BRANDON HILL CAPITAL

Jangada Mines (AIM)

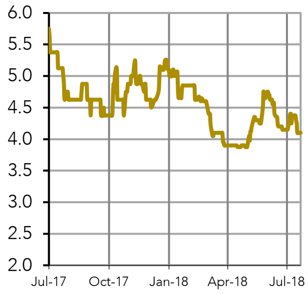
MINING – INITIATING COVERAGE

08 August 2018

Stock Data

Share Price	4.10p
Market Cap (£)	8.1
EV(£M)	7.5

Price Chart



52 Week Range

3.825p **4.10p** 5.625p

Company Summary

Jangada Mining is an AIM listed company operating in Brazil. It acquired the Brazilian platinum group metal assets of Anglo-American in 2013 and declared a JORC (2012) compliant resource.

Source: Bloomberg

MAIN SHAREHOLDERS	HOLDING
Brian McMaster	23.4%
Matthew Wood	23.4%
Luis Azevedo	22.8%
Mark Summer	7.6%

Research:

Peter Rose

Peter.Rose @brandonhillcapital.com

www.brandonhillcapital.com

Platinum Group Metal Project in North-Eastern Brazil

Investment Case

An investment in Jangada offers investors the opportunity to invest in a future PGM producer outside of Southern Africa and its inherent political uncertainties. Further, approximately 60% of the South African PGM miners are currently loss making, representing about 2M oz pa. This contrasts strongly with Jangada where we estimate that after by-product credits, the average cost of producing PGM's will be circa US$100/oz and probably significantly lower once the revised metallurgical circuit is finalised.

Valuation

We have valued the current mine plan using Net Present Values with a 10% discount rate. Using the BHC metal price forecasts this gives a value of US$177M and an Internal Rate of Return of 64.3%.

Upside Potential

There are numerous areas of upside to the Pedra Branca Project. The introduction of dry magnetic separation has the potential to significantly reduce the size and capex of the processing plant and associated water dam. It also holds promise for a higher grade chrome concentrate that could be used for more specialist uses. The latest metallurgical test work also found significantly higher gold values than had been used in previous economic studies, suggesting that gold revenues could be greatly enhanced. Finally, it is known that the orebody contains rhodium and ruthenium, which follow the PGM's in the recovery process. Essentially no work has been conducted with regard to these two metals which offer further potential upside to profitability.

Additional Targets to be Explored

The Santa Amaro orebody, which was recently brought into the reserves/resources, has some modest upside from additional tonnage, but there are another six prospects, two of which have had holes drilled on them and are known to contain PGM's grading around the same as the current reserves. BHC expects these additional prospects to extend the mine life rather than result in higher production, and as such will have only a small impact on the NPV.

Contents

Executive Summary

Jangada Mines Strategy

Jangada Mines plc (“Jangada” or “company”) is a natural resources company focusing on developing the Pedra Branca (the “project”) PGM project in Brazil. Pedra Branca was acquired from Anglo-American whom had been exploring for platinum group metals and associated base metals such as copper, nickel and cobalt. The strategy is to develop a significant PGM mine in Brazil.

Why PGM’s in Brazil

Currently, the bulk of the world’s PGM’s come from South Africa, Zimbabwe and Russia. Small amounts are produced as by-products from nickel mining in North America, Australia and Finland. Further, it is important to realise that the Stillwater mine in Montana in the United States produces approximately 3 ounces of palladium per ounce of platinum produced. Similarly, Russia is mainly a palladium producer which is a by-product of nickel mining by Norilsk Nickel. There are no significant platinum producers outside of Southern Africa, until recently an area of increasing political volatility and it is by no means certain that this improvement will continue. Brandon Hill Capital therefore believes that the western world will welcome a new PGM producer located in a stable and well developed mining jurisdiction.

Valuation

We have valued the current mine plan using Net Present Values with a 10% discount rate. Using the BHC metal price forecasts this gives a value of US$177M and an Internal Rate of Return of 64.3%.

Upside-Potential

The current proposal to add a magnetic separator after the crushing and grinding sections of the processing plant has radically changed the potential valuation. A much smaller plant will bring lower capital and operating costs and has the ability to speed up development as the original proposal of a pilot plant is the correct size for the back end of the plant. Further, seeing as how higher grades will be fed to the flotation plant, higher recoveries could be expected. Added to this is the ability to produce a higher specification chromite concentrate which would receive a higher price and gold. The current modelling only accounts for minimal quantities of gold and the recent metallurgical test work has revealed high gold grades in the magnetic concentrate. Finally, BHC believes that there is rhodium in the orebodies but this has not been included in any of the financial modelling.

Infrastructure

Whilst complete hydrologic and hydrogeologic studies have not been conducted on the project, the proposed mine is located in an arid area of Brazil. Therefore, water is at a premium and may drive Pedra Blanca to dry crushing and grinding. The current power line in the area is adequate to supply the office, laboratory, canteen and other minor facilities. For the beneficiation plant a diesel power station is considered a better and more reliable option to supply the energy required. There are good sealed roads around 30km from the mine all the way to the port of Pecem, approximately 310km away.

PGM Grades

The majority of the global PGM deposits are mined underground at grades of 1.8g/t to 3.5g/t Pt and 1.7g/t to 2.1g/t Pd, of 3.5g/t to 5.6g/t Pt + Pd, over very narrow intervals. The grades that Jangada are proposing to mine are 1.36g/t Pt+Pd but using open pit methods with a low strip ratio of approximately 1:1. The introduction of the magnetic concentrator has indicated that the PGM grades can get as high as 8.1g/t which are expected to make the mine very competitive.

Company History

Time Line of key Historical Events

29th June 2017	IPO on AIM and Capital Raise of £2.5M
11th Jul 2017	Major Grade & Value Boost from Ni & Cu credits
16th Aug 2017	Additional Cobalt and Chrome By-Product Credits
4th Sept 2017	Positive Progress Update & Cost Savings
10th Oct 2017	Resource Upgrade at Pedra Branca
23rd Oct 2017	Vanadium Deposit Sampling & Metallurgical Results
31st Oct 2017	PGM Project Potential Highlighted in Scoping Study
11th Dec 2017	Update re Pedra Branca Project
20th Dec 2017	Production target update
15th May 2018	Resource increase at Pedra Branca PGM Project
11th Jun 2018	Positive Metallurgical Tests from Pedra Blanca
18th Jun 2018	Results of Preliminary Economic Assessment

Source: Jangada Mines

The Project

Project History

The project was first discovered by local geologists in the 1960’s and by 1969 a resource of 43,000t of material grading between 10-28% chromite had been established through the drilling of five holes. Nothing then happened until 1985 when both Glencore and Rio Tinto discovered platinum and palladium mineralisation and completed airborne magnetic and radiometric surveys followed by mapping, soil sampling and trenching. The work resulted in the discovery of 10-15 scattered showings of chromite and copper-nickel soil geochemical anomalies. Rio Tinto focused on the most northerly chromite occurrences, known as Esbarro 1 and 2, which lie within 400m of each other. Meanwhile, Gencor targeted the central and southern portions of the ultramafic belt carrying out trenching and drilling eight holes into the Trapia 1 and Trapia 2 showings. Both Rio Tinto and Gencor ceased exploration following a slump in platinum and palladium prices.

As the price of platinum and palladium started to increase in the late 1990’s, Altoro Gold Corp. (which has since merged with Denver-based Solitario Exploration & Royalty Corp.) acquired the project and started drilling in 1999. In January 2003, Anglo-American Platinum and Solitario formed a Joint Venture which commenced extensive resource drilling on the target deposits. This amounted to around 30,000m of drilling which having been conducted with drill spacing’s between 25-40m, allowed the calculation of a resource estimate. This was followed between 2003 and 2005 by a scoping study with metallurgical testing conducted on the drill core and in 2012 a SAMREC compliant resource estimate was completed.

In 2013, a regional scale high quality airborne geophysics survey was completed and additional process metallurgy test surveys were conducted on ore. In 2014, metal prices collapsed and Anglo American found itself in challenging circumstances, not helped by severe labour unrest at Anglo-American Platinum in South Africa. As this was not seen as a core asset, the decision was made to divest the asset. Previous owners of the Project, over several decades, have spent in excess of US$35M developing the Project.

At this point, Jangada acquired the asset and declared a JORC (2012) compliant resource.

Project Location

The Project is located 280km southwest of Fortaleza, the capital of Ceara State, north-eastern Brazil. Access to the project area is via a paved Brazilian state Highway (BR020) that connects Fortaleza to Brazilia. At the town of Bom Jesus, 280km by road from Fortaleza, a dirt road branches off to the east to the village of Capitao Mor, 18km to the east. Driving time from Fortaleza is approximately four to six hours.

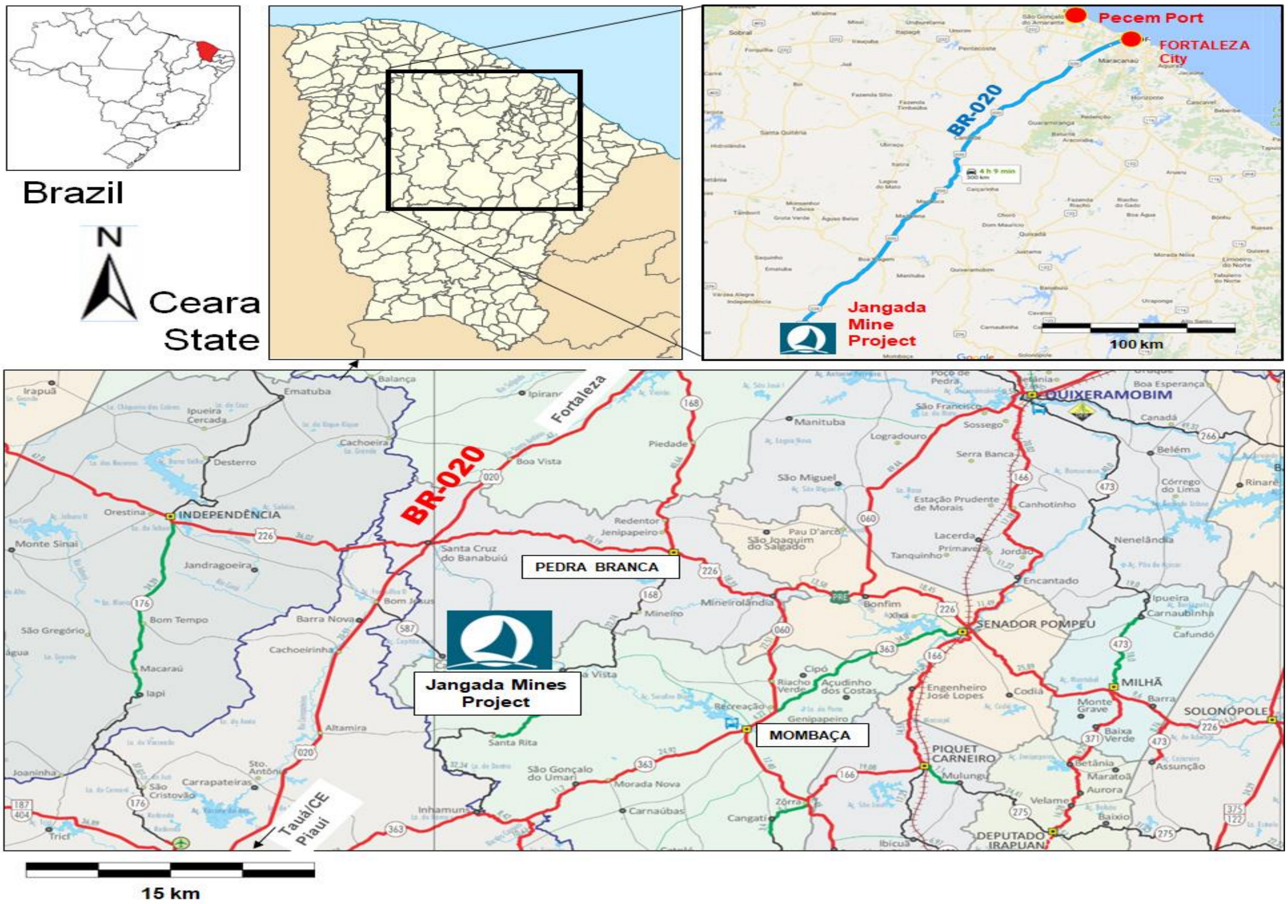
Capitao Mor lies immediately west of the Project and serves as the base camp for the project. An extensive network of dirt roads and trails provides access throughout the Project area. The village has a population of approximately 800 – 1000, a public phone, electric power, tapped potable water and a sewerage system. There is no mobile phone network coverage but the area is covered by a recently installed (2013) wireless internet service.

Infrastructure

The scoping study operating costs were based on the use of generators for electricity. But, there is major power infrastructure located within 50km of the site. If this were to be used, a connection line would be required, but this would be offset by the fact that a power station would not be required and operating costs could reasonably be expected to drop.

The water supply for the operation is an important issue as the proposed mine is located in an arid part of Brazil and any mine will have to be careful with water conservation. Part of the capital expenditure includes the construction of a dam near the processing operation. There are some medium sized dams in the area from which some water could be obtained, but the plan is to drill for ground water in addition to this.

EXHIBIT 1: PEDRA BRANCA PROJECT LOCATION



Source: Jangada Mines

Geology

The PGM deposits at Pedra Branca are hosted by the Paleoproterozoic ultramafic Troia Unit, consisting of altered dunite intruded into Archaean Basement Gneisses. PGM mineralization is associated with chromite-rich horizons and base metal sulphides within the dunite. Regionally, the rocks have been deformed by at least three deformation events which have left the dunite intrusion folded and dismembered.

Tectonic Framework

The Pedra Branca PGM project is situated in the Borborema Structural Province, in Ceará State, Brazil.

The Borborema Province is a Braziliano-Pan African tectonic province that resulted in the convergence of the Amazonian, West African/Sao Luis and San Francisco-Congo Cratons during the assembly of West Gondwanaland ca. 600Ma. However much of Ceara's basic structural framework was established during the earlier Transamazonian orogeny. This orogenic accretion event involved the collision of Paleoproterzoic terranes along with fragments of Archaean crust. Subsequent to this were a number minor tectonic and magnetic episodes prior to the onset of the Gondwana-related Braziliano orogeny.

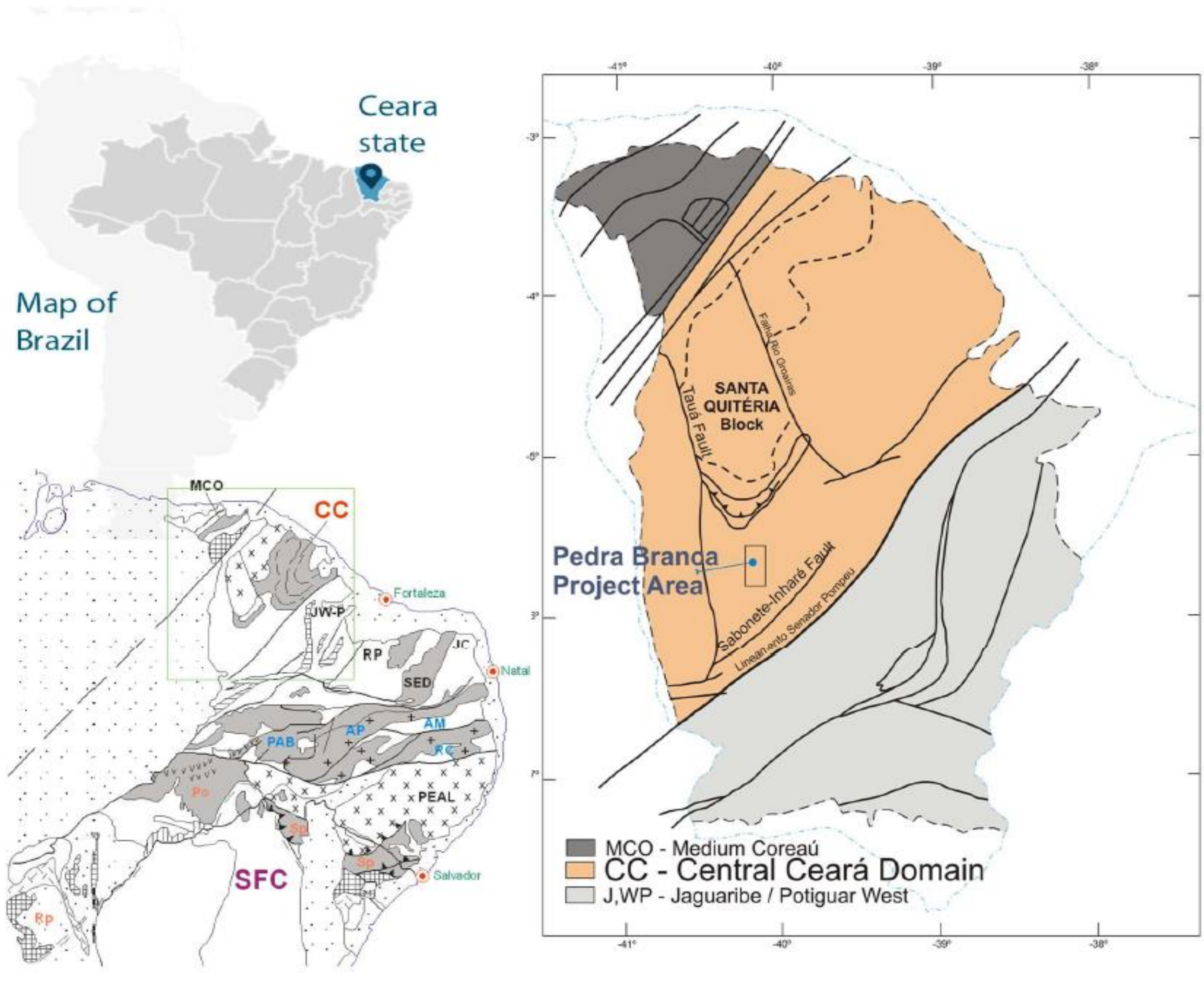
In Ceara this commenced ca. 622 Ma, with the intrusion of calc-alkaline granatoids of continental arc affinity. These intrusions were as a result of subduction associated with ocean basin closure. Continued closure of the Gondwana massifs continued until ca. 614 Ma. Subsequent to this, tectonic activity was dominated by the formation of extensive shear zones and associated magnetism. The youngest granitic intrusive dates 540-520 Ma, and appears to be related to the relaxation of the Braziliano orogeny.

The Borborema Province thus comprises Archaean Nuclei, Paleoproterzoic basement gneissmassifs, Paleoproterzoic to Neoproterzoic supercrustal fold belts and cover sequences, and syn-to post kinematic Brazilano granatoid plutons. As noted above the province is also affected by a number of shear zones that can be traced in Africa and divide the province into a number of crustal domains and blocks.

The primary zone – "Patos Lineament" (Lineamento Patos), marks a major boundary, possibly an oceanic suture. This lineament bisects the Borborema Province into northern and Southern domains with virtually all of Ceara lying within the northern belt.

This northern belt is cut by two north-easterly trending features, the TrabsBraziliano (north) and Senador Pompeu (south) lineaments. These subdivide the northern domain into three main crustal blocks: the Northwest Ceara domain, the Central Ceara domain, and the Rio Grande do Norte terrane. Of these domains only the Central Ceara domain, occupying as region of approximately 80 000km sq. is of direct relevance. The exhibit 5 shows the tectonic setting of Pedra Branca in the Central Ceará Domain (CC) of the Borborema Province and the major lineaments defining the tectonic boundaries in the northeast of Brazil.

EXHIBIT 2: THE TECTONIC SETTING OF PEDRA BRANCA IN THE CENTRAL CEARA DOMAIN(CC)



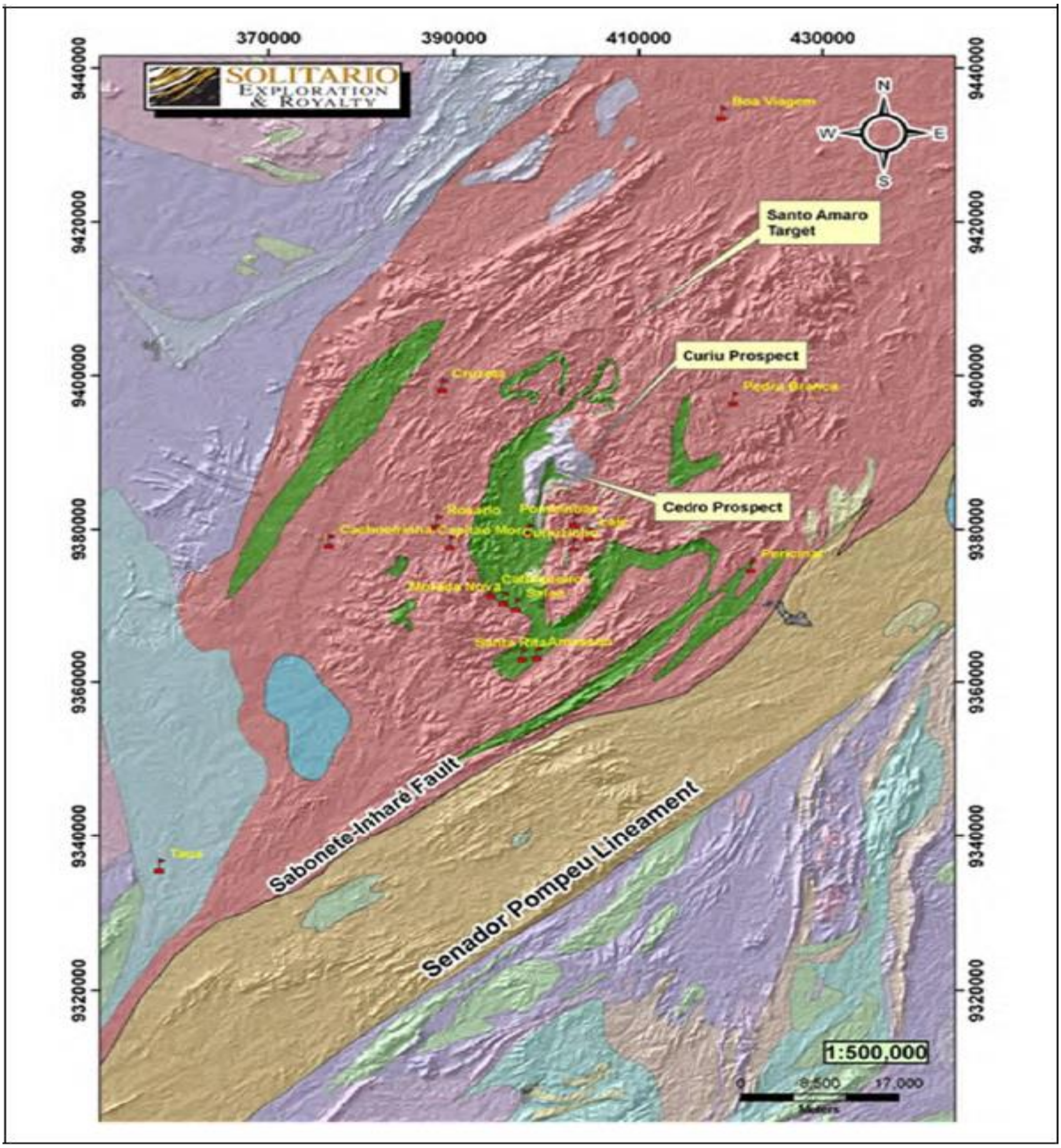
Source: Jangada Mines

Local Geology

In Ceara State, the Cruzeta Complex in the Central Ceará Domain is a polycyclic basement unit composed of the Archean Tróia-Pedra Branca Massif. This complex is stragraphically divided (from bottom to top) into the mafic/ultramafic Troia Unit (TU), the calcic-sodic gneiss of the Pedra Branca Unit and the sodic-potassic gneiss of the Mombaça Unit. The TU, in particular, is characterized by an important PGE-bearing layered ultramafic sequence. Tectonic reworking of these terrains created a 70 km long almond-shaped mega-structure with a NE-SW trend delimited by sub-parallel, deep-seated crustal shear zones of extensive proportions. The principal strands of shearing are the Sabonete-Inharé Fault, the Senador Pompeu Lineament and the more distal Tauá Fault.

The Troia Unit is composed of coarse- to medium-grained olivine-websterite, peridotite and dunite cumulates. These rocks are folded, sheared and recrystallized by metamorphic processes. Diorites and probable leuco-gabbroics and even tonalites constitute a more evolved mafic unit. Later tabular injections of pegmatitic and tonalitic composition commonly cut the complex and resulted in metasomatic lenses composed of phlogopite and chlorite. Primary mineral textures vary from adcumulate to mesocumulate; however, metamorphism and metasomatic processes have rounded primary cumulate crystals or partially to totally replaced primary textures with secondary mineral aggregates. The figure below shows a typical stratigraphic column of the Troia Unit from the Curiu target.

EXHIBIT 3: MAFIC AND ULTRAMAFIC PORTIONS OF THE TROIA UNIT



Source: Jangada Mines

Chromitite horizons from 30 cm to 3 m in thickness occur in classical transitional facies form of layered complexes. Chromite occurs as euhedral octahedral grains from 0.3 mm to 1 mm in a secondary groundmass of foliated chlorite or fine-grained tremolite. These chromite-rich cumulate rocks are strongly associated with the highest PGM grades. This oxide phase also appears as an intercumulatic phase among the principal silicate crystals and its crystallization features demonstrate independent conditions of nucleation from the silicates (no cotectic crystallization paths with the larger silicate crystals. Lightgreen (greyish) coloured chlorite, tremolite/actinolite prisms and subordinate serpentine are formed by later metamorphic/metasomatic events. Trace amounts of chalcopyrite, pyrite, bornite and pentlandite occur in the secondary matrix.

Later PGM-deficient chlorite-bearing layers were formed by shearing during metamorphism and intrusion of younger felsic rocks. Additionally, there are local massive or brecciated Ni-rich sulphide layers up to 3 m in thickness at the basal contact of ultramafic bodies with the basement gneiss of the Cruzeta Complex or pegmatite-textured felsic injections.

Drill core of chromitite layers in TU contain up to 5% Cr, 8 ppm Pt and 21 ppm Pd. Observed Pt to Pd ratios are variable, ranging from 0.29 to 1.9. Normalized to primitive mantle, many chromitites arericher in Au, Cu, Zn and V than host rocks. Ti, Al and Cr variations within chromite suggest diverse environments of formation.

Besides the primary chromitites, important PGM values occur as a result of redistribution and enrichment by structural/metasomatic processes in response to regional left-lateral shearing. Cu, Ni, Sr and P also have been structurally remobilized, along with PGE. Many occurrences of mineralization display a SW-NE trend, in accordance with a stretching lineation developed on the S2 axial foliation plane, which can be demonstrated geochemically on a microscopic up to a regional scale. District-wide magnetometry has been effective at mapping these trends regionally within the altered and tectonized ultramafic bodies.

Two metamorphic events are recorded in the Pedra Branca Mafic-Ultramafic Complex. The first was a regional metamorphism of medium to high grade and the second a more local, hydrothermal metamorphism of low grade with an age of 0.550 Ga (Brito Neves, 1975). The Esbarro body comprises mainly metaperidotites with minor mafic schists and serpentinites and contains several chromitite lenses within which cumulate texture is locally preserved, albeit in a generally chloritic matrix. The Exhibit 3 is a regional geological map of the Pedra Branca Region with the extent of the mafic and ultramafic portions of the Troia Unit (green), country rock gneisses (pink) and granitoids (light blue) at Pedra Branca. The map demonstrates the structurally deformed nature of the units as well as the location of Pedra Branca's target areas.

Structural Geology

The ultramafic bodies which host the PGM mineralization at the Project are elongated lenses with the long axis of the lenses commonly orientated between 70 and 110 degrees. Sizes of the bodies vary but most have a similar aspect ratio, with a length:width:thickness of about 4:2:1. The reason for this may be the geological characteristics of the ultramafic rocks and adjacent gneisses metamorphism. This characteristic may be useful in screening of magnetic anomalies for those most likely to be caused by mineralized ultramafic bodies during high-grade dynamic/thermal. The ultramafic bodies are generally overlain by a sequence of amphibolite rock interlayered with granitoids. The footwall is a diverse suite of generally well-layered gneisses, granitoid and amphibolites.

Tectonic reworking of these terranes created a 70km long almond-shaped megastructure with a NE-SW trend delimited by subparallel, deep-seated crustal shear zones of extensive proportions. The principal strands of shearing are the Sabonete-Inharé Fault, the Senador Pompeu Lineament and the more distal Taua Fault.

Where observed, contacts of the ultramafic bodies with their host rocks are sheared. The ultramafic bodies themselves are variably cut by altered shear zones. These shears are most often at low to moderate angles, however late steep shears sometimes associated with quartz or pegmatite veins are locally present.

The ultramafic rocks were originally composed primarily of pyroxene and olivine. Alteration has affected the mineralogy however; primary cumulate textures are often well preserved. Four main types of alteration have been recognized. An early pervasive alteration has altered the olivine to serpentine and the pyroxenes to tremolite. This alteration is generally pervasive although petrographic work often shows relic olivine and pyroxene is present in small amounts. Locally light coloured pyroxenite layers have been only partially altered. The alteration of olivine to serpentinite was accompanied by the development of magnetite.

The second phase of alteration is the development of chlorite tremolite schist from peridotitic rocks. This alteration is often accompanied with a distinct texture designated corona texture. This texture is comprised of serpentinite after olivine altering to chlorite but with a rim of tremolite around the olivine.

A third phase of alteration is tremolitization of the serpentinized olivine. This occurs both as pervasive alteration with very sharp boundaries (alteration front) and as a non-pervasive mottling fabric parallel to foliation and generally near shear zones or the margins of the ultramafic bodies. This type of alteration is strongly structurally controlled.

A fourth type of alteration is associated with brittle fractures, quartz veins and/or felsic intrusive rocks. It is generally restricted to structures and fracture selvedges. The mineralogy is often zoned from a central zone of phlogopite schist outward to chlorite phlogopite schist, chlorite actinolite schist and tremolite schist. Structures associated with this alteration are commonly steeply dipping.

The last two types of alteration are generally accompanied with at least partial magnetite destruction.

Prospecting Licences

A Prospecting License entitles the holder, to the exclusion of all others, to explore for minerals in the area of the License, but not to conduct commercial mining. A Prospecting License may cover a maximum area of 50 hectares and remains in force for up to 5 years. The holder may apply for a renewal of the Prospecting License which is subject to approval by DNPM. The period of renewal may be up to a further 5 years

Exploration Licences

A Mining License entitles the holder to work, mine and take minerals from the mining lease subject to obtaining certain approvals. Mining rights can be denied in very rare circumstances, where a public authority considers that a subsequent public interest exceeds that of the utility of mineral exploration, in which case the Federal Government must compensate the mining concession holder.

In Brazil, a Mining License covers maximum areas ranging from 2,000 hectares to 10,000 hectares, depending on the geographical area, as detailed above, and remains in force indefinitely. The holder must report annually on the status and condition of the mine.

As with other mining tenements, a Mining License is granted subject to conditions regulating activities. Standard conditions regulating activities include matters such as:

- The area intended for mining must lie within the boundary of the exploration area;
- Work described in the mining plan must be commenced no later than 6 months from the date of official publication of the grant of the Mining License, except in the event of force majeure;

Ore Resources

- The Pedra Branca Project contains a JORC (2012) compliant resource of 34.513Mt at 1.307g/t (Pt+Pd) and containing 1,487,300oz of platinum + palladium + gold, classified in Measured, Indicated and Inferred Resources. This was a significant increase in resources, giving a 53% increase in PGM's, a 28% increase in nickel to 140M lbs, an 11% increase in copper to 26M lbs and a 4% increase in cobalt to 6.7M lbs over the previously released figures.

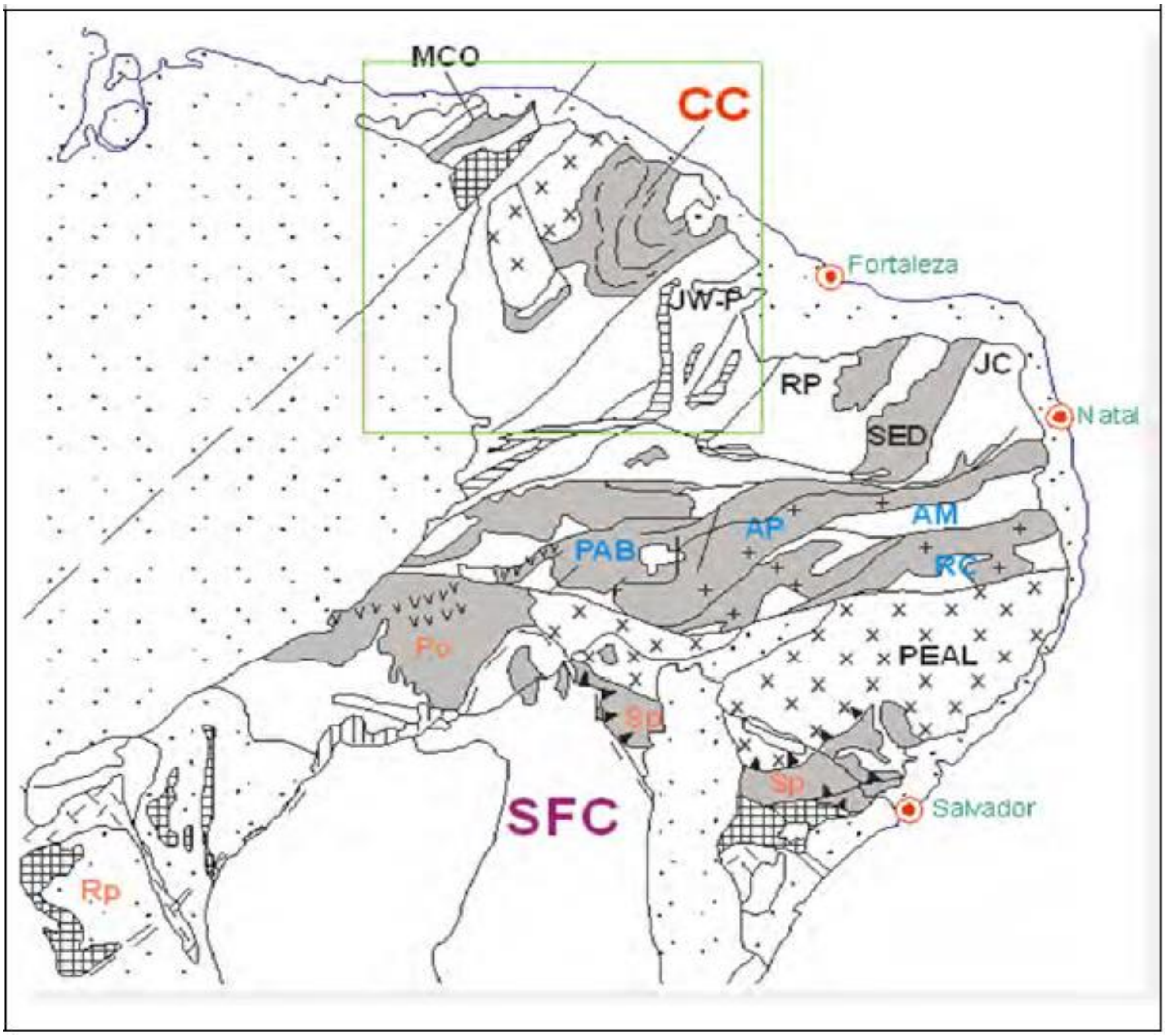
EXHIBIT 4: PEDRA BRANCA PROJECT ORE RESOURCES

		Tonnes (kt)	PGM (g/t)	Pd (g/t)	Pt (g/t)	Au (g/t)	Cu (%)	Ni (%)	Cr2O3(%)	Co (g/t)	PGM (koz)	Pd (koz)	Pt (koz)	Au (koz)
Cedro	Indicated	3 798	1.066	0.665	0.383	0.018	0.043	0.196	0.789	118.73	130.2	81.2	46.8	2.2
	Inferred	2 003	1.522	0.934	0.569	0.019	0.032	0.179	0.812	109.40	98.0	60.2	36.6	1.2
Curiu	Measured	1 061	2.091	1.043	0.957	0.091	0.038	0.218	1.156	130.123	71.3	35.6	32.6	3.1
	Indicated	382	2.046	1.035	0.893	0.119	0.037	0.199	2.382	122.121	25.1	12.7	11.0	1.5
	Inferred	37	2.967	1.550	1.294	0.123	0.056	0.206	2.099	109.791	3.5	1.8	1.5	0.1
Esbarro	Measured	2 985	1.316	0.863	0.428	0.025	0.047	0.249	1.145	139.677	126.3	82.8	41.1	2.4
	Indicated	7 126	1.206	0.771	0.405	0.031	0.047	0.227	0.600	128.516	276.3	176.6	92.8	7.1
	Inferred	495	0.996	0.549	0.424	0.023	0.056	0.178	0.276	109.553	15.9	8.7	6.7	0.4
Trapia	Indicated	2 529	1.113	0.639	0.422	0.052	0.055	0.216	0.910	133.035	90.5	52.0	34.3	4.2
	Inferred	2 717	1.320	0.605	0.616	0.099	0.045	0.202	1.184	122.955	115.3	52.9	53.8	8.6
Santo Amaro	Inferred	11 380	1.360	0.650	0.690	0.020	0.010	0.120	0.710	105.870	497.0	237.0	252.0	7.0
Total	Meas+Ind	17 881	1.252	0.767	0.450	0.036	0.047	0.221	0.846	128.898	719.7	440.9	258.6	20.5
	Inferred	16 632	1.366	0.676	0.657	0.033	0.020	0.142	0.790	109.205	729.7	360.6	350.7	17.4

Source: Jangada Mines

Importantly, there are a further six known targets to explore which, with the overall district expansion potential, translates to Pedra Branca being potentially much larger and of significantly greater value than originally anticipated.

EXHIBIT 5: THE TECTONIC SETTING OF PEDRA BRANCA IN THE CENTRAL CEARA DOMAIN(CC)



Source: Jangada Mines

The Exploration Programme

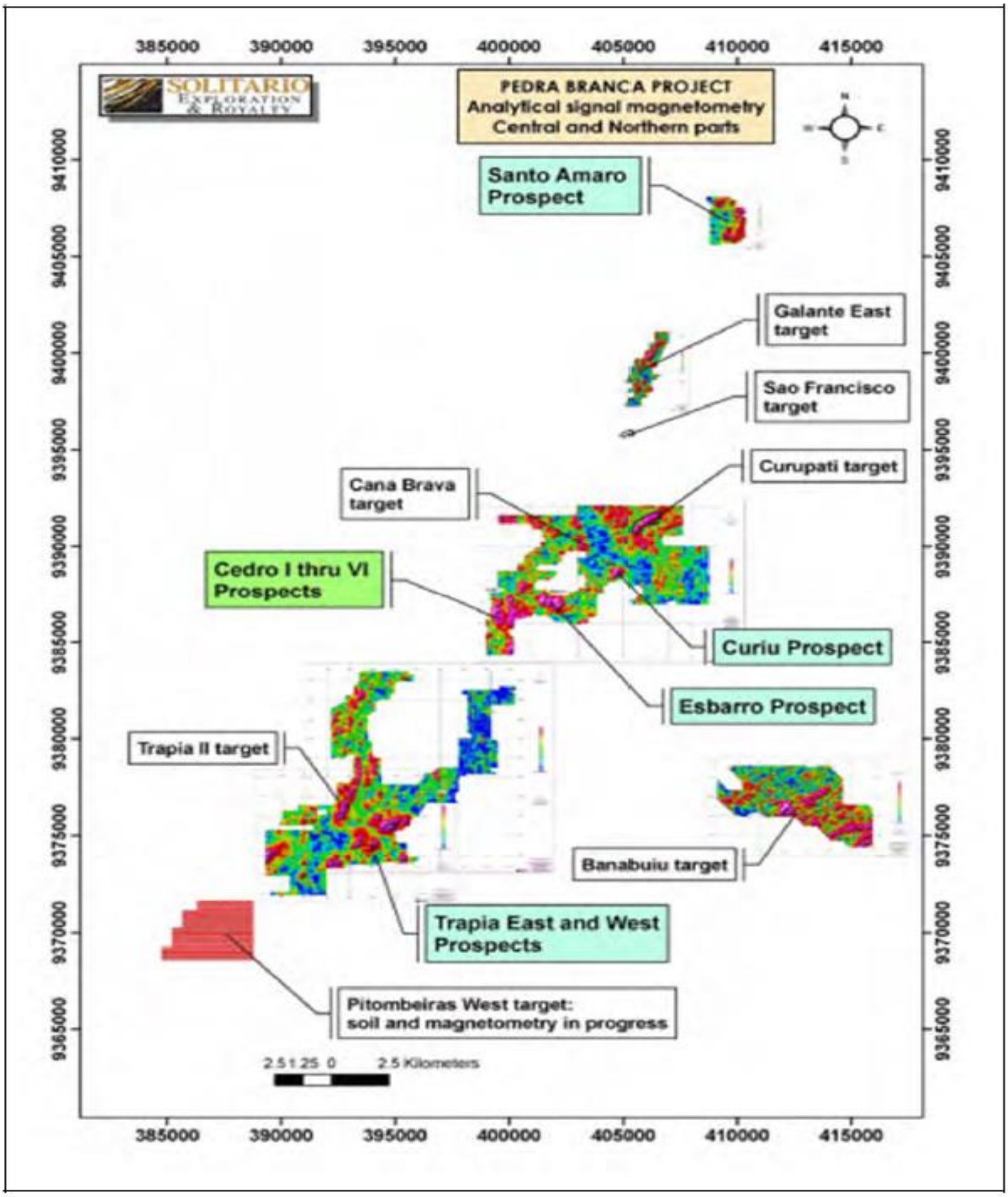
Various exploration programs were carried out by previous companies. The last of these companies, Anglo, completed a total recheck and validation of the project database. Jangada integrated all the available information validated by Anglo and carried out their own validation programme.

The exploration database consists of remote sensing, geological mapping, soil sampling program, ground geophysics, diamond drilling, topographic survey, chemical analysis laboratory, petrography and technological characterization.

Target Areas

Target areas were delineated in accordance with historic geological work done including outcrop occurrences of chromite and ultramafic rocks, the presence of PGM mineralization, sampling and geophysical anomalies and drilling. Target area names are traditionally derived from the closest human settlement or node. In the Pedra Branca region these are usually small villages or "vilas". The map below shows the various target areas at Pedra Branca.

EXHIBIT 6: THE MAIN TARGET AREAS AT PEDRA BRANCA PROJECT



Source: Jangada Mines

Mining

The ultimate pit and mine plan was developed by GE21 to optimize plant feed for 2.2Mtpa of production. The mine plan developed in this report is based on Measured, Indicated and Inferred resources and gives a mine life of 14 years.

The Pedra Branca Project will be an open pit operation utilizing a contract mining fleet of hydraulic excavators, front-end loaders and haul trucks. The mine planning model adopted is considered to be a “diluted” model, adding approximately 5 % dilution to the source model.

The disposal of waste rock, and low grade mineralized material will be in an area close to the pit. The site shall be adequately prepared to include drainage at its base and channels to direct the flow of water with the aim of aiding geotechnical stability and mitigating the erosion of the stockpiled material.

EXHIBIT 7: PEDRA BRANCA PROPOSED MINING SCHEDULE

Potential Viability of Mineral Resources																				
Mineralization														Product						
		Mass	Au	Pd	Pt	Au Equiv	Co	Cr2O3	Cu	Ni	Waste	Total Mined	Strip Ratio	Au	Pd	Pt	Cu	Ni	Cr	Co
Deposit		Mt	ppm					%			Mt		t/t	Oz troy x 1000			kt			t
Esbarro/Curiu	1	2.18	0.026	0.965	0.562	1.20	118.7	0.84	0.04	0.20	2.4	4.6	1.12	0.74	46.1	26.4	0.71	1.11	29.5	18.1
	2	2.19	0.029	0.831	0.443	1.00	129.1	1.04	0.04	0.23	1.5	3.7	0.70	0.82	39.8	20.9	0.75	1.31	36.4	19.8
	3	2.18	0.030	0.795	0.398	0.93	124.7	0.89	0.05	0.23	1.5	3.7	0.70	0.83	38.0	18.7	0.87	1.31	31.3	19.1
	4	2.19	0.031	0.802	0.471	1.01	126.7	0.81	0.05	0.23	1.7	3.9	0.80	0.87	38.4	22.2	0.78	1.31	28.3	19.4
Esbarro/Curiu/Cedro	5	2.18	0.042	0.771	0.525	1.05	125.7	0.71	0.04	0.21	2.9	5.0	1.31	1.19	36.8	24.7	0.62	1.21	24.9	19.2
Cedro/Trapia	6	2.19	0.017	1.233	0.688	1.49	113.3	1.28	0.03	0.20	4.4	6.6	2.00	0.48	59.0	32.4	0.58	1.16	44.8	17.3
	7	2.20	0.017	0.727	0.525	1.00	105.6	0.63	0.03	0.16	3.3	5.5	1.51	0.47	35.0	24.9	0.55	0.92	22.4	16.3
Trapia/Santo Amaro	8	2.19	0.027	0.751	0.461	0.96	124.3	0.89	0.04	0.19	3.5	5.7	1.61	0.75	35.9	21.7	0.69	1.07	31.4	19.0
	9	2.18	0.062	0.494	0.609	0.97	110.9	1.06	0.03	0.16	5.1	7.2	2.32	1.75	23.6	28.6	0.49	0.90	37.0	17.0
Santo Amaro	10	2.19	0.024	0.613	0.658	1.05	101.4	0.70	0.01	0.12	2.2	4.4	1.01	0.68	29.3	31.0	0.22	0.70	24.6	15.5
	11	2.18	0.016	0.648	0.682	1.09	100.6	0.68	0.01	0.12	1.4	3.5	0.62	0.45	31.0	32.1	0.15	0.68	23.9	15.4
	12	2.19	0.015	0.626	0.720	1.11	101.0	0.71	0.01	0.12	1.4	3.6	0.66	0.42	29.9	33.9	0.15	0.67	25.0	15.5
	13	0.79	0.014	0.645	0.738	1.14	105.6	0.73	0.01	0.12	0.2	1.0	0.26	0.15	11.1	12.6	0.05	0.25	9.2	5.8
	Total	**27.04**	**0.028**	**0.768**	**0.567**	**1.074**	**114.9**	**0.85**	**0.03**	**0.18**	**31.6**	**58.7**	**1.17**	**9.60**	**453.9**	**330.1**	**6.61**	**12.60**	**368.7**	**217.4**

Source: Jangada Mine

This gave a mineral inventory of 27.04Mt grading 0.768g/t palladium, 0.567g/t platinum and 0.027g/t gold, with associated base metals. The following metallurgical recoveries were used for each mineralised zone.

EXHIBIT 8: PEDRA BRANCA PROJECT, METALLURGICAL RECOVERIES IN MINING SCHEDULE

Metal	Mineralized Zones		
	Oxidized	Transition	Fresh
Pd	**60%**	**70.0%**	**86.0%**
Pt	**60%**	**67.0%**	**83.0%**
Au	**50.0%**		
Co	**48.8%**		
Cr2O3	**70.0%**		
Cu	**87.9%**		
Ni	**48.8%**		

Source: Jangada Mines

The metallurgical recovery parameters are scoping-level estimates only and are based on historic metallurgical borehole and surface sample bench-scale test work completed in 2017 and assumptions from geologically similar ore deposits.

The mining will be conducted by blast and haul methods using a fleet of CAT 345 hydraulic excavators using 2.5m^3 buckets and Scania 43.5 tonne trucks or similar which has been carefully matched to the mine schedule. There will also be a fleet of ancillary equipment available for mine maintenance and eventual plant services. The total size of the mobile fleet is relatively small at 2 excavators and three trucks for the first ten years of operation before the truck fleet jumps to thirteen in year eleven reflecting the increasing strip ratio and longer haul times.

The strip ratio for the life of the mining operation is 1.1:1, which is very low for open pit mining by today's standards. In the early years of the mine the stripping ratio is substantially below 1:1 and only rises significantly above this figure in year 11 of full scale mining.

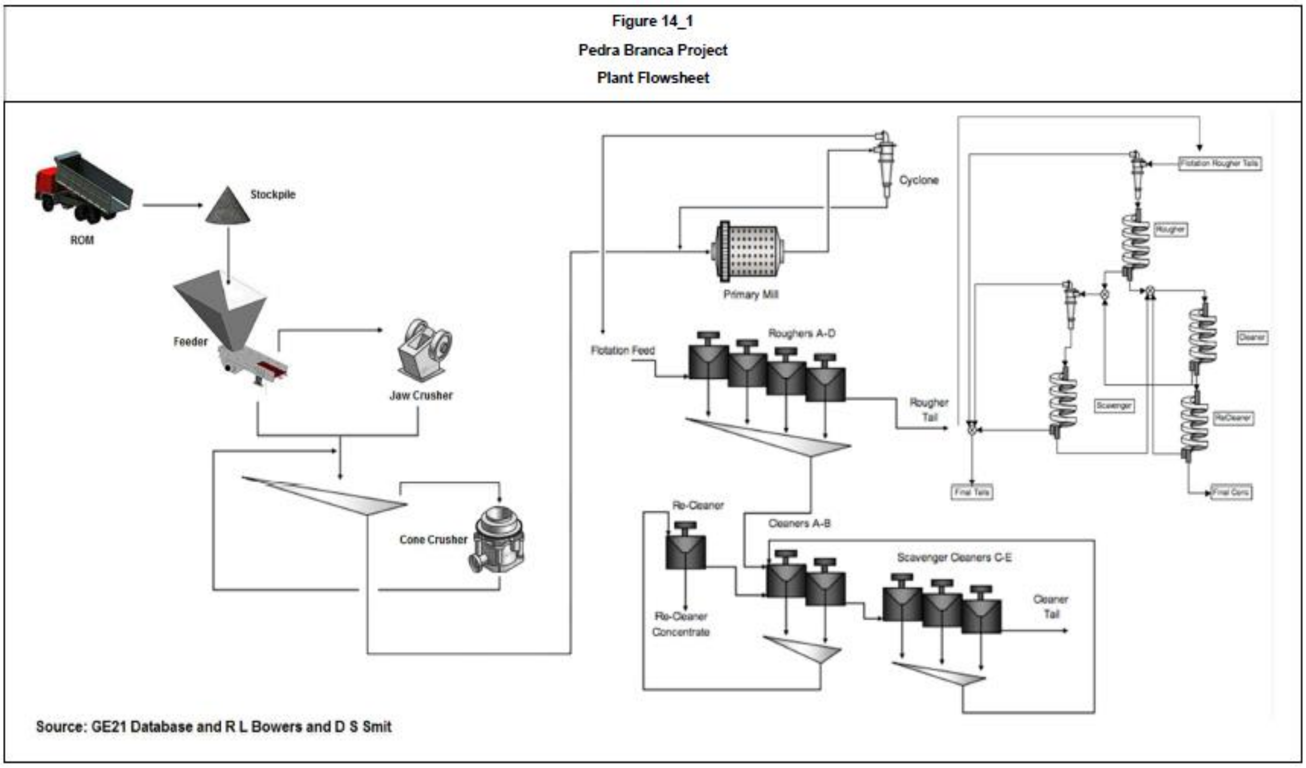
Metallurgy

The metallurgical process is pretty standard. The run-of-mine ore is trucked to the plant where it is crushed and fed to conventional ball mills. The mills grind the ore to the required size with the mill product cycloned to produce the required flotation feed. The ore is subjected to standard sulphide flotation techniques of a rougher, cleaner and scavenger cells. It is the intention to produce one flotation concentrate containing all the recoverable metals with the exception of chrome.

The rougher tailings from flotation are feed to a spiral gravity concentrator to produce a chrome concentrate. The tailings from the spiral plant go to final tails.

The cleaner concentrate is feed to a recleaner bank of float cells with the recleaner concentrate being thickened and filtered read for shipping. The tailings from the cleaner scavenger cells are sent to tailings.

EXHIBIT 9: PEDRA BRANCA PROJECT- PROPOSED PLANT FLOWSHEET



Source: Jangada Mines

Current Metallurgical Testwork

Currently, there is metallurgical test work being conducted that suggests that higher metal recoveries may be achieved. This work involves magnetic separation, a talc pre-float and work on the optimum grind size.

It was noticed that the chromite grains were weakly magnetised, and would make ideal feed for a high intensity magnetic separator. It was found that a 20% mass pull on a feed of 2.2Mt pa would provide sufficient tonnes for a 35kt pm flotation plant.

This circuit has a number of major advantages which could lead to a substantially positive impact on the economics of the Pedra Branca ore. Magnetic pre-concentration yielded increased recoveries of PGM's along with unexpectedly high gold grades and chrome grades. Hence, Jangada are researching how a magnetic concentrator could be incorporated.

One large benefit is that Pedra Branca is located in an arid part of Brazil and the magnetic separation can be conducted dry.

The grind size is particularly important since reducing the d50 size has indicated much higher recoveries on three of the four orebodies. The preliminary results of magnetic separation achieves a chrome grade in concentrate of 42% Cr_2O_3, a 25x upgrade from feed. This grade is high enough to be sold as metallurgical grade, but it is currently thought that by processing the flotation tailings though spirals, it may be possible to significantly upgrade the chrome concentrate and sell it as a higher value product, chemical grade or perhaps foundry grade.

Jangada had been seriously considering a pilot plant test the proposed flowsheets given the differing requirements of each of the four orebodies. This pilot plant has been costed and could be installed relatively quickly. By co-incidence, the size of the pilot plant matches the concentrate tonnage produced by the magnetic concentrator. This would enable a much less expensive plant to be built and it could also be brought into production much quicker than the full size option.

A further surprise was that the magnetic separation increased the recoveries of PGM's and yielded unexpectedly high gold grades. This pre-concentration yielded PMG grades of up to 8.1g/t and average gold grades of 15g/t, with the highest being 75.5g/t. It is well known that there is gold in the general area of Pedra Branca, but the grades were surprisingly high. With the flotation gold recovery only 40%, there could be significant upside with the addition of a carbon-in-pulp plant on the flotation tailings. This has the ability to greatly boost cashflows.

In addition, the magnetic concentrator tailings will be impounded in a designated area. This will have been mined, crushed and ground to a fine size. If the combined value of the recoverable metals in these tailings is more than the cost of processing, then they could all be processed at the end of the mine life.

EXHIBIT 10: MAGNETIC SEPARATION PERFORMANCE

Metal	Magnetic concentration			Clenaner/Reclenar Flotation		
	Mass Recovery %	Metallurgical Recovery %	Concentrate grade	Mass Recovery %	Metallurgical Recovery %	Concentrate grade ppm
Platinum	-	-	-	1%	**67%**	**54.4 g/t**
Palladium	-	-	-	1%	**68%**	**105.4 g/t**
Gold	-	-	-	1%	**40%**	**2.02 g/t**
Nickel	-	-	-	1%	**26%**	**7.91%**
Copper	-	-	-	1%	**77%**	**6.11%**
Cobalt	-	-	-	1%	**7%**	**0.14%**
Chromium	**12%**	**67%**	**42%**	-	-	-

Source: Jangada Mines

Taxation in Brazil

PIS/CVOFINS

In Brazil, companies that export 100% of production have a federal incentive and don't need to pay 9.25% of these taxes.

Compensação Financeira pela Exploração Mineral- CFEM

Translated this stands for Financial Compensation for the Exploration of Mineral Resources ("CFEM") and is a consideration paid to the Union for the use of mineral resources. As defined in the decree, CFEM focuses on net sales, in the case of the sale of the raw and beneficiated ore, or in the intermediate cost of production, when the mineral product is consumed or transformed into an industrial process. In our modelling we have assumed that 2% will be the rate charged.

Imposto de Renda IR - National Income tax

This is a 15% tax rate on pre-tax profit, based on Real Profit, is applied, if this profit is less than R $ 240,000.00, or a rate of 25% on pre-tax profit, if this profit is greater than R $ 240,000.00.

Social Contribution on Net Profits

The social contribution is 9% for calculation based on Real Profit which equates to EBIT.

Royalties

For the Pedra Branca Project, the royalty was considered at 1%.

Valuation

Valuation Technique

BHC has modelled a scenario whereby full-scale production commences in the March quarter of 2020 at the rate of 275kt per quarter. The project has been modelled quarterly out until the end of 2025 and then half yearly until the end of the proposed mine life in 2032.

Key Points

- Full-scale production commences from March 2020
- Platinum and palladium account for around 58% of revenue with the balance coming from gold, copper, nickel, cobalt and chrome
- Nickel and chrome are the next two important metals with respect to revenue
- Recoveries of all metals varies with the type of ore being processed

The cashflows from the mine are the discounted, using a 10% discount rate, half-yearly over the life of the mine. The NPV is measured 12 months out from the latest set of financials reported by Jangada.

Being a polymetallic mine with seven distinct revenue streams does help protect the mine. However, under the current modelling and recovery/grade assumptions the three major revenue streams are palladium, platinum and nickel. Together these account for around 86% of total revenues. There are also different payables for each of the elements. Most of the payables have been modelled at 85%, the two standouts being cobalt where a payability of 20% is used and chromate where a payability of 95% has been applied. Although we describe the mine as polymetallic, platinum and palladium are expected to account for about 58% of the net revenue and the mine is therefore classified as a PGM mine.

The recoveries of platinum and palladium vary with the three different types of ore mined whereas the recoveries of the other metals are pretty constant. The details are tabled in exhibit 8 on page 14 in the mining section.

The commodity price and grade assumption have been averaged over the period of the mine life. We particularly note that the cobalt price used is low compared to today's spot price, however, BHC takes the view that the current price represents a "possible bubble" and that much of the cobalt in lithium ion batteries may be replaced with nickel in the future. In the event that cobalt was displaced by another commodity the current cobalt price is unlikely to remain at today's levels over the longer term (the 14 years modelled period). Also, exploration efforts for cobalt have been energised recently, driven by the current high cobalt price and are expected to bring the future price down to more normal levels. We have noted that should this long term pricing assumption be incorrect and that Cobalt will remain at these current levels it will materially improve the NPV.

Commodity assumptions used are:

Platinum Price	US$1023/oz
Platinum Grade	0.54g/t
Palladium Price	US$1055/oz
Palladium Grade	0.91g/t
Gold Price	US$1319/oz
Gold Grade	0.03g/t
Copper Price	UC$3.02/lb
Copper Grade	0.04%
Nickel Price	US$5.90/lb
Nickel Grade	0.12%
Cobalt Price	US$51.6/lb
Cobalt Grade	0.01%
Chromium Price	US$200/t
Chromium Grade	1.02%

The assumptions used are:

LOM strip ratio	1.1:1
Processing Rate	2.2Mt pa
Mine life	14 years
Discount rate	10%
Mining cost ore	US$3.09/t
Processing cost	US$10.5/t
G&A costs	US$0.30/t
Opex(per oz/PGM)	-US$282
Recovery	~68%
Mineral Royalty	1%
Tax	36%
Initial Capex	US$64.7M
Sustaining capex	US$0.4M pa
Net present value(10%)	US$177M

In Brazil a 25% company tax rate is applicable. However, total taxation is far more complicated than this and we have outlined the taxes and tax rates that apply on page 17. To simplify these taxes we have used a 1% royalty rate and added the other taxes together and applied them as one 34% company tax rate.

The modelling assumes that the concentrate is sold FOT at the mine gate, and therefore includes no transport costs. This may not be the case and would reduce the valuation.

Potential Upside Scenarios

There are a number of areas of upside to our valuation.

1. Cobalt Price

In our modelling we have taken a very hard line with the cobalt price, assuming it is a bubble that will burst before long. Our metal price projections are based on the forward curve from Bloomberg and they have the cobalt price reducing to US$50/lb in 2024, as we see the current high rice of cobalt, and the sustainability of its production leading to substitution. If we are incorrect and the price stays strong for longer, there is modest upside to our valuation. However, it is important to realise that cobalt is not one of the major revenue streams.

2. Rhodium Production

Rhodium is known to occur in the orebody and there are two assays for the metal. It is assumed that it occurs in small amounts throughout the orebody and will naturally report to the flotation concentrate. Given its value, currently US$1,700/oz, this has the potential to add substantial value to the project.

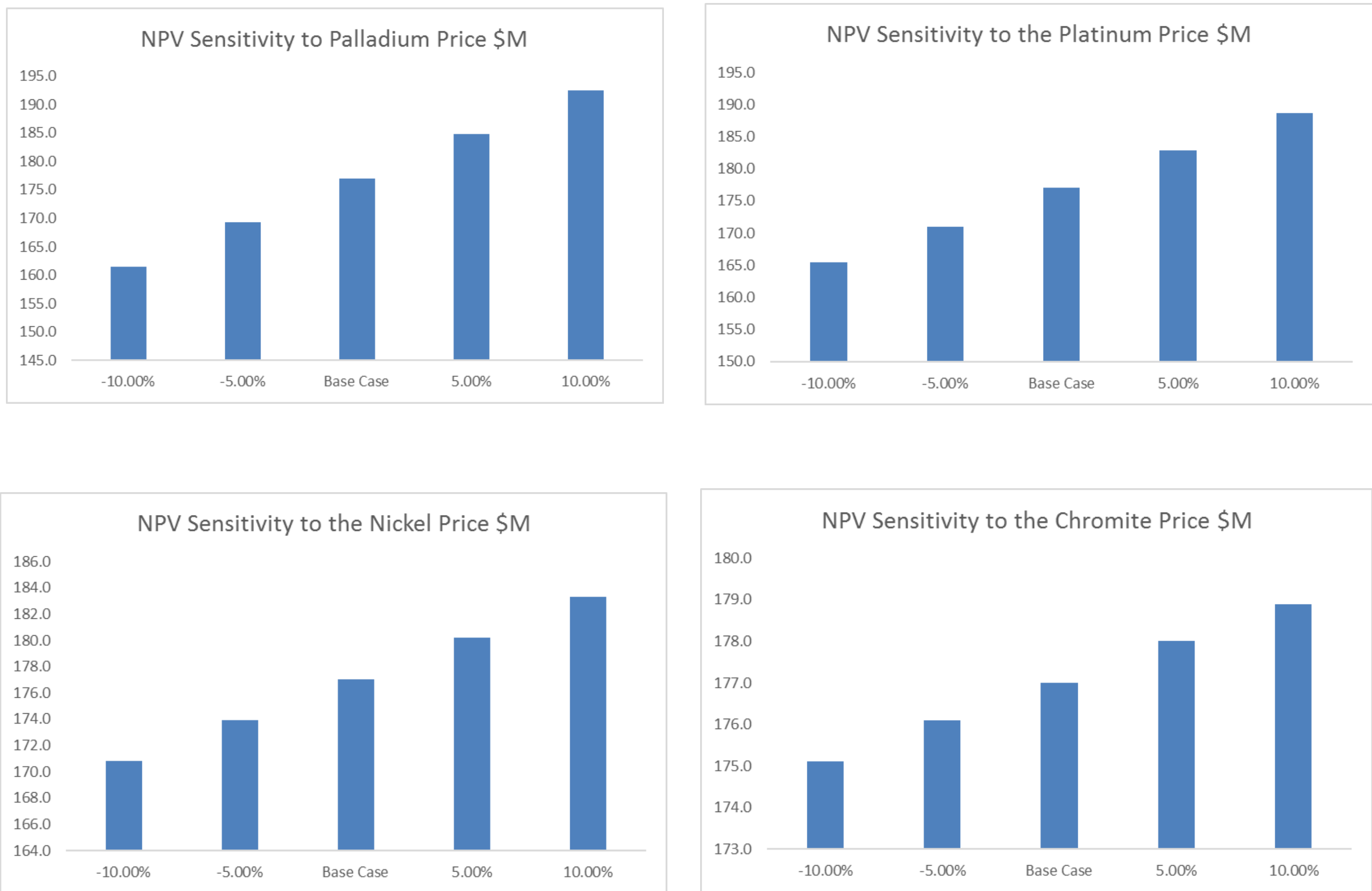
3. Recoveries

Jangada is continuing with its metallurgical test work. This includes high intensity magnetic separation, grind size and a talc pre-float amongst other tests. One of the problems is that the four ore bodies that Jangada expects to mine all have slightly different characteristics. The good news is that the recoveries used in the BHC modelling are now looking very conservative. We believe that there could be significant upside in our valuation from increased recoveries and we have tabled this below.

4. Reduced Capital Costs

As we mentioned in the section on infrastructure on page 5, the potential use of grid power and differing sources of water, have the potential to reduce both capital and operating costs. A further development that is currently being investigated is the production of chrome by magnetic separation. This has several advantages the key one being that it is a dry process and would reduce water consumption. In addition, it could also serve as a method of pre-concentration for the other metals in the ore. As a general rule of thumb, the higher the grade, the higher the recovery. Finally, BHC believes that a magnetic separation plant would be a much smaller installation than a spiral plant which one would expect to reduce capital and operating costs. As all of these options are currently being investigated, we have no confirmation of capital and operation cost savings, except to say that they could be substantial.

EXHIBIT 11: NPV SENSITIVITY TO METAL PRICES



Source: Brandon Hill

As part of our sensitivity analysis, BHC ran a scenario whereby all commodity prices were reduced by 50% over the life of the mine. Under this harsh scenario, the model still generated a positive NPV (10%) of US$49.3M. This gives a good idea of just how robust this project is before considering the latest metallurgical upside.

Platinum Comparisons

In our list of comparatives for Jangada, the most obvious comparison is with Tharisa Minerals.

Tharisa Minerals (LSE)

Tharisa is an operating mine and despite the low grades of its PGM's it is profitable in no part due to the high percentage of chromite in its ore, which provides the company with a major by-product. It has a huge resource base of 867Mt grading 1.59 PGM's, but a much smaller reserve of 97Mt. Further, Tharisa is in South Africa, and BHC believes that the world really wants a PGM project outside of Southern Africa to eliminate the political risk associated with that area.

There are several projects in Australia.

Platina Resources (ASX)

The Owendale project of Platina Resources is essentially a scandium project with nickel and cobalt by-products. The PGM content of the orebody is miniscule and the project is being defined by its scandium content. Therefore, this is not a very good comparative. Similarly, Platina's Skaergaard project in Greenland is very remote and will have very high operating costs. BHC does not believe that this deposit will be developed in the short term.

Panoramic Resources (ASX)

The Panton Sill project owned by Panoramic Resources has potential with a combined platinum and palladium grade of 4.58g/t with some modest gold, copper and nickel credits. But, this project lies very close to Panoramic's Savannah nickel, copper and cobalt project. As the company's presentation says, "it's all about Savannah" where a feasibility study has shown that it has a robust mine plan with excellent potential for mine life extensions through exploration success.
The close proximity of Panton to the Savannah Project offers a number of potential capital and operating synergies not available to previous owners, which could substantially improve the economics of the Project. Panoramic is continuing to investigate the use of alternative processing options to help unlock the inherent value of the Project. Recent test work undertaken by Panoramic has identified the potential for improved metallurgical recoveries and higher concentrate grades together with the potential to upgrade the ore via ore sorting. Ore sorting test work demonstrated chromite ore (containing PGMs) can be separated from waste rock with a high degree of efficiency.

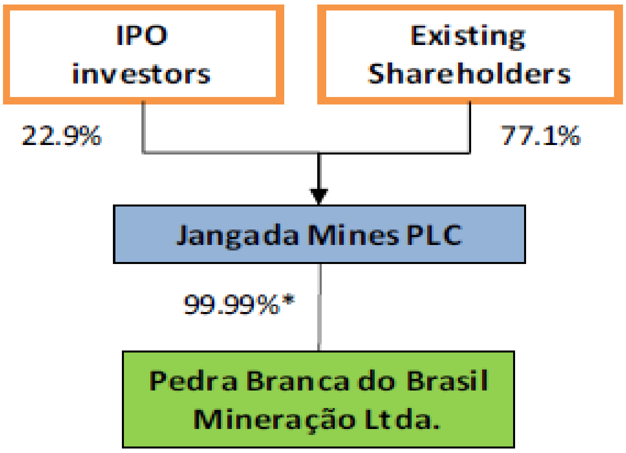
Podium Minerals Limited (ASX)

Podium's Weld Range project is we believe the best comparison outside of Southern Africa. However, it is at a very early stage and the commencement of metallurgical testwork and resource estimation at Parks Reef has only just begun.

Its mining deed has been amended to modify the definition of Oxide Minerals to exclude all sulphide minerals and all gold, silver and base metals (excluding Chromium) associated with PGMs unless they exist within the currently defined oxide resources held by EVM. These amendments are positive as they provide for ownership of the mining rights for all PGMs, gold and base metals within both the oxide and sulphide zones of Parks Reef by Podium.

Podium has recently initiated its first drilling programme with the first results announced in April 2018. The first results indicated substantial widths of up to19m grading around 2g/t 3E PGM which were very shallow. Further results showed high grade sub layers with intercepts greater than 3m with most grades being between 2 and 3g/t 3E PGM and all potentially open pittable. Subsequent deeper drilling, up to 159m downhole, gave similar intercepts if marginally lower grade. The most recent drilling has encountered a base metal and gold enriched layering above the PGM horizon that extends the mineralised width of Parks Reef. The base metal and gold horizon would be mined in any open pit operation targeting the PGM horizon potentially generating significant additional revenue. This points to a similar sort of orebody, and it is worth noting that BHC has calculated that the chromites will account for approximately 8% of Jangada's revenues.

Capital Structure



Source: Jangada Mines

Investment Risks

Metal Prices/Currency

The platinum group metals have been suffering from low prices for a number of years, despite demand having exceeded supply for several years now. Much has been said about electric cars and the fact that they do not need catalytic converters, the main source of use for PGM's currently. However there is a consensus emerging that the bulk of the powertrain market share will be retained by vehicle with pure petrol of diesel engines and hybrids until well past 2025. This augers well for continued automobile demand for PGM's. Further production has been falling and some expect this to lead to a significant increase in prices in the near future.
Currency is always an important consideration in determining the profitability of all mines. This is due to the fact that just about all commodities are sold in US$'s so an appreciating or depreciating currency will impact all the revenues from all metal streams. The Brazilian real has oscillated greatly over the past 12 months, mainly as a result of politics. It approached 4 to the US$ when President Dilma Rousseff was impeached, but is currently weakening again.

Financing

The Group's capital requirements depend on numerous factors. The availability of equity funding is subject to market risk at the time and there is no guarantee that the Group will be able to secure any additional funding or be able to secure funding on terms favourable to the Group.

Any additional equity financing will dilute shareholdings, and debt financing, if available, may involve restrictions on financing and operating activities. If the Group is unable to obtain additional financing as needed, it may be required to reduce the scope of its operations, scale back its exploration programmes and this may result in loss of tenure, as the case may be.

Permitting

In theory it is fairly easy to renew tenements in Brazil, although it can take time. Despite there being no minimum work requirement on the Group's licenses, the Group cannot guarantee that the DNPM will renew licenses held by its Brazilian subsidiary that have not had any work performed on them during their tenure of that license.

All exploration work will initially be focused on the defined Mineral resource areas of the Curiu, Cedro and Esbarro prospects that sit within the three Mining Licenses, rather than any of the Exploration Licences that the Group owns.

Geological

There appears to be very little geological risk since they already have a JORC compliant resource and the metallurgical test work is proving very encouraging. However, whilst there are no minimum work requirements on the Group's licences, there is no guarantee that the DNPM will renew licences held by Jangada's subsidiary that have not had any work performed on them.

Country Risk

Brazil is not seen as the easiest country in which to work and the tax regime is seen as somewhat convoluted. Overall the Fraser Institute 2017 Survey sees Brazil as a mid-ranking country with a ranking of 30 out of 94 for ease of Investment Attractiveness and a score of 54.76 in the Best Practices Mineral Potential Index which rates the country 36 out of 94. IN 2016, Transparency International rated Brazil 79th in its corruption index. Whilst this does not sound too impressive, it does rate the country above Peru which is perceived as a mining friendly country and Argentina but a long way behind Chile which rated 24th.

Technology

The technology that Jangada proposes to use in well tried and tested. This is contract mining using truck and shovel operation for the mining. For the mineral processing it is essentially gravity and flotation. The circuit could become more complicated as the test work yields an improved flowsheet including magnetic separation, but nothing is anywhere near cutting edge technology.

Appendix A – Directors & Management

Board Directors

Brian McMaster — Executive Chairman

Mr. McMaster has almost 20 years' experience in the area of corporate reconstruction and turnaround and performance improvement and 20 years in the mining industry. Mr. McMaster's experience includes founding Highfield Resources, an ASX listed potash company with projects in Spain as well as numerous reorganisations and the recapitalisation and listing of 12 Australian companies. Mr. McMaster's career to date includes significant working periods in the United States, South America, Asia and India. Mr. McMaster was a founding director in venture capital and advisory firm, Garrison Capital Pty Ltd, and is also currently a director of a number of ASX listed companies.

Peter Heinrich Muller — Chief Operation Officer

Mr Muller is a professional geologist with mining and exploration experience gained through a variety of international roles, including at the Pedra Branca Project. From 2011 to early 2017, Mr Muller was employed by Anglo American Platinum, which included, between 2012 and 2015, time as the Managing Director at the Pedra Branca Project. At the Project, he was responsible for all technical and corporate aspects and their execution. Mr Muller also spent over two years working at the Amandelbult mining complex in South Africa, where he was involved with on-mine exploration, as well as introducing operational efficiencies. Mr Muller holds a B.Sc. (Hons) in Applied Geology from Stellenbosch University and is a member of both the Geological Society of South Africa and the Prospectors and Developers Association of Canada.

Luis Azevedo — Non-Executive Director

Mr Azevedo is a resource industry professional with over 35 years of international experience. He is both a licensed lawyer and geologist with over 25 years of business and mining experience specifically in Brazil. He is currently the Managing Partner at FFA Legal Ltda, a legal firm he founded with its main office in Rio de Janeiro, Brazil, and which is focused solely on natural resources companies. Mr Azevedo is also a Non-Executive Director of Harvest Minerals Limited and previously worked for Western Mining Corporation, Barrick Gold Corporation and Harsco Corporation. He assembled land packages that resulted in four initial public offerings of Canadian companies in Brazil (Talon Metals Corporation, Avanco Resources Ltd, Beadell Resources Ltd, Brazilian Gold Corporation) since 2004. Mr Azevedo also sits on the board of directors of Avanco Resources Ltd, Brazil Minerals Inc and Talon Metals Corporation. Mr Azevedo received a geology degree from UERJ – Universidade do Estado do Rio de Janeiro in 1986, a law degree from Faculdade Integradas Cândido Mendes in 1992, and a post graduate degree from PUC-Rio, Pontifícia Universidade Católica of Rio de Janeiro in 1995.

Nicholas von Schirnding — Independent Non-Executive Director

Mr von Schirnding is a board-level executive with over 25 years' experience in the natural resources sector. Previously, Nick was CEO of Asia Resource Minerals plc (formerly Bumi plc), a FTSE listed mining company, where he played a significant role in restructuring the group. He was also the deputy chairman of Berau Coal, one of Indonesia's largest coal producers. Prior to that Nick was a senior executive at Anglo American plc and De Beers where he worked for over 20 years. He is currently a non-Executive Director of Ortac Resources Limited, a UK listed company and chairman of Fodere Group, a private mining company. Mr von Schirnding has a Bachelor of Law from the University of Cape Town.

Louis Castro — Independent Non-Executive Director

Mr Castro has over 30 years' experience in accounting and corporate finance both in the UK and overseas. He is a Non-Executive Director of AIM quoted Stanley Gibbons plc and recently was the Chief Financial Officer at Eland Oil & Gas plc, an AIM quoted company where he was one of two executive directors. Previously he was the Managing Director of Northland Capital Partners in London and before this he was Head of Corporate Finance at Matrix Corporate Capital and at Insinger de Beaufort. He started his career by qualifying as a Chartered Accountant with Coopers & Lybrand (now PWC). Mr Castro has widespread international experience of advising the Boards of companies. He has led on numerous public listings and has been chairman of the audit committee at Eland Oil & Gas plc and at Pan European Terminals plc. Mr Castro is a Fellow of the Institute of Chartered Accountants in England and Wales. He graduated in 1980 from Birmingham University with a BSc & BComm (Hons) in Engineering Production & Economics.

Appendix B - Brazil

Population (2017)	210.8M
Major Language	Portuguese.
Capital	Brazilia.
GDP (as of 2017)	USD 1,954 Billion.
Major Religion	Christianity.
Major Exports	Iron Ore, Crude Oil, Soybeans, Sugar, Coffee.
Currency	Brazilian Real.
Unemployment Rate (May 2018)	12.9%
Major Natural Resources	Iron Ore, Manganese, Bauxite, Nickel, Gold, Platinum, Uranium, Tin, Petroleum.

Brazil had been under the rule of the Portuguese monarchy for nearly 3 centuries and the lasting effects of that rule can still be seen, as Brazil is the only South American country where Portuguese is the official language. It shares borders with every South American country with the exception of Chile and Ecuador.

Brazil is a country of approximately 211M people on a land mass of over eight million square km, thereby placing the country, on a land mass basis, as the fifth largest in the world and the largest in South America. Brazil is often grouped, alongside Russia, India and China, as one of the 'BRIC' economies and benefits from a large domestic market, diversified economy and a broad selection of trading partners. FDI in the country was estimated at US$70.3B in 2017.

The political institutions in Brazil are well established. Until 2016, the country had experienced more than 25 years of stable democracy, with policy makers showing a continued commitment towards maintaining economic stability. However, Brazil has recently faced a political crisis following the impeachment of President Dilma Rousseff on 31 August 2016, who was found guilty of breaking budgetary laws. In May 2017, the Brazilian stock markets and currency dropped significantly after corruption allegations emerged surrounding the current President Michel Temer, which has also led to numerous calls for him to resign and fresh elections be called. The President refutes the allegations and is ignoring calls for him to resign – the situation remains fluid.

From 2003 to 2014, Brazil experienced a period of social and economic development in which over 29M people emerged out of poverty. According to The World Bank, from 2002 to 2012, the income of the bottom 40 percent of the population grew, in real terms, on average by 7.1 percent. Brazil is Latin America's largest economy and the world's ninth largest economy with GDP in 2015 in excess of US$1.7 trillion. The country was also one of the first emerging markets to begin a recovery following the global financial crisis that began in 2008. By 2010 both investor and consumer confidence recovered significantly, such that GDP growth reached 7.5 percent that year.

During 2015 and 2016, Brazil experienced a period of deep recession. GDP decelerated consistently since 2010, from an average annual growth rate of approximately 4.5 percent between 2006 to 2010 to approximately 2.1 percent between 2011 and 2014. GDP declined by approximately 3.8 percent in 2015 and it was expected to have contracted by at least 3 percent in 2016. However, economists have forecasted the GDP to remain unchanged in 2017. The Central Bank of Brazil is now easing monetary policy more aggressively, which representatives of the Central Bank of Brazil believe will assist with the emergence of Brazil's economy from recession. In addition, the government is actively working to support the economy, and in March 2017 launched an infrastructure concession programme that seeks to kick-start investment for infrastructure. In 2015, the Brazilian government announced US$64B in new infrastructure investment, with investment from China anticipated to be in excess of US$50B. GDP increased slightly in 2017 compared to 2016 with a rate of 0.98% and is expected to continue growing in 2018 as a result of lower inflation, improved confidence and a less-tight monetary policy, as outlined. Whilst the improvement is not expected to be significant this year, data from the Central Bank of Brazil's Focus Bulletin suggests that GDP should increase 2.3 percent in 2018.

The climate in Brazil is mostly tropical, except for the Southern areas, where it is temperate. Along with their highly advanced manufacturing sector and rich natural resources, Brazil's tourism industry is vital to the economy as well.

The Directors believe the country has excellent demographic trends, with the population growing by over 15 percent since 2000, with a fast growing middle class and increasing urbanisation. Approximately 86 percent of the population live in urban environments. Brazil's economy is largely driven by household consumption and has well developed service, manufacturing, agricultural and mining sectors

EXHIBIT 12: BRAZIL

Source: operationworld.org

Appendix C – PGM Commodity Market Review

The PGM Market

PGM's are a group of metals, namely platinum, palladium, rhodium, iridium, ruthenium and osmium, which have similar physical and chemical properties and tend to occur together in the same mineral deposits. However, it should be noted that there has been no mention of iridium and osmium at the Pedra Blanca deposits.

The usefulness of PGM's is determined by their particular chemical and physical properties. Certain of these properties are shared by other materials, but it is the unique combination of properties that makes the PGM's so valuable in their end-markets.

PGM's have high and specific catalytic activity, high thermal resistance, are chemically inert, biocompatible and are hard but malleable for forming into shapes.

Platinum, palladium and rhodium are used in higher-volume industrial applications, while iridium and ruthenium have niche high-technology applications. Alongside their established applications, PGMs' attractive properties make them all the subject of intensive research and development into novel end-uses.

All the PGM's are constantly subject to risks of substitution from cheaper alternatives, but in most applications their unique properties render them relatively secure. The high cost of PGMs inevitably drives efforts to use lower quantities through thrifting, thereby reducing the loadings in applications.

Major Uses of PGMs

The main uses of platinum are as a catalyst for automotive emissions control, in jewellery and in industrial catalytic and fabrication applications. Platinum is also important in fuel cells, an application that is likely to become increasingly important and which we discus more thoroughly later in this section.

Palladium is primarily used as a catalyst in the automotive sector, mainly in gasoline-powered on-road vehicles, and has displaced platinum in some parts of on-road diesel engine autocatalysts. The second main use of palladium is in electrical components, specifically in multi-layered ceramic capacitors (MLCCs), as conductive pastes and in electrical plating.

Rhodium is used mainly in the automotive sector, which represents 84% of total consumption, with a growing amount is used in optical fibre coatings. Rhodium is especially good at removing NOx and this has led to an increase in its recycling rate of 200% since 2016.

The combustion of fuel in a motor vehicle engine produces pollutant emissions of hydrocarbons (HC), oxides of nitrogen (NOx), carbon monoxide (CO) and particulate matter (PM). An increasing focus on environmental pollutants and regulatory changes imposing environmental standards have led to the widespread use of catalytic converters in automobiles to reduce emissions and thereby improve air quality. PGM's have a unique set of properties that convert exhaust pollutant emissions to harmless compounds, and accordingly have been the main metals used in catalytic converters to date.

Platinum is particularly effective at catalysing the oxidation of CO and HC under oxygen-rich conditions, so has been the metal of choice for diesel engines. Platinum and palladium are equally effective under the conditions found in a gasoline engine, where there is a balance between oxidants and reductants in the exhaust gas, and are generally used in combination, with relative proportions dependent on the relative costs of the two metals.

The clean-up and reduction of sulphur in diesel has, since 2006, allowed palladium to be used in diesel catalytic converters. In certain catalytic applications, the combination of platinum and palladium is more effective than either metal alone. Owing to its historically lower price, palladium has been substituted for platinum in both types of combustion engine and now makes up around 84% of most gasoline catalysts and around a third of diesel catalysts in Europe (2015) for passenger cars and light commercial vehicles. Rhodium is used specifically to catalyse the reduction of NOx to nitrogen.

Despite their high cost, platinum and palladium face no foreseeable competition in this area. Several other metals are good oxidation catalysts in other environments but do not have the thermal durability and resistance to poisoning necessary to survive in the harsh autocatalytic conditions.
The recent "deiselgate" scandal has seen a huge swing away from diesel towards petrol powered engines. This has been responsible for the increase in the palladium price and the move from surplus to deficit for palladium. However,

this has raised further questions. Although the production of NOx has gone down, CO_2 production is up significantly due to the lower efficiency of petrol engines. This could potentially mean that car makers do not reach their CO_2 emission targets and be liable for fines. In the USA there are diesel vehicles that are meeting very stringent emission regulations that would easily pass all European emission requirements. Therefore it is presumed that the European produced vehicles could easily comply.

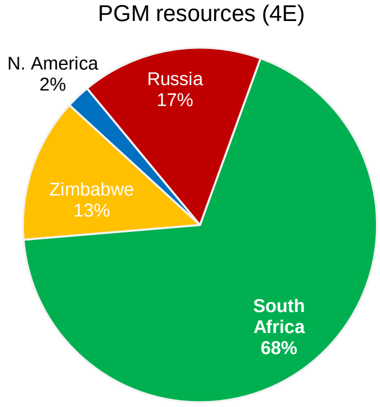
PGM ore reserves and mineral resources

The majority of PGM resources are located in Southern Africa, which accounts for over 80% of global PGM resources. The PGM contained in mineral resources (inclusive of ore reserves) of PGM-producing countries reported in terms of 4E, (platinum, palladium, rhodium and gold) are set out in Exhibit 13 below.

Exhibit 13: World PGM Reserves and Resources

Country	4E Moz
South Africa	1,415
Russia	345
Zimbabwe	270
North America	45
Total	2,075

Country resources are inclusive of reserves



Source: SFA (Oxford)

PGM Demand

The demand for PGM is driven by industrial applications and, in particular, the automobile industry.

Vehicle exhaust emission controls began in the USA in 1975, using PGM-containing catalysts on light-duty vehicles. Subsequently, most other countries adopted similar legislation. Over time, emissions standards continue to tighten, which can lead to higher loadings of PGMs per catalyst or varying formulations and technologies to adhere to regulations.

Emerging economies' car markets are forecast to continue to expand. These countries are adopting standards similar to European emissions standards.

Total global vehicle production reached approximately 97.3M vehicles in 2017 (source: OICA) with China being by far the largest producer. This represents an increase of around 2.3M vehicles from around 95M vehicles produced globally in 2016, and a rise of 35M vehicles from the recent low of 62M vehicles produced in 2009. The upside growth potential in autocatalyst demand from increasing vehicle ownership can be seen in these statistics.

China is forecast to lead the sales growth over the next five years with stronger growth from emerging economies. This together with inelastic demand growth from the tightening and roll-out of exhaust emissions standards worldwide should lift platinum, palladium and rhodium requirements.

Platinum Demand

In 2017 global gross demand for platinum was estimated to be 7.84M oz of which approximately 5.1M oz, or 65% of global consumption was in industrial applications, largely in autocatalysts in motor vehicles. The balance of 2.7M oz was consumed mainly by jewellery.

It is estimated that demand for platinum will continue to be dominated by the automotive and jewellery industries, and global use of platinum is forecast to continue to decline slowly as diesel demand decreases and net investment declines. In 2017, automotive demand for platinum was down by just 1%. As producers switch to the higher palladium grade ores, production is forecast to decline marginally, but be more than offset by an increase from recycling.
Platinum demand in the automotive industry will continue to be driven legislatively. Of the three PGMs used in autocatalysts, platinum is the most geographically concentrated, with Western Europe its dominant market. However, new clean air initiatives have lead investors on both sides of the Atlantic to believe that platinum could play a much greater role in supporting emissions control in gasoline cars, not just diesels, in the near future. This fact, and how fast the transition to electric vehicles will determine total platinum demand.

Work completed by Strategy Analytics suggests that the output of hybrid electric vehicles/electric vehicles would increase from 3.3M units in 2015 to 11.6M units in 2020, a CAGR of over 28%.

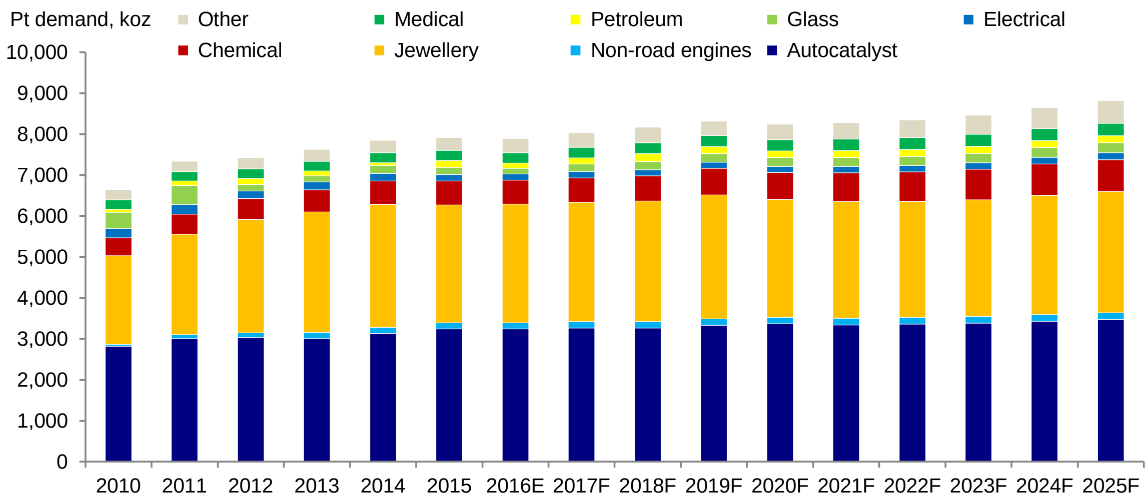
There is also a potentially very significant demand for platinum in fuel cells, which we address separately.

Jewellery currently represents around one-third of the platinum market, and in the past, has provided a cushion to falling prices. It is expected that 2018 will see the first increase in global jewellery demand for 4 years, with an increase of 3% forecast.

Global platinum jewellery consumption will continue to increase over the coming years owing to the resilience of the long-established markets and their contribution to platinum jewellery demand growth, coupled with concerted marketing campaigns to expand in the Indian market. Q4 2017 saw double digit growth in demand for platinum in India and platinum outperformed gold where growth was only 4% Y-on-Y. It is also expected that this will be assisted by a resurgence in Chinese demand which became evident in the Q4 2017.

The one bright spot for platinum demand in 2018 is growth in its industrial applications. Glass manufacturers are set to purchase unusually large quantities of platinum for new LED and fibreglass facilities, while chemical demand will remain at historically high levels. Before investment, which we anticipate will be a negative figure, consumption is likely to increase, only to be met with increasing secondary supplies from autocatalyst recycling.

Exhibit 14: Platinum demand



Source: SFA (Oxford)

Palladium Demand

Global gross demand for palladium is estimated to have been approximately 10.1M oz in 2017, an increase of 8% over the 2016 demand figure. Over 10.4M oz was estimated to have been consumed in industrial applications primarily in autocatalysts in motor vehicles. The balance was disinvestment.

Palladium has now become largely an autocatalyst metal. It is projected that, for the ten-year period ending in 2025, palladium demand will continue to rise year-on-year, assuming no significant macroeconomic disruptions, primarily driven by the automotive industry. This position has been reinforced by the deiselgate scandals which has seen consumers switching away from diesel powered cars to petrol.

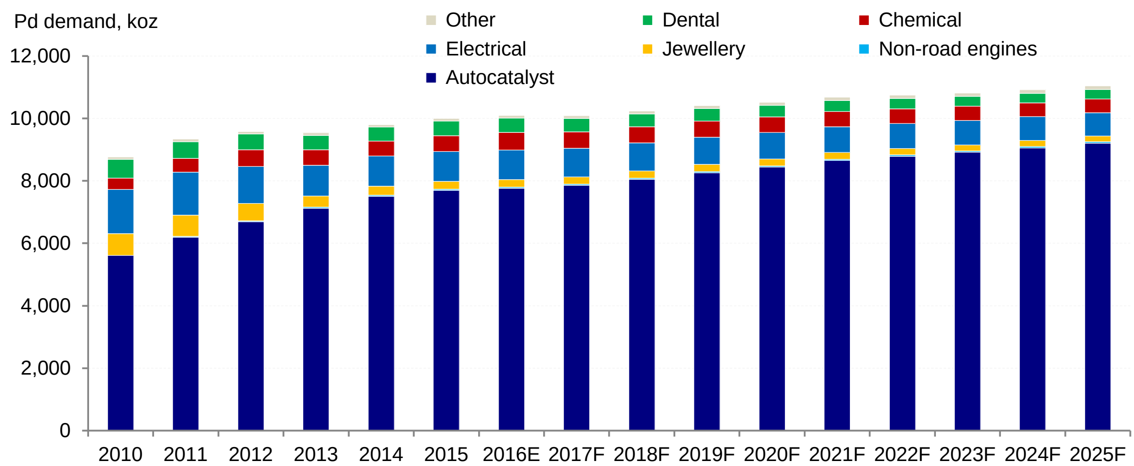
Palladium autocatalyst demand stood at 8.4 M oz in 2017, an increase of nearly 0.5M oz from the 2016 figure. North America was the largest market at 2.1 M oz, followed by China at 1.7 M oz. Consumption of palladium in autocatalysts is forecast to increase by an average of 1.7% p.a. over the next five years.

Palladium finds wide applications in electronic components. Palladium has retained a niche in very demanding applications, such as military and some transport, where its performance and durability advantages outweigh the price premium over nickel. Palladium is also used in the plating of electrical contacts as a substitute for lead, and the rising gold price has promoted substitution by palladium in the plating compounds used for connectors.

Palladium is also used as a catalyst in a wide range of chemical processes ranging from bulk petrochemicals to speciality products such as pharmaceuticals. One of the largest increases in usage for palladium has been as a catalyst in the manufacture of hydrogen peroxide where demand is estimated to be growing at 5% pa.

The global light duty vehicle demand is expected to have risen 2.8% in 2017, with demand for palladium benefitting from the increased percentage of petrol fuelled vehicles. This has seen the price of palladium rise. At the end of 2017, the premium for palladium over platinum was US$130/oz, a premium that has been sustained into 2018. However, if this premium continues to be maintained, then platinum has potential upside from palladium substitution.

Exhibit 15: Palladium demand



Source: SFA (Oxford)

Rhodium Demand

Rhodium is used mainly in the automotive industry and is an effective catalyst at removing NOx from diesel and gasoline emissions. Automotive industry demand for rhodium increased from 830 k oz in 2014 to 865 k oz in 2015, led by North America (260 k oz) and Western Europe (235 k oz). This reflects the growth in the production of gasoline vehicles and the higher loadings in the USA.

Rhodium's other main uses include catalysts for chemical processes, tooling in the glass industry, electrical components and some plating in the jewellery industry.

Rhodium is used to catalyse a variety of chemical processes such as the production of nitric acid and acetic acid.

In the glass sector platinum-rhodium alloys are utilised in manufacturing equipment, including bushings used in glass fibre fabrication, whilst minor amounts of rhodium are also used in component parts for a number of electrical appliances.

Researchers in Switzerland may have discovered a potential new use for rhodium. When water and carbon dioxide are passed over an activated cerium surface, the water, H_2O is converted to hydrogen and the carbon dioxide, CO_2 into CO. These gases are then converted to methane using a rhodium catalyst. This technology, whilst in its infancy, could potentially use solar power to produce liquid fuels. Given that transport currently accounts for 25% of energy use and carbon emissions, this technique effectively recycles CO_2.

Recycled PGM's from Vehicle Catalysts

Palladium recycling has grown by over nine times the levels of 2000 to 2.1M oz in 2015, with an average growth rate of 15% p.a. over the period 2000-2015. Recycling now represents approximately 23% of all palladium supply with auto catalysts accounting for 79% of this.

Looking ahead, there are large quantities of vehicle catalysts that could be recycled in the next few years. Palladium will continue to dominate catalyst returns in the medium term, as the majority of catalysts secured by collectors will be palladium-rich from scrapped gasoline vehicles in the US.

Palladium recycling from auto catalysts is mainly from gasoline vehicles. Substitution of platinum by palladium in diesel cars began in the 2000's and the autocatalysis from these vehicles are expected to contribute 14% of palladium recycling. Most diesel cars in Europe have had two catalysts (diesel oxidation catalyst (DOC) and diesel particulate filter (DPF)) since the introduction of Euro 5 legislation in 2009.

In the near term, recycling feed from auto catalysts has been affected by lower prices. The decline in scrap steel and PGM prices impacted collection rates in 2015 and early 2016 as scrapyards withheld catalysts and led to a decline in recycled metal. Price volatility always has a temporary impact on the collection of catalysts, but once volatility settles down, normal flow resumes.

Secondary supply of platinum has grown more slowly than palladium averaging 7% p.a. from 2000 to 2015 to reach 1.7M oz in 2015, when recycled platinum represented 22% of total platinum supply with auto catalysts accounting for 70% of this.

PGM Supply

In 2017, South African platinum production grew to 72% of global primary supply, rebounding after the prolonged strikes reduced the country's share to only 62% in 2014. This figure has proven to be remarkably constant in recent years and a similar percentage is expected for 2018.

South African platinum output is forecast to decrease by 4% y-o-y to 4.17M oz in 2018 (4.4M oz in 2017). Production is likely to be impacted by the strengthening of the Rand.

South African mine supply in recent years has been temperamental, with shaft closures and/or project deferrals taking place at eleven operations since 2012, plus numerous projects have stalled before reaching construction stage. Unsustainably high operating costs, low productivity and exposure to weak rhodium prices have impacted on South African output, particularly affecting UG2 Reef (rhodium-rich) operations. At current low PGM prices, a production basket with a significant yield of base-metal by-product components is essential to maximise revenue per tonne hoisted. Exhibits 16 and 17 show the outlook for platinum and palladium supply.

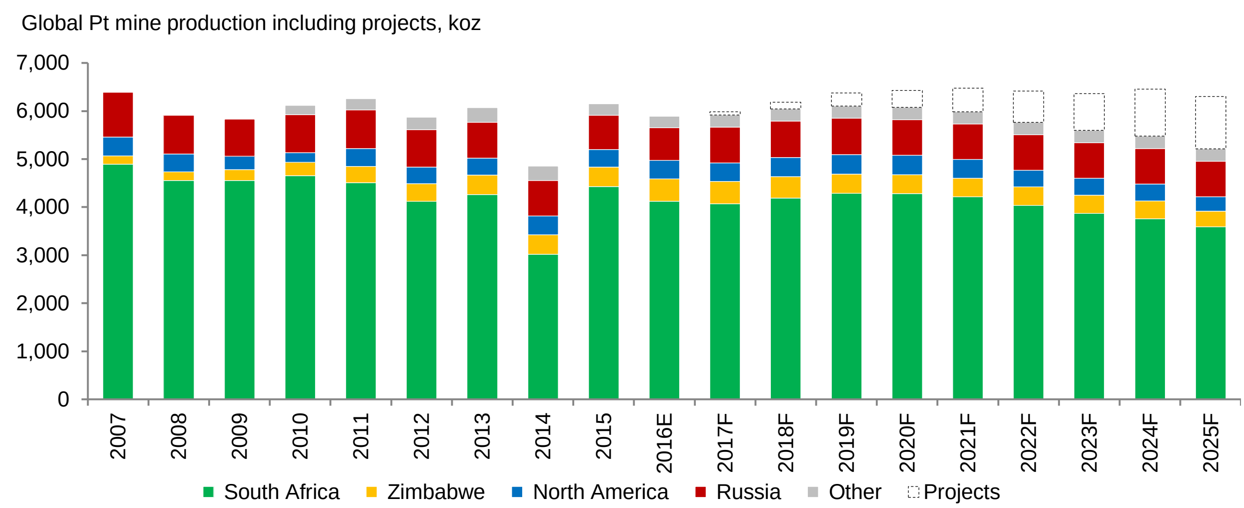
Supply outside of South Africa decreased by 4.7% y-o-y to 1.61M oz in 2017 (1.69M oz in 2016).

Russian PGM supply, with the exception of PGMs produced in the Kondyor, Koryak and Urals regions, is mostly generated as a by-product of nickel mining (from Norilsk Nickel) and is the world's largest source of palladium. Russia is also the second-largest producer of platinum and rhodium, accounting for approximately 26% of the world's total PGM supply in 2017.

While production from Russia is expected to be lower this year (processing reconfiguration), plant maintenance that reduced output from North America in 2015 resulted in higher yield from the region in 2016. Production from Zimbabwe is boosted by the processing of stockpiled material from a smelter outage in 2015. Overall, global platinum supply decreases by 4.3% y-o-y to 5.89M oz, palladium supply falls by 4.6% to 6.62M oz and rhodium supply drops by 8.1% to 703 koz.

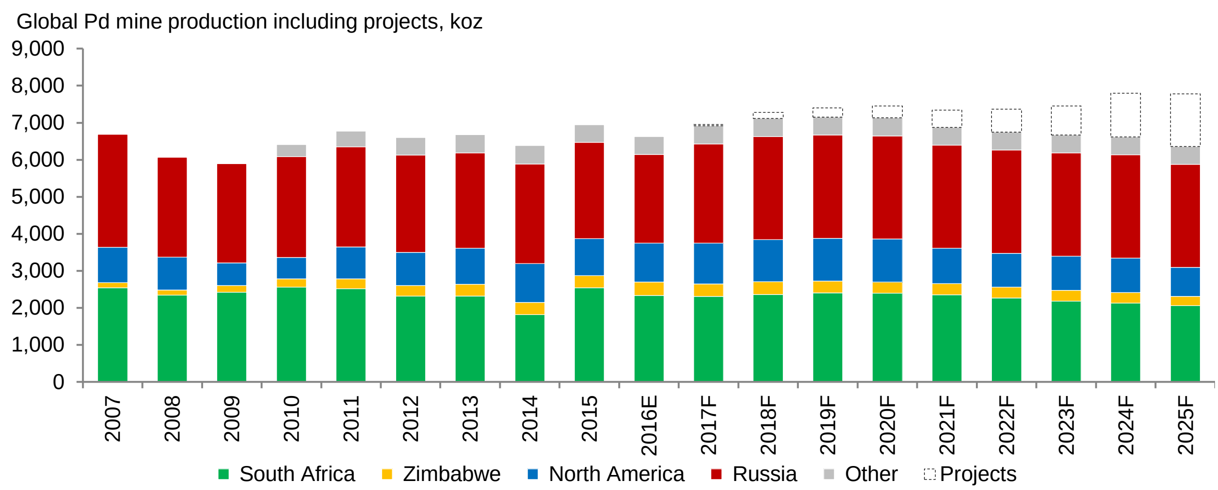
Other key platinum mining regions include Zimbabwe's Great Dyke, the Stillwater Complex in the US and the Sudbury Basin in Canada. The recent change in President in Zimbabwe could have positive ramifications for PGM production in Zimbabwe.

Exhibit 16: Global Platinum Mine Production



Source: SFA (Oxford)

Exhibit 17: Global Palladium Mine Production



Source: SFA (Oxford)

Supply Economics

The cost of mining platinum in South Africa has accelerated markedly in recent years. Over the past ten years, the weighted average operating cash cost per 4E ounce (net of by-product credits) has increased at a rate of 15% p.a. (nominal). South Africa recorded a 13% reduction in the weighted average net cash cost in 2015 as production improved following extensive strike disruption in 2014 (costs increased 29% y-o-y in 2014). The 4E PGM basket price for South African producers has increased by an average of 12% p.a. (nominal) over the past decade.

Overall, net total cash costs (NTCCs) rose by 48% between 2011 and 2015 (partly owing to falling production levels), while the South African 4E basket price increased by just 15% over the same period. As a result, NTCCs in Zimbabwe, North America and Russia are lower than the majority of Bushveld-based producers on a cost per oz basis. Since 2012, the basket price has closely tracked the 80th percentile production cost, prompting shaft closures and project deferrals.

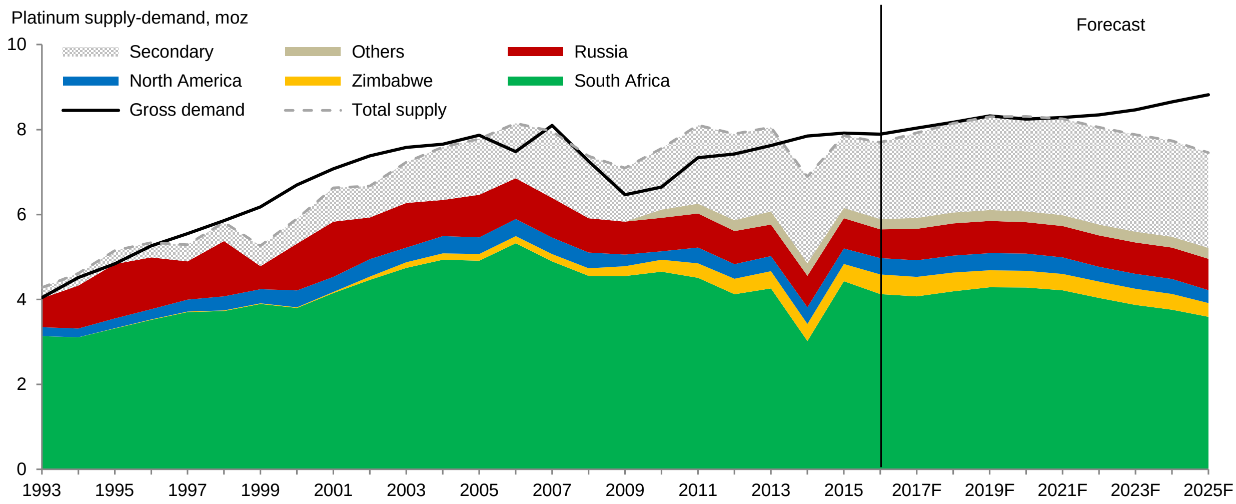
While cost improvement initiatives will remain a priority, a number of South African specific factors are likely to continue to result in cost increases that could offset the gains made and limit production expansions. Those factors included the costs of mining consumables, labour costs and power costs.

In the long term, a lack of primary supply growth in platinum could leave the market severely under-supplied. Recycling is forecast to rise as an increasing proportion of diesel cars with platinum-rich catalysts are being scrapped. However, supply will most likely disappoint, and the market will shift to structural deficit. This deficit is forecast to reach critical levels in the 2020's as cuts to capital expenditure and severe reserve depletion become evident, as illustrated in Exhibit 18.

The palladium market has been in fundamental deficit since 2007, excluding Russian stock sales. Demand has grown by over 2.3M oz since 2006, despite the financial crisis and falling jewellery consumption, owing to a significant increase in use in auto catalysts. Primary supply has struggled to keep up with demand growth and the market had a 0.6M oz deficit before stocks in 2018.

A narrowing deficit is seen ahead, as secondary supply is forecast to rise faster than gross demand. The growth rate forecast for auto catalyst demand has eased as expansion projections for emerging markets have been reduced. Stocks will be drawn down more slowly if global growth remains modest.

Exhibit 18: Global Supply and Demand for Platinum



Source: SFA (Oxford)

Fuel Cells

Fuel cell electric cars are expected to have a significant impact on future platinum demand. A number of motor manufacturers have launched cars utilising fuel cell technology. Current platinum demand for fuel cells is circa 50k oz and growing strongly. In addition to passenger vehicles, fuel cells are extensively used by Walmart and Amazon in off-road application, specifically fork lifts. Hyundai launched a vehicle, the ix35 in 2013 followed by Toyota with the Mirai in 2015. This was followed by Honda, with the Clarity in 2016 with Mercedes Benz planning to launch the GLCF-Cell in 2018 although it will not be available in the USA until 2019. In order to power these vehicles, hydrogen infrastructure is being rolled out. Denmark and Germany are the furthest advanced, both planning national coverage from 2016 with greater than 100 refuelling points in Denmark by 2015 and more than 400 in Germany by 2015. In the UK, the roll out is focused on London where 65 refuelling points are forecast by 2020 and they will then be expanded outwards. Shell recently opened its first hydrogen refuelling station near Cobham on the M25 and has recently opened the second refuelling point at Beaconsfield services on the M40. Elsewhere, both California and Japan planned numerous hydrogen refuelling stations by the end of 2016 which will then be expanded significantly.

At the 2018 Mining Indaba conference, Robert Friedland gave a presentation on the future demand for platinum. Whilst he was obviously talking his own book to a degree, he is developing a platinum mine, it is important that fuel cells have a "champion" to promote the story, much as Elon Musk does for lithium ion batteries. In his presentation Friedland pointed out that that fuel cells are exothermic. Therefore in colder climates, they are a preferred option as they do not drain the batteries quickly. In addition, the range of hydrogen powered fuel cell cars is around 590km, much better than that of lithium ion battery powered cars and they only take 5 minutes to refuel. There is some poetic licence here, but generally speaking, the use of heaters, air conditioners, windscreen wipers and lights do put additional power demand on whatever system the car uses, but if one starts with a longer range, then this additional demand becomes less of an issue.

Hydrogen Production Technology

There has recently been a technological breakthrough with hydrogen production. A team of scientists from CoorsTek, a global engineering ceramics manufacture based in Golden, Colorado, in conjunction with Norway's University of Oslo and the Instituto de Tecnologica Quimica in Valencia, Spain have successfully completed laboratory testing of a ceramic membrane capable of generating compressed hydrogen for automotive fuelling from natural gas and electricity. This process is completed with near zero energy loss, making it a highly efficient way of producing hydrogen. CoorsTek believe that their membrane can make hydrogen the cleanest and least expensive option for future automotive refuelling- surpassing not only petrol and diesel but also electricity from the grid.

One of the key advantages of this system is that it is a one step process and it comes in compact units. Hydrogen can therefore be made in small quantities close to where it is used. This means that the system could be de-centralised, with no need to transport hydrogen around the country. Any country with a gas distribution system could easily establish this technology. The litmus test for this technology is whether gas is used to heat homes. If gas is the preferred fuel, this is a good indication that hydrogen fuel made from natural gas can be competitive.

It is not only automobiles that could benefit from this technology. Already a number of cities in the UK, including London use buses powered by fuel cells. Locating this ceramic membrane technology at every bus depot, could make hydrogen a very competitive fuel.

Another hydrogen production technology is also under investigation. Researchers at the University of York in the UK, has proposed carbon capture system uses seawater, recycled aluminium and renewable energy to transform captured CO_2 into a safe material, in this instance dawsonite. The key point of interest for fuel cells is that this system produces hydrogen as a by-product.

It was recently announced in the Financial Times that "Japan's Kawasaki Heavy Industries has teamed up with the Australian government to lead a A$500M ($388M) project to turn coal into liquid hydrogen, in what it has described as one of the world's first attempts to commercialise the technology. The pilot project aims to generate "green energy" for use in cars, electricity generation and industry in Japan from one of the dirtiest fuels, brown coal. It involves converting coal to hydrogen at a power plant in the Latrobe Valley — a region in Australia with some of the world's most abundant supplies of the fossil fuel, which is also called lignite. "The global hydrogen market is booming," said Eiichi Harada, deputy general manager of Kawasaki Heavy's technology division. "We are thrilled that both the Victorian and Commonwealth governments wish to participate in this project, which has the potential to deliver a critical option for future energy needs." Japan is making a big gamble on hydrogen-powered vehicles with Toyota backing its Mirai to win a green energy battle against electric powered rivals, including Tesla. J-Power, Iwatani and Marubeni Corporation are partners in the Australian project, which also includes AGL, Australia's biggest energy company. The coal to hydrogen project has won A$100M backing from government, which is seeking ways to continue to utilise its ubiquitous brown coal reserves. AGL will host the pilot project, which if successful will see a commercial coal to hydrogen plant built on a site near its Loy Yang lignite mine in the Latrobe Valley."

However, whilst the technology for converting coal to hydrogen is well established, the success of this project will depend on the ability to capture the CO^2 produced. Without carbon capture this project will not be allowed to commercialised by the Australian Government. BHC's view on this is that the lithium battery technology is by no means a given for the future of electric cars.

Elsewhere, both California and Japan had a significant number of hydrogen refuelling stations by the end of 2016 which they are planning to expand significantly.

Potential Growth in Railway Sector

The use of fuel cells applies to trains, trucks and buses besides cars. Recent press articles in the UK have suggested that new regional trains using fuel cells are tipped as an alternative to diesel powered trains and transport secretary Chris Grayling says he would like to see the technology introduced "within a short period of time." An ongoing public consultation on the future of the Great Western rail franchise, which covers Bristol, south west England, South Wales and the Cotswolds and Malvern's, says hydrogen trains could be a solution to a shortage of carriages on the network. In reality, it is probably cheaper to use fuel cell powered trains rather than electrify the entire rail system, especially on the branch lines.

The consultation document says: "There is a limited supply of rolling stock across the GB rail network and, although over 6,000 new carriages are being introduced to the network by 2024, trains to operate on non-electrified routes are likely to remain in short supply as many existing diesel trains approach life-expiry. "Addressing rising passenger demand on non-electrified routes is therefore likely to require additional trains, either through new-build or by applying innovative "bi-mode" technologies to existing trains.

"Hydrogen-powered trains will shortly start operation in regular service in Germany, and could also potentially be a solution." Hydrogen train technology is being spearheaded by French company Alstom, which is testing the low-emission transports in Germany. If introduced in the South West, the trains would be the first of their kind in the UK. The trains, called the Coradia iLint, are powered by a hydrogen fuel cell and are silent" according to Alstom. Managing director of Alstom UK and Ireland, Nick Crossfield, said: "We strongly support the government's decision to consult on bringing hydrogen trains to the Great Western route. Hydrogen is the most sustainable and efficient way of eliminating pollution on non-electrified rail lines and Alstom's hydrogen technology is already being proven in Germany.

It is very important for platinum use that fuel cells become used in larger forms of transport than cars. There are several reasons for this. The current fuel cell as used in cars contains between 30 and 80g of platinum. Loading levels are expect to fall, and could be reduced by as much as 50%, but are not expected to fall into the high single digits which is the DoE target of 7.5g. However, it is important to keep in mind the use of fuel cell electric vehicles within the broader recycling system; Amplats have highlighted in the past that there is likely a loading below which recovering the platinum from a fuel cell stack in recycling becomes too difficult; so there is a natural "floor" to the platinum loading for a fuel cell vehicle.

Each fuel cell electric vehicle will contain a fuel cell stack that is itself made up of lots of individual fuel cells. A fuel cell stack could contain only a few or as many as hundreds of individual cells, depending on technology type, voltage and application. For fuel cell electric vehicles, a good way to think of it is there will be a linear relationship between the power of the fuel cell stack and the platinum loading. For example, the Toyota Mirai is said to contain 30g of platinum with an output power of 100kW; so a fuel cell electric bus with output power of 150kW would have 45g of platinum etc. Obviously, trains would require much more than 150kW and would require substantial amounts of platinum. Modern electric engines for freight traffic may be 3,000hp or more which is equivalent to 2207kW and would require up to 662g or 21oz of platinum.

Some experts maintain that hydrogen fuel cell vehicles are less efficient overall when compared to a battery electric vehicle (BEV). This is true in the sense that electricity taken from the national grid and stored in a BEV battery involves fewer steps than using the electricity to first generate hydrogen, which is then used to generate electricity in a fuel cell.

However, while fuel cell production costs remain high (see below), current FCEVs have significant performance advantages over BEVs: the range of most FCEVs is around three times that of the average BEV and refuelling times are significantly shorter.

The current thinking is that BEVs will be used for shorter, lighter work - commuting, running to the shops or school etc. with FCEVs used for long-distance or heavy duty applications. The technology is already regularly found in trials for buses and lorries where the green credentials combine with high power and long range capabilities.

A potential boost for fuel cell technology could come from a very different direction. It was announced at the end of February 2018, that the UK will explore the potential for reducing carbon dioxide emissions by as much as 6Mt pa by mixing hydrogen into the normal gas supply. A one year trial will be held at Keele University on its private gas network and will determine the level of hydrogen which could be used by gas customers safely without making any changes to their behaviour or domestic appliances.

The UK is committed to reducing its CO2 emissions by 80 per cent by 2050 from a 1990 baseline, but while progress has been made to decarbonise the electricity system, very little has been done to decarbonise heat, argued David Parkin, the director of safety and network strategy at Cadent.

Cadent hopes the project will spur a wider roll out, though it is unlikely that would occur until the mid-2020s. Should this occur, the demand for hydrogen across the UK would expand significantly, and it may well be the spur needed for the widespread introduction of fuel cell vehicles.

The Brandon Hill View

We do not think that the move to electric vehicles will proceed as fast as some commentators forecast and will be driven more by legislation than anything else. One key measure here is that VW are gearing up to produce 2.5M EV's per year, but with total production running at around 10M vehicles per year, it suggests that there will be 7.5M hydrids or internal combustion engine vehicles produced annually. Another example of the widespread use of hybrid vehicles is the London taxi. From 2018, any new taxi licenced for use in London has to be capable of running with zero emissions. In practice, this means battery power, but with a 1.6l petrol engine which can be used as a "range extender". Naturally, the extender motor will be equipped with convertors on their exhaust and these will use either platinum or palladium.

On the supply side, the reduction in South African production of 1.4M oz PGM's over the past 7 years is due to the reduction in capital expenditure from R30B pa to R10B pa. When viewed in US$, these figures show an even more precipitous drop from US$3.6B to US$0.75B. This drop has been brought about for several reasons:

- The drop in the prices of PGM's and the increasing realisation by the mining companies that they must make a competitive return on capital
- The high inflation in South African mining due to the increasing costs of labour and electricity
- Perceptions of increasing political risk in Southern Africa, although with the removal of President Zuma, political risk and corruption are expected to diminish.
- The current trend is to close shafts rather than develop new ones.

The net result of these events is that despite the downturn in the world's economy since the Global Financial Crisis, global demand has exceeded supply for platinum in each of the past six years. However, platinum production exceeded consumption marginally in 2017, but the platinum price has defied logic and declined by 42% from the end of 2012 until the end of 2017. It has since recovered a little of this drop, the nadir being reached in January 2016, probably due to the decrease in stocks.

The large switch from diesel to petrol automobiles has resulted in palladium showing a substantial deficit for 2017 of 670K oz. Whilst this deficit is not as large as the 1.87M oz reported for 2014, it is the sixth successive year that demand has exceeded supply for palladium. The recent news out of Germany that older vehicles could be banned from some parts of Stuttgart and Dusseldorf could possibly increase the demand for platinum, which could ease fears about the growing surplus.

According to the WPIC's most recent Platinum Quarterly report, the platinum price has started to respond to fundamentals and the price increased by 15% in 2016. Global above ground stocks are forecast to be 1.87M oz at the end of 2016 compared to 2012 when they were 4.14M oz.

The one major game changer on the horizon is electric vehicles. However, we believe that their penetration of the market will be slower than many expect. Therefore, the demand for platinum and palladium will remain strong for many years to come.

This said, the technology for zero CO_2 emission vehicles could be decided by China where steps to minimise pollution are well in train. Being the largest producer of motor vehicles may well be the biggest determinant in the choice of technology. Already the incentives favour fuel cell vehicles over battery electric vehicles and plug-in hybrid electric vehicles. Larger applications are gaining traction.

Rhodium loadings are expected to increase, driven by stricter legislation in the major automotive markets. This could trigger further speculation and strategic buying which would result in rhodium supply becoming tight, despite the supply and demand statistics showing the metal should remain in a modest surplus.

Chrome

Chromite is the commercial name for iron chromium oxide ($FeCr_2O_4$), a mineral containing chromium (a transition metal with multiple oxidation states) and iron oxide. In its purest form, chromite comprises chromium (Cr_2O_3) at 68% and iron oxide (FeO) at 32%. Chromite occurs exclusively in ultramafic rocks such as dunite, peridotite, pyroxenite and serpentinite. High purity deposits are rare owing to replacement by certain elements. In nature, ferrous iron tends to be partially replaced by magnesium, while chromium may be partially replaced by aluminium or ferric iron.

As a result, a range of chromite grades can occur in any deposit, with each grade suitable for a specific application.

Grades produced include metallurgical and non-metallurgical applications:

Foundry grade		Cr_2O_3	min.	46%	sizing	AFS	40-50	45-55	50-60
Refractory grade	Cr_2O_3	min.	46%	sizing	typ.	98%	<	2	mm
Chemical grade	Cr_2O_3	typ.	45% - 47%	sizing	typ.	98%	<	1	mm
Metallurgical grade	Cr_2O_3	typ.	30% - 45%	various sizings					

South Africa is by far and away the most important producer, with 2016 production of 14,000t. This was followed by Kazakhstan with 5,500t, Turkey 3,500t and India 3,200t. Brazil is also a major producer with 2016 production of 500,000t. Zimbabwe, Finland and Iran are also significant producers.
The key reason why South Africa is the major producer is that it is the world's largest producer of PGM's. Chromite is a by-product of PGM mining.

World chromite reserves are estimated to total around 7.6B tonnes, with the majority of this located in South Africa. The country is by far the single largest holder of the world's chromite reserves, accounting for 5.5 Bt (72%) – much of which is held in the Bushveld Igneous Complex. Other important sources of chromite include Zimbabwe (with 12% of the world's reserves), Kazakhstan (4%), Finland (2%), India (1%) and smaller amounts in Turkey and elsewhere. World production of chrome ore totals about 25Mt pa and is dominated by South Africa (41%), followed by India (16%), Kazakhstan (15%), Turkey (8%), and Oman (3.5%).

Ferrochrome markets typically consume 92% of the chrome ores produced; which are the metallurgical grades. Chemical and foundry grade chromites consume around 3% each of total chromite production, with about 2% used in refractories.

The key differences between the different grades are the percentage Cr_2O_3 in the material and the silica content. Metallurgical grade chromite has the lowest Cr_2O_3 requirement at between 30% to 45%. Foundry grade, chemical grade and refractory grade all require Cr_2O_3 grades of around 46% or better.
During 2017 the chrome price was very volatile. In the December quarter 2017 it was US$179/t for 42% metallurgical grade material and in the year ended September 2017 it averaged US$200/t.

Research Disclosures

Peter Rose

Peter has 32 years' experience in equities as a resources analyst; he has been at Brandon Hill Capital, formerly Fox-Davies Capital for 11 years. Prior to that he spent 11 years with Deutsche Bank in Australia. Prior to this he spent 2 years with Prudential Bache and 6 years with James Capel. Peter's industry experience includes 16 years as a metallurgist, 3 years with De Beers in South Africa and 8 years in the uranium industry, 5 of which were spent at the Ranger Uranium mine. Peter holds a BSc degree in Applied Mineral Science from Leeds University UK and a Bachelor of Commerce from the University of South Africa. Peter is also a member of the Institute of Materials, Mining & Metallurgy and a chartered engineer.

+44 (0)203 463 5034
Peter.Rose@brandohillcapital.com

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Research disclosure as of 08 August 2018

Company Name	Disclosure
Jangada Mines	1,2,7

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Brandon Hill Contact List

International Sales

Oliver Stansfield
Tel:+44 20 3463 5061
Email: oliver.stansfield@brandonhillcapital.com

Pierre Iseux
Tel:+44 20 3463 5024
Email: pierre.iseux@brandonhillcapital.com

Research

Peter Rose
Tel: +44 20 3463 5034
Email: peter.rose@brandonhillcapital.com

William Arnstein
Tel: +44 20 3463 5020
Email:william.arnstein@brandonhillcapital.com

Corporate Finance & Broking

Jonathan Evans
Tel: +44 20 3463 5016
Email: jonathan.evans@brandonhillcapital.com

Wei Jiao
Tel: +44 20 3463 5019
Email: wei.Jiao@brandonhillcapital.com

Robert Beenstock
Tel:+44 20 3463 5023
Email: robert.beenstock@brandonhillcapital.com

Enzo Aliaj
Tel:+44 20 3463 5026
Email: enzo.aliaj@brandonhillcapital.com