BOAT BASIN FARM
Westcoast Vancouver Island

521811
92F/4 & 5

Log and Sawmill Division

September 3, 1986

John Brock
Suite 1027
470 Granville Street
Vancouver, BC

BY HAND

Dear John,

Enclosed is a report on the Tofino Inlet platinum/palladium/copper/nickel massive sulphide property which I promised to forward to you on completion. The author of this report, Ian Mason P.H.D., was Cominco's geologist on the property but Ian now is an independent consultant.

Several exploration companies and consultants will be receiving this report as they independently approached me for same. The property is wholly-owned by the undersigned and I am seeking an Option arrangement which provides a cash deposit, shares, option payments and a royalty interest.

Peter Leceuter, Cominco's geologist in charge of the project this year until its abandonment, is preparing geology maps and other data and this should be available next week. Should you wish further information please give me a call at 661-2413.

Yours truly,

Peter Buckland

PB/mgg

encl.

TOFINO PLATINUM

BRADAN EXPLORATION

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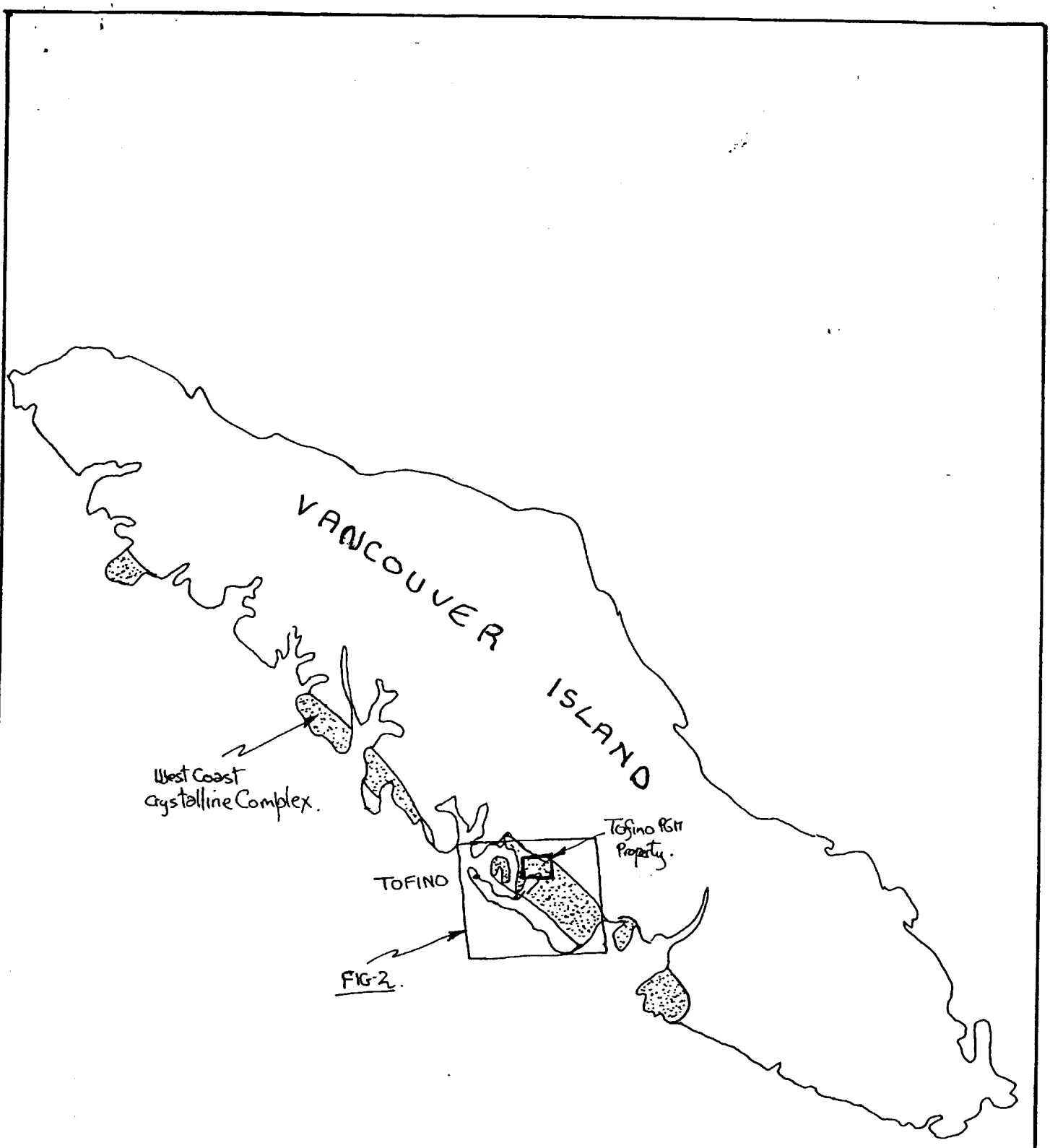
TOFINO PGM

Evaluation Report

by

IAN M MASON

Ian M Mason PhD FGAC



Scale 1 : 2 million

0 20 40 60 Km.

FIG-1 location of Tofino PGM. and distribution of WC3 rocks.

July/86 WM

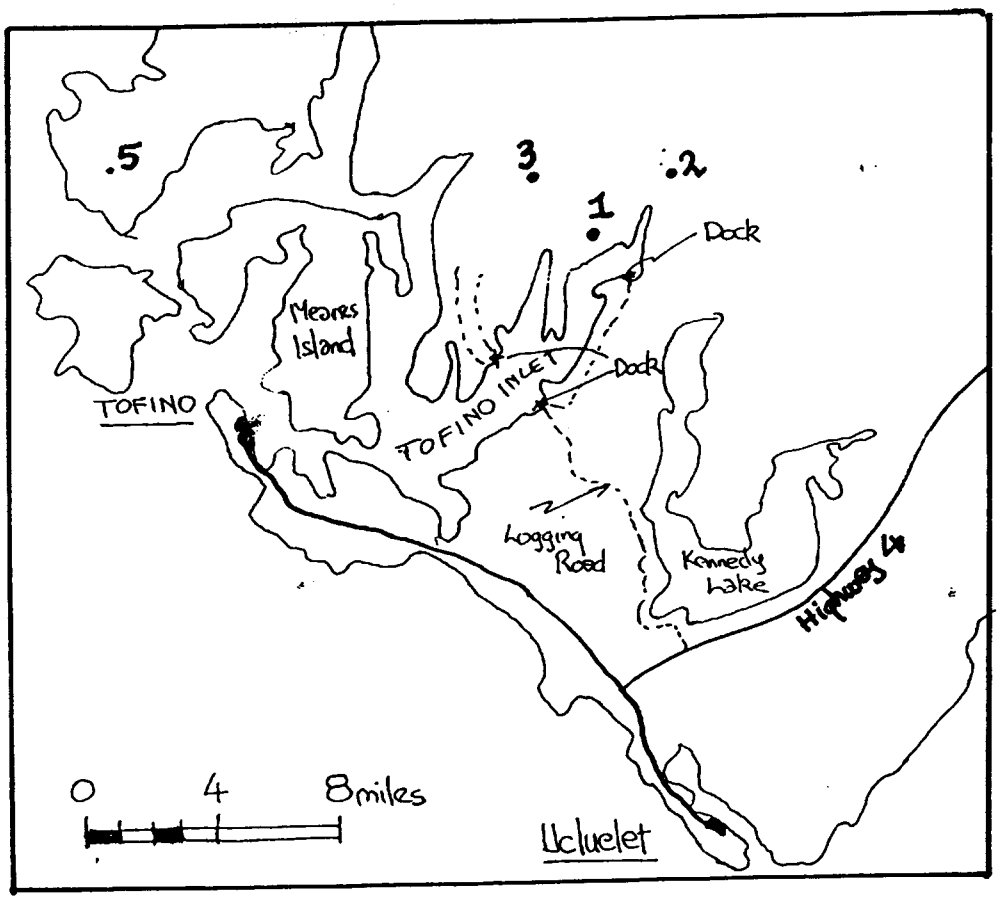


Fig 2. location of Tofino PGM showing.

1 Tofino PGM Showing
2. Area of Co/Mo skarns
3. Former Fandora Au
4 Catface (Porphyry Cu)

TOFINO P.G.M.

Summary

Analyses from isolated outcrop on an unmapped 100 claim property on Vancouver Island demonstrates the presence of ore-grade platinum group metals [P.G.M.] in a 2 m. wide sulphide band. Table 1 and compare Table 2.

While the isolated outcrop is only 30 m. x 10 m. the associated rock types (altered ultramafics and anorthosite) and the Cu/Ni sulphide bands suggest it is part of a much larger body - i.e. that it is not a freak, inconsequential occurrence. The property thus has both demonstrated grades and potential for significant tonnage: latter is considered critical point and should be focus of initial exploration.

The property is located on a forested peninsula, ranging from sea level to 300 m., near the town of Tofino in S.W. Vancouver Island. The location and elevation of the property permit year round exploration with virtually zero mobilisation costs. It is recommended that advantage be taken of this to stage exploration in small segments. Stage I should include mapping of property (since assessing potential depends on location and distribution of appropriate rock types) plus preliminary evaluation of nature of overburden depth and distribution.

Since initial data suggests magnetic surveys will not be useful mapping adjunct, Stage II will probably involve trenching (back hoe) to increase data on rock types, depending on results of Stage I.

It is estimated that P.G.M. prices will increase by values ranging from 40-100% over the next 15 years (depending on assumptions used) even if there is no disruption of supply from South Africa. This virgin property represents one of only a handful in North America with demonstrated ore grade values.

TOFINO PROPERTY

Evaluation Report

1. Mineralisation

A small isolated outcrop (30 x 10 meters), containing up to 30% sulphides in two bands, was mapped and sampled in 1984. Analyses of the samples showed that not only were there significant copper and nickel values, as expected, but that the mineralised zones also contained ore-grade platinum group metals (P.G.M.)[1]: Table 1 - compare Table 2.

The mapping, and subsequent petrography, showed that the sulphides occurred in two parallel bands in a host interpreted as altered ultramafic and anorthositic rocks, with the sulphides confined to the ultramafic bands. Despite differences discussed later, this association of P.G.M. with layered ultrabasic/basic rocks occurs in all known lode P.G.M. deposits. For example, 80% of total world production is currently extracted from the "reefs" of the layered Bushveld Complex in South Africa. The best known of these, the Merensky Reef, has an average thickness of 0.75 m. and grade of 5-8 g/t - c.f. chip samples of Table 1.

The Stillwater Mining Company is currently preparing a P.G.M. deposit in this type of host rock in Montana for production in 1987. Reserves are estimated at 12 million tons with grade of 15 g/t. Initial production is at 500 tpd rising to 1,000 tpd by 1991. The project is estimated to have a rate of return of 22.5% in constant 1985 dollars. The project's cash flow is estimated to run positive in the second year of mill operation, and payout 6 years after initial production: the mine will operate for 20 years but there are clear indications from geology and widespread drilling that further reserves will be defined. The defined mineralised zone is 1,000 m. x 2 m.

The showing at Tofino Inlet has grades of the right order and, equally important, the geological setting is perfectly consistent with extensive development of mineralisation: see Section 3.

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[1]P.G.M. used most commonly to mean platinum + palladium (85-90% of total P.G.M.) but strictly speaking also including ruthenium, rhodium, osmium and iridium, but because of much lower tenor in mineralisation and lesser economic importance the latter are often relegated to trace role.

TABLE 1

Analyses from Tofino Showing

	Total P.G.M.	Pd g/t	Pt g/t	Au g/t	Ni %	Cu %	Co %	Pt/ Pd+Pt
1.	6.35	4.70	1.65	0.36	0.25	3.57	-	0.25
2.	2.65	1.80	0.85	0.14	0.61	0.20	-	0.32
3.	19.20	15.40	3.80	0.62	8.50	0.43	-	0.20
4.	>3.30	-	3.30	0.03	14.00	-	0.14	-
5.	>4.30	-	4.30	0.24	0.50	-	0.16	-
	(1-5 Grab Samples April 1984)							
6.	6.40	4.70	1.70	0.13	1.46	0.98	0.17	0.27
7.	0.40	0.30	0.10	0.11	0.08	0.36	0.002	0.25
8.	0.52	0.50	0.02	0.03	0.48	0.19	0.01	0.03
9.	>11.0	>10.0	1.15	0.60	1.45	5.40	0.05	0.10
10.	3.25	2.10	1.15	0.08	0.55	0.23	0.08	0.35
11.	6.85	5.60	1.25	0.01	1.64	0.86	0.07	0.18
	(6-11 Grab Samples June 1984)							
12.	8.40	6.10	2.30	-	0.35	2.97	-	0.27
	(12 Chip samples over 1.75 m)							
13.	9.60	7.30	2.30	-	3.80	1.26	-	0.24
14.	1.37	1.07	0.30	-	0.58	0.46	-	0.30
15.	4.70	3.55	1.15	-	2.88	0.51	-	0.25
	(13-15 conterminous chip samples - 0.5 m, 1 m, 0.5 m)							
16.	4.26	3.25	1.01	-	1.96	0.61	-	
	(16 wt. average of 13-15 - 2 m)							

Table 1 - Notes

1. Pt, Pd analyses carried out by Chemex. Fire assay method with collection on Pb followed by A.A. analyses. While this is a common procedure it is not the most up to date (collection on Ni sulphide followed by neutron activation analysis.

2. Note Pt/Pd+Pt ratio about 0.25 except for cases where P.G.M. are very high or very low (8. & 9.).

TABLE 2

Ores of P.G.M.

	Location/Mine	Total P.G.M. g/t	Pd g/t	Pt g/t	Au g/t	Ni %	Cu %
1)	W. Platinum [SA] (Merensky Reef)	5.3+	1.6	3.7	0.4	0.16	0.079
2)	Rustenberg [SA] (Merensky Reef)	5.4	1.55	3.66	0.20	-	-
3)	Vlakfontain [SA] (Ni Sulphide pipe)	3.3+	2.0	1.3	0.1	9.7	1.2
4)	Sudbury	0.7	0.3	0.3	0.04	1.5	1.3
5)	Stillwater [USA]	14.7	11.4	3.3	-	0.12	0.04
6)	Noril'sk [A] (Russia)	9.6	5.6	1.90	0.3	-	-
7)	Noril'sk [B]	9.4+	8.4	1.0	0.45	1.3	3.0
8)	Noril'sk [C]	9.5+	6.90	2.6	0.23	1.3	1.6
	Tofino (Avge. Table 1)	4.06	3.3	0.76	0.14	0.81	1.17

Table 2 - Notes

1. South Africa (1,2) produces about 80% of total world production and Noril'sk (6,7,8) a further 17%. At both Noril'sk and Sudbury P.G.M. is produced as by-product of Cu/Ni production, thus their contribution is limited to some extent by condition of this market.

2. Stillwater planning production (1987?) at mining rate of 1,000 t.p.d.

3. Mine grades in P.G.M. are notoriously difficult to ascertain and appear to vary with who is talking. Those given are believed to be within 25% of true value since they represent a fair consensus of values published in various sources.

2. Location and Access (Figs. 1 and 2)

The showing is located at an elevation of 270 m. on a forested peninsula separating Tofino and Tranquille Inlets on the west coast of southern Vancouver Island. The property extends from tidewater over the main ridge.

Access has been by a one hour boat trip directly from the town of Tofino. Logging this summer, however, has reached the shore, 1 km. across Tofino Inlet from the property, which can now be reached from a jetty at this point. The 20 km. logging road connects with the main island highway at the south end of Kennedy Lake, i.e. closer to Ucluelet than Tofino. Presumably, in the near future logging will eventually reach the property, accompanied by a road network and new outcrops.

This ease of access leads to economical mobilisation, the property being reached by a three man crew, via truck and ferry in less than 6 hours from downtown Vancouver, at a cost of $60.00! Moreover, because of its location and elevation the property can be worked on a year round basis, allowing exploration to be economically staged in smaller segments.

3. Previous Work

Although the showing was mentioned as a Cu/Ni showing in a B.C. Department of Mines report on the now defunct, nearby Fandora gold mine (Fig. 1), it does not appear to have stirred the blood of prospectors; probably because originally the showing was quite small and Vancouver Island just wasn't an 'in' place for Cu/Ni. There was no previous knowledge of P.G.M. The only historical work seems to have been done by Lorne "Bus" Hansen who included the occurrence in property he staked to cover Cu/Mo skarn veins to the north (Fig. 1). By a judicious programme of blasting, outcrop-clearing, trail-making, etc. he succeeded in keeping the property in good standing for thirty years without substantively impinging on its potential.

Cominco briefly visited the property in 1984/85 and as a result of mapping and sampling the property was optioned from Peter Buckland - Hansen's successor. Work carried out by Cominco included resampling the showing, plus a reconnaissance sweep of the shoreline of Tofino Inlet in 1985. In early summer of 1986 a mag/V.L.F. survey was carried out by Cominco, just prior to an upcoming option payment, and failing to get obvious major conductors and being unable to expeditiously negotiate a third party J/V, the property was returned to Buckland. Details of this survey are not yet available.

The property has not yet been mapped and such minor geochemistry and geophysics, as has been done, is restricted to local area of showing.

4. Geology

a) Regional

The Tofino property occurs in a 250 x 15 km. belt of gneissic rocks (West Coast Crystalline Complex or WC3) exposed along the west coast of Vancouver Island from Berkley Sound to Brooks Peninsula (Fig. 2). There is not yet a definitive age for the WC3, except that it is cut by dated Tertiary Intrusions. A reasonable geological argument can be made that it represents an uplift of Paleozic rocks equivalent, in part at least, to the Sicker and Karmutsen which occur, essentially unmetamorphosed, in the Insular Belt which covers all of Vancouver Island east of WC3.

On G.S.C. maps (the only regional data available) the complex is cavalierly treated as basement and shown as a single unit, although map legends identify quartz-feldspathic gneisses, amphibolites, minor carbonates, diorites, gabbros, pyroxenites and anorthosites as being present. In the present context these last three units are considered significant.

b) Tofino Inlet

Reconnaissance mapping of the shoreline of Tofino shows that dominant rock is foliated quartzo-feldspathic gneiss with no textural evidence of protolith. The mafic folia are chlorite with minor amphibole and patchy epidote - garnet in only one specimen. Lacking chemical data it can only be inferred that this mineralogy is consistent with upper greenschist regional metamorphism of either a greywacke or andesitic volcanic/pyroclastic. Also present are bands of impure limestone - now present as diopside-garnet marble. In this area a notable feature of the shoreline is the abundance of fine-grained amphibolite dikes - locally forming up to one-quarter of the total outcrop. Mineralogy, and lensy nature of the narrower (20 cm.) of these dikes, indicate they were also involved in metamorphism. [Note that in Nootka Sound area the Insular Belt Sicker is described as being composed of "siltstone/argillite and greywacke with occasional limestones which are intimately interlayered with sills of diabase which in places exceed the sediments in thickness."[2]]

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[2]Mueller Cameron and Northcote, 1981, G.S.C. Paper 80-16.

If the WC3 is an uplifted, originally deep level section of the Sicker/Karmutsen succession then this adds credence to postulate that the gabbro-pyroxenitic-anorthosite triumverate of WC3 represents a sub-volcanic basic intrusive related to the Karmutsen lavas. That the Karmutsen lavas are so voluminous (covering most of Vancouver Island to a depth of at least 5,000 m.) suggests related intrusives will also be large. While an encouraging suggestion, the age and equivalences of WC3 rocks are not critical since grades and interpreted rock type are significant irrespective of age..

c) Tofino Showing

The showing itself at an elevation of 270 m. is reached by a rough trail from a cabin on Tofino Inlet. It consists of two contiguous outcrops on the west bank of a small intermittent stream, and covers an area of only 30 m. x 10 m. (It appears that blasting and trenching carried out by 'Bus' Hansen has loosened soil and enlarged original outcrop.)

Geologically it is made up of interbanded dark grey and white bands with the westerly 2m. grey band containing sulphide throughout. On the east the mafic rocks are in fault contact with quartzo-feldspathic rocks, while the other sides disappear under till. Because of the high P.G.M. values a preliminary petrographic study was made of the rock types. This showed that the dark grey bands were composed wholly of a felted mass of colourless tremolite blades or, in a few cases, dark green hornblende. There is no definitive evidence of original texture, nor of any alignment of amphiboles: note also complete lack of magnetite - magnetic survey will not be useful.

The white bands are composed of saussuritised plagioclase as a mosaic of straight-sided polygons, with a grain size of 0.5 mm. Significant points here are, monomineralic composition and the relatively fine grain size and the polygonal texture: the latter two features suggest annealing under elevated temperature of strained rock, consistent with recrystallisation under late stage metamorphism. Fine grain size argues against texture being due to adcumulus growth of cumulate crystals.

In hand sample, pyrite and variable amounts of chalcopyrite are only sulphides evident. Polished thin sections show assemblage to be pyrite-chalcopyrite-violarite with minsr millerito and trace pentlandite. This is an unusual assemblage which would have appeared 'queer' to geologist/prospectors familiar with the universal pyrrhotite/pentlandite/chalcopyrite in this association with mafic intrusives. 'Queer' may have been interpreted as insignificant, contributing to the general lack of interest in the showing.

Now, while the general association of platiniferous Cu/Ni sulphides with mafic/ultramafic rock is perfectly normal, some of the details indicated above are individually atypical. However, as a group, these variations from the nerm all indicate the same culprit - recrystallisation under elevated temperature in presence of fluid phase (i.e. hydrothermal alteration). In this case this hydrothermal alteration may be related to the metamorphism that affected the host gneisses since it seems unusually pervasive and not restricted to local zones. Not only are the mafic minerals, in this case originally pyroxenes, altered to hydrated amphiboles, but the plagioclase is heavily saussuritised and annealed, and even the sulphides have been altered to pyrite-chalcopyrite-violarite.[3]

Table 1 lists analyses of grade and chip samples from the 2 m. sulphide band. Table 2 gives basis for comparison with <u>all</u> current and potential producers and shows that grades at Tofino are solidly in a superior category.

<u>The critical unknown at Tofino is the tonnage. Determining this, either directly or indirectly, must be the principal goal of future exploration.</u>

The data available at this stage, and the arguments to be drawn are patently encouraging on this point.

i) <u>Petrography</u>

Host rocks are reasonably interpreted as part of an altered layered intrusion. Since hypabyssal intrusions such as sills and dikes, are virtually never layered, this in itself implies significant size. It may be that the showing itself is a faulted slice of some larger body and the real potential is elsewhere on the property.

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[3]Violarite is a nickeliferous variety of the linnaite series generally only found in local, clearly altered situations in typical Ni/Cu ores - rimming primary pentlandite in shear zone.

ii) Regional Geology

If the gneisses of WC3 are correlative with the Sicker of the Insular Belt, and the amphibolite dikes are correlative with feeders to Karmutsen then, since the upper greenschist metamorphism proves original deep burial of this section, then due to the subsequent uplift of the WC3 we are seeing the level at which sub-volcanic intrusives equivalent to the Karmutsen lavas would crystallise. We note that both the Bushveld, Stillwater and Noril'sk are all considered to be sub-volcanic intrusives, although differing in size.

iii) In the map legends Mueller notes the presence of gabbro/pyroxenite/anorthosite (without locating them) so we know there are areas in WC3 with rocks appropriate to layered intrusions - i.e. Tofino showing is not somehow a freak outcrop. Area round Tofino Inlet has never been mapped at a scale of better than 1:250,000.

iv) The pervasive alteration, evident in both silicates and sulphides, may be a positive feature in upgrading the tenor of P.G.M. in the sulphides. P.G.M. are soluble under certain conditions, conventional wisdom to the contrary, and are also extravagantly chalcophile and concentrate in sulphides. In local areas of alteration, usually related to faults, in both Boston Bay intrusion and the Bushveld, P.G.M. are much higher than normal. While in these situations the high values are inconsequential because of limited extent, I am not aware of any data on totally metamorphosed layered intrusions: in fact, such beasts are very rare in the geological record. Although not exactly analogous, note that wholly serpentenised ophiolites can contain, locally, very high concentrations of P.G.M. as, for example, on Unst in the Shetlands.

5. Discussion

The value of the Tofino property depends heavily on its tonnage potential which, to a first approximation, is a function of size of host. It seems clear that, at present level of erosion, there is no hope of locating an intact Bushveld-size complex (diameter 200 km.). Chances of locating a Stillwater-size (40 x 10 km) are probably only slightly better, even allowing for inadequacies of available maps. Faulted blocks of such complexes are, however, quite conceivable.[4] On the other hand, the (2 km. x 200 m.) intrusives of the Noril'sk/Talnakah deposits could easily have been missed, considering scale of mapping, amount of overburden, and lack of importance that was attached to this aspect of the geology at this time. In the Lac Des Iles area of Ontario an inferred 7 m tons of platiniferous material occurs in a gabbro with exposed area of 7 km. x 2 km.: this size is also conceivable in the vicinity of the Tofino property.

When considering P.G.M. potential, however, it should be kept in mind that in the total history of P.G.M., they have only been produced commercially from a handful of sources. The monstrous Bushveld has dominated P.G.M. production - 80% of world total. Significant amounts also derive from by-product of Cu/Ni smelting/refining from Sudbury (low grade) and Noril'sk (high grade).[5] Recoveries from placer and laterite operations are minuscule in total picture. Stillwater, which is essentially identical to the Bushveld, can produce about 2-3% of annual P.G.M. demand. A result of this dominance by the Bushveld is that negligible exploration effort has been devoted to P.G.M., until the last few years, and much of this is heavily modelled on the Bushveld.

This situation is in many ways analogous to that of uranium in the 1960s. The only 'real' targets then were Proterozoic conglomerates with local emphasis on roll-fronts (western U.S.) and veins: the potential of all uranium occurrences were considered and rated with reference to these models until the Saskatchewan and Australian deposits appeared - effectively reducing preexisting <u>deposits</u> to the status of uranium <u>anomalies</u>. Since even grades 10 times higher than what is now considered high grade P.G.M. (e.g. 80 g/t) would probably escape notice in hand specimen, it is reasonable to accept any indication of P.G.M. as worthy of close scrutiny.

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[4]The Stillwater, for example, is only part of a much larger intrusion, perhaps comparable to Bushveld in size.

[5]Noril'sk could probably be mined as P.G.M. deposit, treating Cu + Ni as by-product (stockpiled), but this is not likely in foreseeable future unless there are catastrophic events in South Africa.

Until more is learned of the Tofino occurrence it would be inappropriate to downgrade it merely because it does not appear exactly analogous to the Bushveld in size and grade. Just as it is unlikely that Blind River deposits would be mined if found today, so there are problems with the Bushveld (narrow pay-zone, high heat-flow) that could militate against production in North America if discovered today: note Stillwater, although smaller than Bushveld, is higher grade and has thicker pay-zone. A small, high grade deposit will probably prove to be as attractive, if not more so, than a large, low grade one.

Just as it would be unnecessarily hidebound to denigrate situations not exactly analogous to Bushveld or Noril'sk, so it would be equally obstinate to continue tilting at insubstantial windmills. Recommended procedure is to proceed in stages and evaluate the reality of progress made at each stage. The location of Tofino, fortunately, allows such a programme.

6. Recommendations

With this in mind, a first stage programme should address the following:

1. Confirm the hypothesis that outcrop is part of a layered intrusion. This will increase confidence underpinning other work.

2. Search for extension of known outcrop, which appears to be limited by faulting to east.

3. Examine property for rock types consistent with layered intrusion (gabbro, pyroxenites, anorthosites) keeping in mind:

   (i) rocks will probably be altered;

   (ii) only local sections of 'layered intrusions' are visibly layered;

   (iii) individual layers can be 100's of metres thick of uniform rock.

4. Centre more detailed studies of such areas.

5. Gather and synthesize data bearing on the setting and nature of the Tofino showing that might reflect on P.G.M. exploration in WC3 setting: it would be shortsighted to pioneer work in this area and end up with second best deposit.

To achieve these aims the following constraints should be considered:

1. Since the rocks of the showing appear to have been pyroxenites (rather than peridotites or diorites) and anorthosites, they are low in magnetite so that magnetics will <u>not</u> be a useful indirect mapping technique. However, since localised sections of layered intrusions in upper sections can be rich in magnetite, further work may indicate areas where magnetic surveys could be helpful.

2. Since P.G.M. mineralisation is related to sulphide zones, some form of electromagnetic surveys should be useful in delineating drill targets. Since such zones may be thin and contain trace to 30% sulphides, detailed I.P. would be optimum technique but it is recommended that prior to this an attempt should be made to identify areas of particular interest rather than initial blanket coverage.

3. Again, since P.G.M. mineralisation is related to Cu/Ni sulphides, Cu/Ni geochemistry would appear to be natural focus, but they will only be useful to pick out probably narrow sulphide zones, rather than areas of encouraging host rock - and probably best left to a secondary stage when clearer picture of overburden is reached.

In this case most direct method of achieving initial aim is a low tech combination of mapping and trenching (or OV drilling). Initial programme recommended is:

1. Outcrop mapping 1:10,000.

2. Preliminary hand-trenching to evaluate nature and thickness of overburden.

3. Evaluation of what is involved, and cost estimate, of locating backhoe on property. This will probably involve road building unless logging operation, currently on opposite side of ridge from showing, is planned to expand in the near future.

4. Geological evaluation of Stage I results.

5. Planning and budgeting Stage II exploration.

Estimate Stage I will require 2-3 men x 3 months to cover Stage I work on 100 claim property.

Stage II may include trenching and blasting in areas defined in Stage I. If overburden proves particularly intractable overburden drilling may be necessary.

While identifying P.G.M. zone is ultimate goal, realistic and essential initial goal is to identify location and distribution of potential host rocks.

Ian N Pitcher

30 July 1986.

APPENDIX I

ECONOMICS OF P.G.M.

(Summary)

PRICE FORECAST (Table A-1)

Since the economic value of the target is as critical as the probability of success in rating exploration programmes, some evaluation of the former is appropriate, particularly since there is little conventional wisdom on this point outside the close knit P.G.M. community.

In my view the salient point is that, even assuming no disruption of supply from South Africa or Russia, which together total 90% of world supply, predicted increasing industrial demand will cause price increases of:

Pt: Real increase of 40% to 70% by year 2000 in constant 1985 $

Pd: " " " 65% to 110% " " " " " " "

[Lower estimate assumes S. Africa will be able to 'freeze' production costs (in constant dollars) at 1985 values; higher estimate allows contrary.]

There is no other natural resource with such an upbeat outlook. See Table A-1. As stressed in following sections this prediction is based on current trends already established, in both supply and demand, and does not take into account possible changes in supply sources nor new industrial demands based on technology still in R & D stage.

TABLE A-1

Platinum and Palladium Price Forecasts

(In Constant US $ per Troy Ounce)

		(Actual) 1985	1987	1990	1995	2000	Increase over 1985
A)	Platinum	300	350	440	440	440	40%
	Palladium	148	170	185	225	245	65%

(1985 estimate based on assumption there will be no radical change in production costs in Bushveld mines)

B)	Platinum	300	420	445	495	520	73%
	Palladium	148	218	252	309	319	115%

(Estimate assumes increasing costs in Bushveld Mines)

Note that because of variable Pt/Pd ratios in ores different mines will be affected differently by these prices: for example, using published ratios we get:

		1985	2000	
Est. A	Bushveld			
	1 oz. P.G.M. (2.4 Pt/1 Pd)	$254	$381	(50% incr. in value)
Est. A	Stillwater			
	1 oz. P.G.M. (1 Pt/3 Pd)	$186	$294	(58% incr. in value)

but

Est. B	Stillwater			
	1 oz. P.G.M. (1 Pt/3 Pd)	$186	$369	(98% incr. in value)

SUPPLY (Table A-2)

a) Current Production

Mined production of P.G.M. has remained relatively constant since 1976 at close to 6 million ozs/year, which compares with world gold production of 38 m ozs/year. The dominant position of South Africa is based on production from three principal mines, Rustenburg with 55%, Impala 40% and Western Platinum 5%, of total S. African production. All of these produce from the narrow but very extensive Merensky Reef: Fig. A-1. The Merensky Reef is a layer of coarse grained pyroxenite that is present along the 100's of km perimeter of the Bushveld Complex. The pay-zone dips inwards at 20 but is only 75-80 cm thick[4] and, where mined, has grade of 8 g/t in ground, or 5 g/t head grade, due to dilution.

Lower in the section is the UG-2 reef with similar P.G.M. grades[7] but the association of P.G.M. with mill-refractory chromite in UG-2 has delayed production: Western Platinum has made start on mining from this zone - presumably this will be more expensive.

In Russia P.G.M. is refined from massive Ni/Cu sulphide ores present at the base of strongly differentiated dolerite 'sills'.[8] The 'sills' occur at the base of a thick section of flood basalts. Compared to the Bushveld the 'sills' are much smaller, of order of few km x hundreds of metres. Production comes from about 9 mines in two clusters, Noril'sk and Talnakah, about 40 km apart. The setting of Noril'sk and Bushveld, although similar in association of P.G.M. with basic rocks, is in detail radically different, geologically they are different species.

b) Current Reserves

Estimated in place reserves in South Africa are monstrous: 550 million ozs in Merensky equates to 100 year's supply at current rates of production and a further 1,000 million ozs. in UG-2, which has not yet been proved economic at current prices. However, the Merensky is getting deeper and the very high heat flow is becoming a serious problem.

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[4]The Merensky Reef seems to have a constant grade x thickness value (where reef is thicker grade is lower) so that the Reef is not continuously mined along the perimeter.
[7]But higher than normal rhodium proportion which is of some significance since rhodium sells at $1,000/oz compared to Pt $300-$400/oz.
[8]Russians call them chonoliths which seems to be sills with limited lateral extent.

TABLE A-2

Estimated Production of P.G.M.

(Thousands of Troy Ozs.)

Country	1976		1978	1980	1981	1983	Pt/Pd[12]
South Africa	2,389	(43%)	2,532	2,914	2,320	2,361	2.3
Russia[13]	2,745	(49%)	2,835	2,925	3,150	3,240	0.5
Canada	363	(6%)	301	358	199	145[14]	1.0
Japan[15]	27	(0.5%)	33	41	43	58	0.5
Columbia[16]	17		14	14	20	20	100%Pt
United States	6		8	3	8	6	0.2
	5,547		5,724	6,255	5,740	5,830	

Source: U.S. Bureau of Mines

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[12]South Africa essentially Pt producer while Russia is Pd producer.
[13]Russia historically exports about 10-15% of its P.G.M. Using this estimate gives S. Africa about 80% of western world's supply.
[14]Drop in Canada's production reflects depressed Cu/Ni production at Sudbury, rather than decreasing grade or supply. Clearly Russian production of Cu/Ni was not similarly affected.
[15]Japan figures represent smelter recovery from porphyry copper ores mined elsewhere (Canada, Australia, PNG, Phillipines).
[16]Columbia is placer product and is 100% Pt.

Reserves in Russia have been estimated at 200 million ozs (but clearly with higher variance in estimate). Influence of these on Western prices* depends on Russia's domestic requirement for P.G.M. and also their plans for Cu/Ni production.

Reserves of P.G.M. at Sudbury are estimated at 9 million ozs while the Stillwater has reserves of 35 million ozs.

c) Geological Reserves

Metal forecasters, by their nature, focus on known statistics and already established trends and their forecasts are most useful for short term (1-5 years). Geologists are allowed a little more latitude.

In considering new sources of supply it seems unlikely that there exists, near surface, reserves of size and type of the Bushveld Complex - except perhaps in Antartica below ice or the Sahara below sand. As understanding of the Bushveld increases I expect other mineralised horizons to be discovered - question is will they match the magnitude of Merensky and UG-2? New discoveries are most likely to be of the order of the Stillwater. Discovery of deposits of Noril'sk-type, on the other hand, are eminently reasonable (1) because the related intrusions are not large (and could be easily lying unnoted in covered areas), and (2) because the conditions necessary to form such deposits, while not common, are not unique: Nova Scotia, Victoria Island, Vancouver Island come immediately to mind, and (3) because it is only in last 5 years (corresponding with negative Ni outlook) that sufficient data has been available from Russia to understand their features and genesis.. However, Noril'sk-type deposits, discovered in the West, would have more profound effect on Cu/Ni market than P.G.M. market.

Possible ringer, however, is discovery of new-type of P.G.M. deposit (c.f. uranium). Since very little exploration has ever been directed towards anything other than Bushveld look-alikes this seems a streng possibility. The biggest impact would be discovery of deposit with grade 10 times greater than present types. Intuitively, I would expect such a deposit to be smallish, but nevertheless extremely profitable.

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*General belief, unspoken officially, of marketing agreements between Russia and South Africa.

In summary then, it seems unlikely that there will be discoveries which will have profound impact on established supply pattern by sheer size alone, always a concern in a limited market (c.f. situation in Rare Earths). A 1,000 t.p.d. operation at twice the grade of Bushveld would only constitute about 1% of total current supply.

Most likely to affect supply picture, in my view, is situation in South Africa vis-a-vis mining conditions. Ore is getting deeper, high heat flow will necessitate refrigeration and thin horizons militate against highly mechanised mining without increasing dilution (already 40%). Bushveld is in danger of becoming very large but high cost producer: presumably they will continue to be price leader. Geologically, it is reasonable to predict that modest tonnage P.G.M. deposits will be discovered that will have better economics than Bushveld (higher grade, thicker pay zone, better milling).

These problems exist independently of final resolution of current political situation in South Africa.

DEMAND

High M.P. (1700° C), high S.G. (20), extraordinary catalytic properties (with high resistance to "poisons"), great corrosion resistance and high thermal and electrical conductivities are unique physical properties of P.G.M., that create industrial demand. There appears to be no viable substitutes in the offing for many of these properties, except Au in some cases and even so such substitutions may not be economically justified. (In terms of total ozs of Pt used compared to total cost of a computer, e.g., it doesn't make much difference whether Pt is $300 or $400/oz.) Rarity and aesthetics contribute to speculative and jewelry[10] demand, although this is confined to platinum rather than P.G.M. as a group.

Important point is that because of these physical properties P.G.M. demand is 70% industrial compared to Au industrial demand of 10%:[11] in other words, its price is not affected merely by fluctuations in economic stability, although there is some effect because of the smaller annual supply: there is future market in P.G.M. but bulk of trading is on a negotiated producer price.

A brief summary of principal areas of P.G.M. consumption is given here to give flavour of the market.

Automotive Catalysts

To remove 3 of 4 major pollutants related to gasoline engines. So far only N. America legally requires such treatment but by 1990's Japan, EEC and Australia will follow suit doubling annual requirement.

Annual Consumption

	1983	2000 (est.)
(US. only)	508,000 ozs. Pt	1,240,000 ozs.
" "	172,000 ozs. Pd	488,000 ozs.
	680,000 ozs. P.G.M.	1,728,000 ozs. P.G.M.

[1983 total supply 6,000,000 Pt + Pd]

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[10]This is particulary strong in Far East where the whiter platinum is considered more attractive on Oriental skin than gold.

[11]Gold promoters achieve higher industrial demand for gold by including gold coins and medallions in non-speculative category.

Electronics

Major user of Pd. Main uses is in ceramic capacitors and electrical contacts on P.C. boards and other integrated circuits - in high growth area of electronics! Critical properties are high conductivity combined with corrosion resistance and ability to form alloys to give range of resistivities.

Annual Consumption

1983	2000 (est.)
220,000 ozs. Pt	315,000 ozs.
915,000 ozs. Pd	2,306,000
1,135,000 ozs. P.G.M.	2,621,000 ozs. P.G.M.

Chemical Applications

Uses in this field are two fold: (i) as catalysts to improve efficiency of chemical reactions (production of HNO3, HCN separation of hydrogen and oxygen, fertilisers plus others in R & D stage) and reducing toxicity of waste products, and (2) as mechanical components in highly corrosive environments (as retorts, nozzles, etc.).

Probable major breakthrough in fuel cells could have dramatic increase in Pt requirements, not included in 2000 estimate.

1983	2000 (est.
260,000 ozs. Pt	410,000 ozs. Pt
503,000 ozs. Pd	915,000 ozs. Pd
763,000 ozs. P.G.M.	1,325,000 ozs. P.G.M.

Petroleum Refining

Used as catalyst at various stages of refining process. Generally agreed that there is higher recycling of P.G.M. in this industry than others so that annual demand is harder to estimate I note, however, that Chevron, one of principals in Stillwater, believe that recovery is less than is generally credited by metal forecasters.

Annual Consumption

1983	2000 (est.
100,000 ozs. Pt	140,000 ozs. Pt
52,000 ozs. Pd	80,000 ozs. Pd
152,000 ozs. P.G.M.	220,000 ozs. P.G.M.

Dental

Use of Pd, in traditional role of Au, developed in 1970's and has increased from 300,000 ozs. in 1976 to 700,000 ozs. in 1983.

Annual Consumption

1983	2000 (est.)
700,000 ozs. Pd	1,200,000 ozs. Pd

Jewelry

Although a significant consumer of P.G.M. this field is not expected to show major growth except in Japan.

Annual Consumption

1983	2000 (est.
758,000 ozs. Pt	1,030,000 ozs. Pt
122,000 ozs. Pd	165,000 ozs. Pd
880,000 ozs. P.G.M.	1,195,000 ozs. P.G.M.

Note: in tabulations and discussions I have not emphasised the Pt/Pd ratio since this varies significantly in different deposits and there is no way to predict its effect before the fact.

Summary

The preceding digest does not include consideration of price elasticity, the aim was merely to denote general background to what I see as an all-round bullish future for P.G.M. I note in particular that it is not contingent on global economic instability and also that legitimate demands arise in applications to make manufacturing processes more efficient and cleaner, and the emphasis is on industries that show strong growth. Allowing for uncertainties enveloping all metal forecasting, and considering that they are heavily biased towards continuation of recent historical trends, rather than applications still in theoretical stage, I would think forecasts are more likely to be conservative than otherwise.

July '86.