts of platinum varying from a trace to nearly 2 ounces per ton, whilst assays of specimens of the pyroxenite showing an abundance of magnetite and remote from the peridotite mass, gave only faint traces or nothing whatever. It can be concluded that the platinum is in extremely fine scales, and that large nuggets are rare and the weathering and concentration of enormous masses of rock must be surmised in order to account for the existence of the platinum-bearing gravels.

Platinum is said to have been found in former years at the mouth of Siwash creek, which enters the Tulameen, three miles above Eagle creek. The country-rock here is a granite in which are evidences of lines of dislocation. Along one of these where the granite is more or less decomposed and stained green by chlorite assays of this material gave traces of platinum. The granite of Siwash creek, which is highly acidic, consists of quartz, orthoclase, plagioclase, biotite and a little epidote. It could not be ascertained whether the platinum was

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confined to the lines of dislocation and brought there by solution or was an original constituent of the granite. However, the presence of platinum in connection with a highly acidic rock is interesting and important to note.

Platinum is said to have been observed in Brazil in quartz veins cutting a syenite gneiss.

In reviewing the different deposits and mineralogical associations of the platinum groups of metals, Prof. Kemp divides them into three types as follows.

I. Placers.—The source of the platinum of these deposits has been traced mostly to peridotite and also in cases to pyroxenites, gabbros, metamorphosed gabbros and syenite. They are the result of the weathering and natural concentration of enormous masses of rock by processes which must have been in action for very long periods of time.

II. Veins.—Occurrences of platinum in veins of different kinds have been recorded, as at Tilkerode, Harz Mts. Germany where it is found, in irregular lodes in diabase associated with quartz, selenides of lead and of mercury, dolomite and calcite; at Minas Geraes in Brazil, in quartz veins; at Santa Rosa, Colombia, and at Beresouk Russia. It has also been found associated with complex antimonial sulphides of copper and other metals (tetrahedrite and bournonite) at Gaudalcagual Spain and Val du Drac France, as well as in the Rambler mine, Wyoming, where it is found in the form of sperrylite in the covellite of the mine.

III. Disseminated in eruptive rocks.—In this case the platinum occurs in two forms as arsenide and in the native state. In the first mentioned condition it is associated with the copper-nickel ores of Sudbury, Canada, but appears in this case to be more closely connected with the chalcopyrite than with the nickeliferous pyrrhotite.

In the second form, that is in the native state, the platinum is found in basic eruptives, especially in peridotite, and it is intimately associated with chromite. Chromite occurs, as a rule, in connection with serpentines, all the deposits of any extent having so far been found in this rock, and hence appear to owe their existence to the process resulting in the alteration of the original olivine. On the other hand chromite has been discovered also in basic eruptives which are not at all altered to serpentine, so that it may also be looked upon as an original igneous mineral.

Mr. Kemp concludes his bulletin with a few suggestions of practical value which are given in full as follows:—

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1.—Experience thus far gained leads to the conclusion that platinum is very sparsely distributed in its mother rock and that the chances of finding it in quantities sufficient to mine are small. There is nevertheless, a chance. If found, the recovery of the platinum by any means other than stamping and washing remains to be solved, and as the metal may be in a very finely disseminated state, this problem is a serious feature of the situation.

2.—Large and permanent placers are to be looked for only in very old land areas which have been subjected to protracted degradation and concentration.

3.—In the assay of antimonial, arsenical, and other copper ores, but especially of tetrahedrite (gray copper or fahlerz) it is worth while to look for small percentages of platinum.

4.—Deposits of chromite deserve similar testing.

Through the kindness of Mr. R.W. Brock, we are enabled to give an advanced statement, of the results of his investigation made for the Geological Survey in British Columbia during 1902 the details of which will appear in forthcoming reports of the Department.

The paper is the result of his observations in the field and the assays of the samples were made by Mr. Donald Locke in the laboratory of the Geological Survey.

The occurrence in question is in the Burnt Basin region, Grand Forks Mining Division, British Columbia, on the 'Mother Lode' claim. On this claim two quartz veins, two feet and six feet wide respectively and some 20 feet from each other, occur in greenstone between two large porphyry dykes. The quartz is somewhat milky and has small amounts of pyrite, galena, blende and a little chalcopyrite and molybdenite, whilst in the oxidized surface ore, free gold and copper carbonates are found and native copper also is reported. The principal value is in gold with a little silver.

The samples taken for assay for the platinum metals gave the following results:—

1.—0·10 oz.	platinum per ton,	from lowest level on six feet vein.
2.—0·05	"	" "
3.—0·06	"	from six ft. vein from depth of about. 45 feet from surface.
4.—Nil		From outcrop of two foot vein.

From these and other reliable assays which gave results varying from nil to 1 oz per ton, it is evident that the platinum is very unevenly

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distributed throughout the vein matter; in some parts of the vein it may be present in commercial quantities, while in others it is absent. It has not been determined in what form the metal occurs, bnt it is probably held by the sulphides.

The district is one of considerable geological complexity. It has been the scene of numerous igneous intrusions extending from probably Palaeozoic to Tertiary times, and it has witnessed more than one mountain-building epoch.

Consequently the older rocks are much disturbed, sheared, fractured and altered. The oldest rocks are limestones, argillites and greenstones, of which the latter are the most extensive. A great part of the district is however composed of later intrusions. The limestones are sometimes pure, sometimes dolomitic. When comparatively unaltered they are dark and carbonaceous but are usually metamorphosed to a white marble. The argillites are often altered to schists and hornfels. These rocks have been intruded by the greenstone, probably an augite porphyrite, though it is usually much sheared and altered.

All the above rocks are cut by a coarse gray grano-diorite which sends dykes and apophyses into the older rocks. The greenstone on the "mother lode" is also cut by a basic gabbroidal rock which has some affinities to the non-basic monzonites. To the north is a large area of a still more recent hornblende granite, from which dykes are sent off into the older rocks. To the east is a large area of syenite of Pulaskite (alkali-syenite) and monzonite habit. This rock is of Tertiary age. Numerous dykes of syenite porphyry, some of them no doubt from the alkali-syenite cut all the older rock.

The veins occur in the more disturbed districts where the porphyry dykes are most numerous. On the 'Contact' properties several quartz veins occur, but a little to the south are veins of zinc blende with a little galena.

Mr. Brock gives his reasons for making the suggestions as to the probable occurrence of platinum in British Columbia, published in the summary report of the Geological Survey for 1901 as follows:—

'The special reasons for suspecting its occurrence in West Kootenay and the Boundary Creek districts were the presence there of basic intrusive rocks, often altered to serpentine, rocks in which platinum has been most frequently found when in place and the rocks which are the source of the Similkameen platinum, and the fact that the chalcopyrite-pyrrhotite ore-bodies of these districts bear a very marked resemblance to the platinum-bearing copper-nickel deposits of Sudbury,

Ontario. The subsequent discovery of platinum in the copper ore of the Rambler mine, Wyoming, in the same form (sperrylite, the arsenide of platinum) as at Sudbury, further emphasized this probability. PLATINUM. Source and associations.

'The basic igneous rocks in which platinum so often finds its home are not confined to southern British Columbia, but are known to occur all through the mountains at least to the Atlin district. The occurrences of ores possibly holding this metal are also similar over wide areas, so that the search for platinum must not be confined to the southern part of the Cordilleran belt in the province.*

In connection with the work recently prosecuted in the Sudbury district by Dr. A. E. Barlow for the Geological Survey Department samples of the mattes obtained were collected and assayed by Mr. Donald Locke of which we are enahled to give a resume below :—The full particulars will be found in Dr. Barlow's report which will shortly be issued.

One specimen of matte from the Mond Company's works yielded : copper, 37·37 per cent ; nickel, 41·88 per cent ; iron, 1·07 per cent ; cohalt, 0·33 per cent ; silver, 4·87 ozs. per ton ; gold, 0·066 oz. per ton, while the platinum group of minerals amounted to 0·4 oz. per ton.

In another sample of matte from the same place the gold and platinum minerals were not separated and amounted together to 0·60 oz. per ton.

In matte produced by the Orford company the results of the analyses were : copper, 34·95 per cent , nickel, 40·37 per cent ; iron, 9·64 per cent ; cobalt, 0·78 per cent ; gold, 0·15 oz. per ton and the platinum group 0·5 oz. per ton.

Another sample from the same place was found to contain : silver, 2·50 ozs. per ton ; gold, 0·10 oz. per ton and the platinum group 0·44 oz. per ton.

In corroboration of the above may be mentioned the results given in a paper by L. P. Silver, on "Sulphide ore-bodies of the Sudbury region" Vol. V Can. Mining Institute, of an analysis of a sample of Bessemer matte which was found to contain : nickel and cobalt, 39·64 per cent ; copper, 42·75 per cent : iron, 1·03 per cent ; sulphur, 14·05 per cent ; silver, 5·30 ozs. per ton ; gold, 0·75 oz. per ton ; platinum group, 0·50 oz. per ton.

* In the report of the Minister of Mines for British Columbia for 1902, reference is made to the occurrence of platinum accompanied by osmiridium in the black sands of the Quesnel River, Cariboo District So far however it is not saved.

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