092H SE NE 199

Shell Canada Calgary Nov.16, 1977

Re: Shell Placer Tests Tulameen River 1967-68

008597

History:

About 20,000 oz of Pt recovered from Tulameen area prior to 1967.

An analysis of Pt grains resulted in values

77.07% Pt
0.19% Pd
2.57% Rh
1.14% Ir
3.39% Cu
8.59% Fe
10.51% iridosmine (Ir + Os alloy)
1.69% Cr

In 1964 Tulameen Mines trenched to depth of 25 feet at placer lease 1364 in the Tulameen River about 20 miles upstream from Princeton B.C.

Tulameen Platinum Mines Ltd. (N.P.L.) found that a mechanical and chemical process was required to separate Pt and Au and used a process developed by Rao and Koch which is as follows:

Gravel is crushed and mechanically processed to produce black sand at a ratio of 50:1. The black sand is treated with concentrated HCl which leaves metallic Pt and PtO_2. The residue is calcined at 450° C converting metal sulphides to oxides. The residue is treated with concentrated H_2SO_4 and washed with H_2O and dried. The dry residue is placed in a reaction vessel with a catalyst and gaseous chlorine is added under 100 to 200 lbs pressure at less than 100° C. Residue cooled and treated with HCl to convert PtCl to soluble chloroplatinic species. Mixture is filtered and the filtrate containing Pt and other

soluble species of noble metals is treated with sodium borohydride which produces a metallic black powder. The black powder is filtered off and dried with a recovery of 2 grams of black powder from 10 lbs of black sand. Pt is present in amounts from >0 to 98% weight. (500 lbs gravel ≤ 2 gms Pt). Recoverable Pt from the sample used in the process is:

≈ 280 g/t black sand
or ≈ 5.6 g/t gravel

Insufficient work was done to determine whether or not this sample is representative of the entire deposit.

Table 1
Tulameen Pt Mines Ltd.
Analytical Data
New Samples Oct.14/66
Analytical Data - R & D

Sample	Tulameen	Prelim. Spec. Analys.	Precise wet Analysis
(1) Gravel 50 t/day processed by 2 men.			
(2) Black Sand Processed from gravel 1 t/day		>10% wt. Fe 1-10 Al,Mg,Si,Ti 0.1-1 Cr,Cu,Mn,Sn,V <0.1 Ca,Pb Ag <0.1% wt. Iridium Detected ≤500 ppm →	4 oz Ir/ton
(3) Processed Black Sand 0.15 ton/day It is used as feedstock to Tulameen's Chlorination Method for rec of Pt		>10% wt. Si 1-10 Al,Cr,Fe,Ti 0.1-1 Mn,Na <0.1 V,Ca,Cu,Mg,Sn Platinum 0.1±0.01% wt. Silver 0.04±0.02 Gold Detected <50 ppm	
(4) Black powder Rec product 400 g/50 tons gravel or 400 g/1 ton Black sand	Platinum	>10% wt. Pt,Cu 1-10 As,Fe,Si,Ti 0.1-1 Sb,Ca,Mg,Ni,Sn <0.1 Al,B,Cr,Mn Platinum 50±10% wt. Silver 0.1 Au detected (≤ 50 ppm) Rhodium detected (≤100 ppm) Iridium detected (≤500 ppm)	Pt 69±0.5% wt.

Table II

Gravity Separation On Riffle Table

Distribution of Pt/Au in Riffle Table Cuts

Shell Sample - May

	Particle Size Cut	Mat. Bal. Around Riffle Table Separation wt. % of Particle Size Cut			Pt/Au Assays of Riffle Table Cuts /Ton of Particle Size Cut			Pt/Gold Loss to Tailings
		Feed	Blk Sand Cone	Tailings	Feed*	Blk Sand Cone	Tailings**	Cut %
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	2½+ in	100	1	99	2.45	0.02	2.43	99
(2)	3/4-2½ in	100	4	96	1.65	0.05	1.60	97
(3)	6 mesh-3/4"	100	2	98	1.65	0.03	1.62	98
(4)	20-6 mesh	100	2	98	1.71	0.07	1.64	96
(5)	65-20 mesh	100	4	96	7.75	0.42	7.33	94
(6)	65 mesh	100	3	97	9.86	1.66	8.20	83

*Assuming Pt @ $160/Troy oz.
Au @ $35/Troy oz.

**obtained by difference (5)-(6)

II Placer drilling was carried out in three lines of drill holes on the Tulameen valley floor, about 10 to 17 miles, upstream from Princeton. Twenty four holes, in three lines, totalling 2500 feet were sampled at 4 foot intervals and each sample was screened to 5 particle sizes. Bedrock was reached in line 2 but only in 3 holes at the edge of the valley in the other two lines.

Assays were disappointingly low, with minor exceptions from the drill holes near the bulk sample pit the levels were less than 0.3 ppm Pt (20 mesh size fraction). During analysis, when it became evident that the values were low, it was decided not to assay every sample. However a minimum of two samples per hole were assayed.

Conclusions:

(1) There is some question regarding the Shell drilling method producing representative assays of the entire volume of gravels.

(2) The form and manner in which the Pt occurs is not clearly established. Tulameen Platinum Mines Limited and Shell found that a process of chemical recovery of Pt as well as mechanical concentration was necessary. There is some thought about Pt being associated with magnetite within rock fragments.

(3) The cost of treating the gravel containing Pt, as conducted by Shell, was prohibitive.

K.E. Northcote

Shell Involvement Tulameen Project

I Bulk Sample

In 1967 Shell obtained a 10 ton sample from Tulameen Platinum Mines Ltd. Placer Lease 1365. Shell split the sample returning one half to Tulameen Platinum Mines Ltd. and carried out a study of the retained 5 tons of samples. Shell's conclusions resulting the study are as follows:

(1) Rao and Koch process used by Tulameen Platinum Mines Ltd. fails:

  (a) Precious metal content is far below the value required for a breakeven operation based on estimated chemical/ operating costs.
  (b) Riffle table concentration of Pt and Au in black sand is ineffective, resulting in a loss of over 90% of the values into tailings.

(2) A new recovery process is required.

(3) Precious metals in 20 mesh fraction offers incentive for further exploratory programs with the following objectives:

  (a) Determination of lateral-vertical distribution of 20 mesh fraction in Tulameen Valley.
  (b) Pt/Au values in 20 mesh fraction
  (c) Search for possible recovery methods.

The 10 ton sample is not necessarily representative of valley but is representative of material in which Tulameen worked. There appears to be some discrepancy between the values obtained in Tulameen Platinum's first sample and that taken by Shell.

Tables only

AN INVESTIGATION OF CERTAIN CANADIAN PLATINUM AND MANGANESE RESOURCES.*

By G. C. MACKENZIE

(Annual Meeting, Montreal, March, 1919)

CIM VOL. OF TRANSACTIONS #22, 1919

Prior to the war, the world's supply of platinum was derived almost entirely from the Russian Urals; but when hostilities commenced in the fall of 1914 the Russian production was reduced almost one-third, due principally to the conscription of miners for the Russian army. This state of affairs was further aggravated by the fact that a very large quantity of platinum was required by the munition industries of England, France and the United States, in the manufacture of sulphuric acid, and also for the ignition apparatus of all types of internal combustion engines.

The U. S. of Colombia, in South America, is second only to Russia as an important source of platinum, producing in 1913, 15,000 ounces as against Russia's 250,000 ounces; but in 1916 Columbia produced 25,000 ounces, the Russian output falling to 63,900 ounces that year.

In 1906 platinum was worth from $20 to $38 per troy ounce; in 1914 its value increased to an average of $45 per ounce. At the end of 1915 the price had again advanced to $85 per ounce, and by December, 1916, had reached a figure of over $100 per ounce. In the spring of 1918 the United States Government made an official fixed price of $105 per ounce of refined platinum and adopted stringent regulations governing its purchase and exportation. The British Government followed suit in the fall of 1918 with the notification that they were prepared to pay the official American price for Canadian platinum.

The whole amount of platinum so far produced in the world to date is estimated by Dr. Geo. F. Kunz at 4,000,000 ounces, a quarter of which is assumed to be in the United States, with the addition of about 400,000 ounces of associated platinum metals.

*By permission of Canadian Munition Resources Commission.

He distributes platinum in the various industries as follows:—

	Oz.
Catalyzing	400,000
Dental purposes	1,000,000
Chemical apparatus, etc	1,000,000
Electrical devices	500,000
Jewellery	500,000

Kunz estimates also that the following amounts used for catalyzing purposes are distributed in the different countries about as follows:

	Oz.
United States	200,000
England	100,000
Germany	70,000
France	30,000
Total	400,000

The following table of the world's production is taken from Dr. Kunz's article in the Mineral Industry, Vol. XXV:

World's Production of New Platinum in 1913-1919, by Countries

(In troy ounces.)

Country.	1913	1914	1915	1916
Russia, crude	(a)250,000	(a)241,200	(a)124,000	(a) 63,900
Canada, crude (b)	(a)50	(a)30	(a)100	(a)60
New South Wales and Tasmania, crude (c)	1,275	(a)1,248	303	222
Colombia, crude	(a)15,000	(a)17,500	18,000	25,000
United States, domestic crude	483	570	742	750
United States, refined from foreign and domestic matte and bullion (d)	(d)1,100	2,905	5,753	2,256
Borneo and Sumatra and other crude (e)	200	(f)	(f)	(f)
Total	268,108	263,453	148,898	92,488

(a) Estimated. (b) In addition to platinum contained in matte and bullion refined in the United States. (c) Chiefly iridosmine. (d) Does not include refined platinum from domestic crude. (e) Includes small production in Madagascar. (f) No basis for estimate.

As a producer of this metal Canada has, up the present, been of very minor importance. A few hundred ounces are recovered annually from the refining of Sudbury copper-nickel matte by the International Nickel Company in the United States, and probably a somewhat larger amount is produced by the Mond Nickel Company at their refinery in England. In this connection it is interesting to note that the Mond Nickel Company are reported to be making a better recovery of platinum metals by their process of refining than the International Nickel Company have so far accomplished at their New Jersey works.

The report of the Royal Ontario Nickel Commission states that in 1916 the matte produced by the Canadian Copper Company was estimated to contain 5,640 ounces of platinum and 8,460 ounces of palladium, and that the recovery of these metals by the International Nickel Company in that year amounted to 1,093 ounces of platinum and palladium together with 257 ounces of other metals of the platinum group. Recent research investigations conducted by the International Nickel Company have shown that it is possible to improve greatly their recovery of the platinum group metals, and it is probable that these improved methods will be practised in the near future. The Mond Nickel Company did not furnish figures of platinum recoveries to the Royal Ontario Nickel Commission, but from assays made by the Commission it would appear that the Mond Nickel Company's matte contained more of the platinum group metals than the matte of the Canadian Copper Company.

The British America Nickel Corporation will employ the Hybinette process of electrolytic refining, which it is expected will make a more or less complete recovery of the precious metals in the matte.

Should the International Nickel Company succeed in recovering a high proportion of the precious metals, it is well within the range of possibility that the total production of platinum-group metals by the three nickel companies will exceed 10,000 ounces yearly.

Some years ago a considerable quantity of native platinum was produced from the Tulameen district in British Columbia.

There are no data of the amount produced previous to 1885, but since that date the platinum recovered has been estimated by Camsell at 10,000 to 20,000 ounces,[1] and at one time this district was the principal producer of platinum in North America.

In view of the serious shortage in the world's supply of platinum, and more especially because of its importance as a war metal, the Imperial Munitions Board, in June, 1918, requested the Munition Resources Commission to undertake an examination of certain platinum occurrences in Alberta and British Columbia.

One of the first properties to be examined was at Fort Saskatchewan, Alberta, on the Saskatchewan river. The

Empire Hand Drill in operation at Fort Saskatchewan, Alberta.

owners of this property having applied to the Imperial Munitions Board for examination of the ground, and subsequent financial assistance, if sufficient platinum were discovered, the Commission was asked to undertake a systematic examination

[1]Memoir No. 26. Geology and Mineral Deposits, Tulameen District, B.C., G.S.C., 1913.

of the property, and to report thereon at the earliest possible moment.

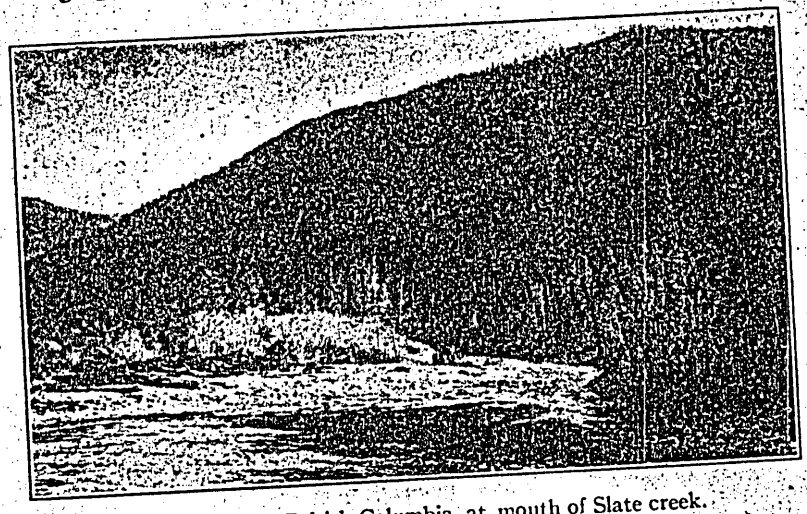
Dr. W. L. Uglow, of the Commission staff, was sent to Fort Saskatchewan early in June, and made a preliminary report to the effect that both gold and platinum were found to occur, although it was difficult to estimate the value of the ground by sampling methods employed in the preliminary examination. It was then decided to survey and drill the property in an approved manner in order to demonstrate beyond any uncertainty the possibility of platinum production, and an Empire drill was placed at Dr. Uglow's disposal for this purpose. Pending the arrival of the drilling equipment at Fort Saskatchewan, Dr. Uglow was instructed to make a quick trip up the Peace river for the purpose of investigating certain alleged platinum discoveries in the vicinity of the junction of the Finlay and Parsnip rivers with the Peace river. His report on the possibility of securing platinum in the Peace River district was not optimistic, and he returned to Fort Saskatchewan and commenced the drilling of the latter property early in the month of July.

Drilling was continued at Fort Saskatchewan until about the middle of August, during which time 22 holes were put down with the Empire drill; of these, 18 were sunk to a bed-rock, which was a clay-shale. The Fort Saskatchewan work may be briefly summarized as follows:

The gold and platinum occur in the form of very small flat flakes or scales rather larger than the fiftieth of an inch in their largest dimensions, and therefore their recovery by dredging operations would be very difficult. The gravel which carries the precious metal has an average thickness of about 11 feet, and covering a very large proportion of this gravel is a mantle of fine sand silt with an average thickness of 16½ feet. The flakes of the precious metals were found to lie chiefly in the upper four or five feet of the gravel, and therefore their recovery would require the entire removal of the overlying mantle of silt, which itself is almost quite barren. The samples, with one or two exceptions, were found to contain less than 10 cents in

gold and platinum per cubic yard of gravel, and while there are smaller and shallow stretches of the gravel on the river bars which yield values from 12 to 58 cents per cubic yard, the property as a whole was not considered valuable for large scale dredging operations.

Meanwhile, early in August, the writer, in company with Mr. Charles Camsell of the Geological Survey, made a careful examination of the stream gravels of the Tulameen river, British Columbia, and concluded therefrom that this stream should be prospected by means of core drills to determine its value as dredging ground. The town of Tulameen is situated in the



Tulameen river, British Columbia, at mouth of Slate creek.

Similkameen Mining Division in southwestern British Columbia, and is reached from Vancouver via Ruby Creek Junction and Kettle Valley railway. The Tulameen river is a small mountain tributary of the Similkameen river, forming a junction with the latter stream in the vicinity of the town of Princeton. In the early days the Tulameen was worked energetically for placer gold, and a considerable amount of platinum was also secured in the past, but as the price of this metal at the time

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of early mining operations was only from $5 to $10 an ounce, its recovery was not given much attention.

During the preliminary survey of the Tulameen some small scale-washing operations were conducted with the object of securing a rough estimate of the value of the ground. In those tests about 90 cubic yards of gravel were washed, and the small clean-up made therefrom was distinctly encouraging. The gold and platinum were found to occur in approximately the proportions of 60% of the former to 40% of the latter, both metals being in rather small grains and flattened scales, although there was sufficient evidence from the character of these small particles to point to the fact that the metals had not travelled far from the source of their origin.

Both Camsell and Kemp have described the occurrence of platinum in this district exhaustively, and there is no need of further amplification. Both of these investigators determined the fact that platinum originated with the pyroxenite rocks of the district associated with chromite and magnetite. It is interesting to note in this particular that we were shown several small nuggets of platinum encrusted with chromite which the uninitiated might readily mistake for pure chromite or magnetite. When these small encrusted nuggets were immersed in dilute nitric acid for a short time the coating of chromite was dissolved away, leaving the kernel of platinum.

During our investigation in the field, there were no large nuggets of platinum discovered, but we were shown a very fine collection of nuggets, the property of a Mrs. Cook, of Coalmont. The largest of the Cook nuggets was about the size of a large kernel of corn, and the smallest about the size of a grain of wheat. These nuggets have been on exhibition at various times, and as they are a very unique collection they should be acquired for the museum of the Department of Mines in Ottawa.

The upper portion of the Tulameen river lying above the mouth of Slate creek has a more or less canyon-like character, the banks being very steep and precipitous, and this portion of the river is being worked at the present time by prospectors for

the recovery of the precious metals. Some of these prospectors are working the high benches from 50 to 100 feet above the creek bottom; others are attempting to recover the gold and platinum from pot-holes in the river bed; but the sum total of their operations is rather small, and the production of precious metals is almost negligible, making little better than wages for the operators.

Below the mouth of Slate creek, and for three miles down stream to the town of Tulameen, the character of the river is decidedly different. The river valley broadens to an average width of 900 feet and the gravel lies in large bars and low-lying benches at depths that vary from 20 to over 100 feet. It was this area that was considered should be prospected by means of core drills, The total quantity of gravel has been estimated roughly at 15,000,000 cubic yards, most of which consists of heavy, coarse pebbles, with many boulders the size of a football. Occasionally, large boulders the size of an automobile are encountered, but they are by no means numerous, and should not present any serious difficulty in dredging operations.

The Kettle Valley Railway touches the Tulameen river at the town of Tulameen, three and a half miles below Slate creek, and follows the river for a distance of approximately 20 miles down stream to the town of Princeton. The question of transportation is therefore solved. The river bed between the town of Tulameen and Slate creek is not heavily timbered, although there is some quantity of poplar and jack pine with an occasional good-sized spruce, and more rarely fir and red and white pine. The river has a fall of 116 feet between Slate creek and the town of Tulameen, and flows for the major part of this distance in a series of small rapids interspaced with quiet stretches with an average speed of approximately five miles per hour. The stream is not deep—probably the deepest holes at the foot of the numerous small rapids are not greater than 15 feet, whereas the average depth of the river at low water is about 1½ feet. The river, like all mountain streams, is very turbulent in the spring of the year, but this condition should

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not seriously affect dredging operations if due precautions are taken.

Drilling with the Empire hand equipment was commenced in the month of September, and after the completion of three holes, the deepest being 62 feet, it was decided to install a power drill of the Keystone type, as the gravels were too heavy and tight to allow of much speed being made with the Empire equipment.

The chief advantage of the Empire hand drill is its mobility. It will take down so that the largest piece to be transported does not weigh more than 250 lb., and providing that the gravels to be examined are not heavy or do not contain too many boulders considerable progress can be made with this equipment. The manufacturers claim that the essential feature of the Empire is the rotation of the casing during the entire drilling operation. A platform is mounted on the top of the casing upon which four abourers stand and alternately lift and drop the drill rods to which are attached the drilling tools. Providing the ground is not very tight and does not consist of heavy gravel, the rotation of the casing by means of horse-power, together with the weight of the equipment and the men on the platform, will sink the casing as drilling proceeds, and the core of sand and gravel accumulated in the inside of the casing is pumped out as fast as it forms.

A power drill of the Keystone type works in a somewhat different manner. The casing is driven into the ground for every foot made, and as a general rule progress is made by alternately driving for one or more feet and then pumping the core accumulated from the previous driving. When exceptionally large boulders are encountered, drilling below the casing is resorted to and is generally permissible. The Keystone casing is larger and heavier than the Empire, and is driven by means of two steel driving-blocks bolted to the drilling stem, the total weight of which is approximately 800 pounds. In driving, some fifty or sixty blows are struck per minute, with a fall of approximately fourteen inches, and it is an exceptionally large

at the summit of the divide between Chemainus and Cowichan rivers, on Vancouver island.

At the time of the first visit the small amount of stripping accomplished had disclosed the outcrop of a secondary deposit of manganese oxide for a distance of approximately 100 feet, striking 10° south of west, and dipping 70° towards the south.

The deposit lies near the contact of the Sicker series and the Cowichan group, described by C. H. Clapp, in map 17A of South Vancouver island, published by the Geological Survey. The orebody appears to be associated with the quartzite rocks of the Sicker series and consists of manganite and possibly some psilomelane which has undoubtedly been derived from the alteration of rhodonite, the silicate of manganese, which is strongly in evidence on both sides of the orebody. Samples taken across the widest portion of the outcrop indicated approximately 12 feet of ore with a metallic manganese content of better than 50% and with less than 15% of silica. Phosphorus was found to be present in amounts generally less than .075%.

The report to the War Trade Board was to the effect that the deposit consisted of a promising prospect of merchantable metallurgical ore, and that the owners were prepared to develop their property under certain guarantees providing for the marketing of the ore produced. The War Trade Board, after some considerable delay in giving consideration to the proposal, eventually declined to furnish the required guarantees, and no production of ore has taken place to date.

A second inspection of this property was made on the 11th November, and as considerably more stripping had been accomplished at this later date a much better opportunity was given of securing representative samples, which on analyses proved to parallel very closely the results from the first set of samples obtained in August.

Unfortunately, the owners contented themselves with merely stripping the surface, and, although they have disclosed a very attractive outcrop of high-grade metallurgical ore, they had not during 1918 accomplished any cross-cutting or sinking

to prove the quality of the ore at depth. This, of course, is to be regretted, as in all secondary deposits of this nature, particularly of manganese, the deciding factor as regards the value of the deposit is the extent to which oxidation of the original mineral has taken place. That the owners realize the importance of this is indicated by the fact that they are now engaged in removing portions of the outcrop to prove the quality of the ore for at least 10 feet below the surface.

If the Cowichan deposits are proved to contain a large tonnage of metallurgical ore, such discovery would be of considerable importance to the iron and steel interests of this country. At the present time, Canadian iron and steel works are using rather over 1,000 tons monthly of ferro-manganese, all of which is imported either from England or the United States, and therefore if a domestic supply of manganese ore can be assured its utilization should be carefully investigated. The situation of the deposits with respect to the market in eastern Canada is unfortunate, and it is a matter of doubt whether it would be advisable to manufacture ferro-manganese on the coast, or transport the ore by boat to Atlantic ports via the Panama canal. The prospect for the manufacture of ferro-manganese on the coast possesses several attractive features and one outstanding problem, which is the cost of electric power. According to figures given to the writer and also quoted by Dr. Stansfield in his report on the iron smelting possibilities in British Columbia, electric power is quoted at a considerably higher figure than would admit of profitable electric smelting, even in the case of ferro-manganese.

The Commission intends to publish very shortly all information at its disposal on the Cowichan manganese deposits, and the possibilities of manufacturing therefrom in Canada high-grade ferro-manganese.

DISCUSSION

MR. J. B. TYRRELL: Mr. Mackenzie has given us an interesting account of his investigations into both the occurrence and the value of gold and platinum in the alluvial gravels and

sands of the Tulameen and Saskatchewan rivers in British Columbia and Alberta, respectively.

These two streams represent different types of valley formation, and consequently the alluvial deposits formed by them, and in which grains of gold or platinum may be present, are arranged in different ways.

The Tulameen river above the mouth of Slate creek would seem from his description to flow in a V-shaped valley with a narrow bottom in which there was comparatively little accumulation of alluvial wash, except such as was dropped behind rocky dams. Apparently the bottom of the valley has not been widened to any extent by meandering of the stream. If, therefore, a paystreak carrying heavy metals such as gold and platinum exists in this portion of the valley it occurs in the point of the 'V,' and its location is in consequence a comparatively simple matter.

Below the mouth of Slate creek the stream would appear to have a much lower grade. It is no longer deepening its valley, but is depositing gravel, in some cases to a depth of 72 feet at least. The valley bottom is now 900 feet wide with the river meandering from side to side in it. It would be interesting to know whether we have here a definite filling of a V-shaped valley with sand and gravel, in which case the paystreak would still continue to run along the bottom of the 'V,' or whether the whole rock bottom of the valley has been widened by the meandering of the stream, in which case the paystreak, if it exists, would mark the original position of the bottom of the old V-shaped valley, even though it now lies on a comparatively level floor. We are told that a paystreak has been definitely discovered, though it has not been traced for any great distance. In that case it would be wise for those in charge of future explorations to have a careful physiographic survey of the valley made in order to determine its exact method of formation and growth, and the consequent position of the remainder of the paystreak under the alluvial gravels. Such an investigation would not be for the purpose of satisfying mere academic curiosity, but would be a definite application of known

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principles on the formation of paystreaks to results of economic and financial value.

The Saskatchewan river in the vicinity of Edmonton and Fort Saskatchewan has a different character from the Tulameen, and has excavated a different style of valley. The rocks through and over which it flows are soft and easily eroded, and form no hard barriers to break the regular and even flow of the water. Consequently, although the stream slowly cut its way through the soft rock and deepened its valley, it also, at the same time, meandered and widened it, depositing beds of sand and silt in the bends. In other words, it cut its valley both downwards and laterally by a constant serpentine or whiplash movement. Such a mode of formation is different from the constant downward cutting of a V-shaped gorge in which water flows in a comparatively narrow channel, and into the bottom of which any heavy metals would settle. The serpentine movement and constant change of position of a stream like the Saskatchewan does not permit of the flow of water for any great length of time in one definite channel, and consequently heavy material carried by it does not continue to drop along a narrow course, as in a gorge, but is distributed by the windings of the river, and the constant changes in the position of its bends, across the whole width of the bottom of the valley. In such a case, therefore, no regular well-defined paystreak was formed, and the only concentration of heavy material that might be looked for would be in association with coarse gravel on the upper side of the bends, and not necessarily on bedrock.

Mr. Mackenzie's investigations furnish interesting corroboration of the above principles in that he finds "the precious metals to lie chiefly in the upper 4 or 5 feet of the gravel" on the banks of the Saskatchewan, and not on bedrock.