Botswana Notes and Records, Volume 51, 2019

From Prospecting to Jewellery: The Story of the Botswana Diamond Pipeline

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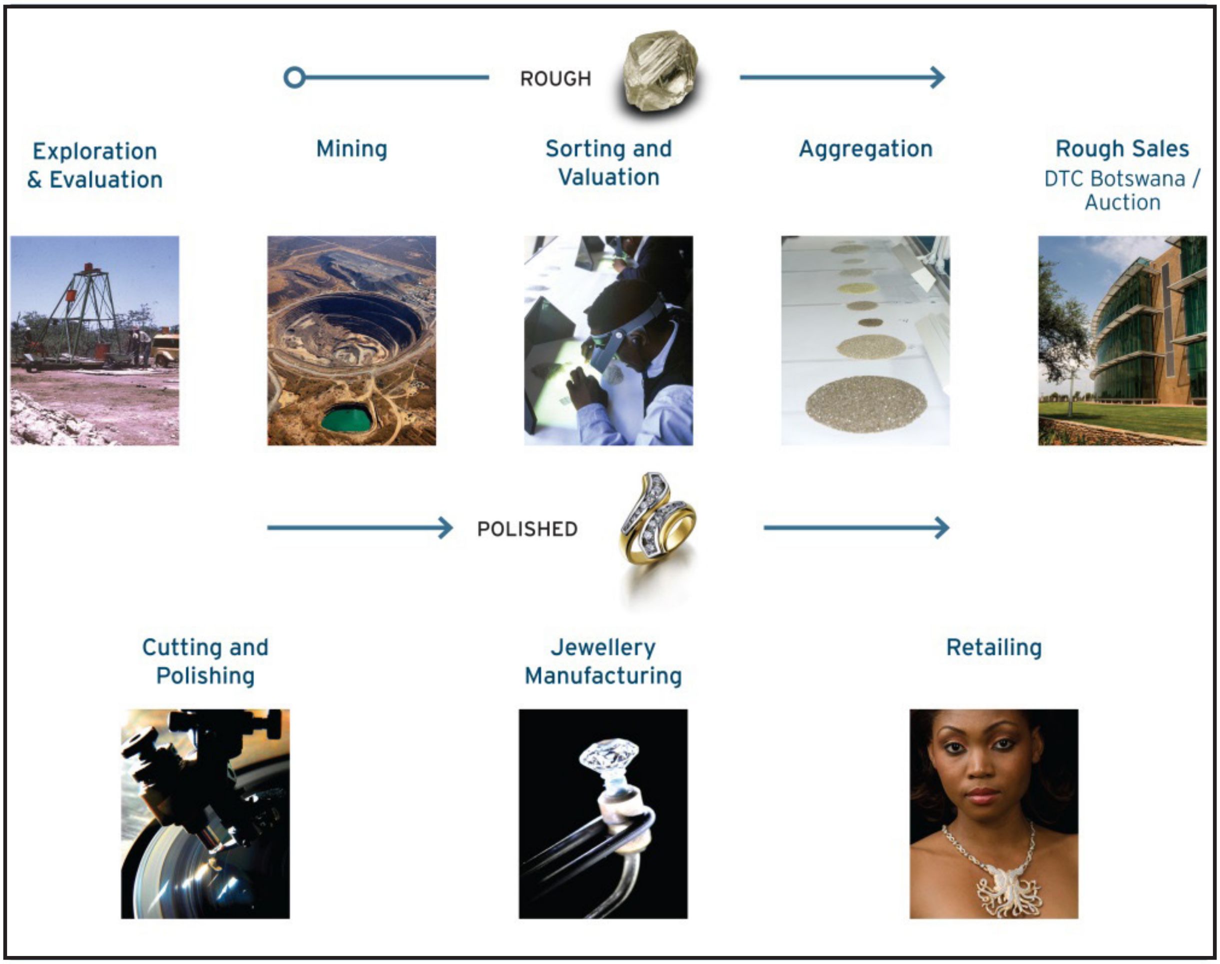
Overview

In this paper I describe the different components that make up the Botswana Diamond Pipeline today – being the supply chain of diamonds, ranging from diamond prospecting to mining, to diamond processing and recovery, to rough diamond sorting, valuation, sales and marketing, to diamond polishing and cutting, and finally to diamond jewellery manufacturing and retail. In Botswana, we can now truly witness the journey of the diamond from 'Rough to Finger' or from 'Mine to Store' as illustrated in Figure 1 below.

Figure 1: The Botswana Diamond Pipeline from Prospecting to Jewellery



Source: Brook (2012a)

Today, Botswana is the world's second largest producer of diamonds by value and volume after Russia, and there are currently eight operating diamond mines. Botswana's diamonds are cut and polished into beautiful diamond jewellery locally and across the globe. The first diamondiferous kimberlite, the only host rock for diamonds in Botswana found to date, known as the B/K1 pipe, was discovered about 30 km east of Orapa, on 1 March 1967, just 6 months after Botswana gained independence from British

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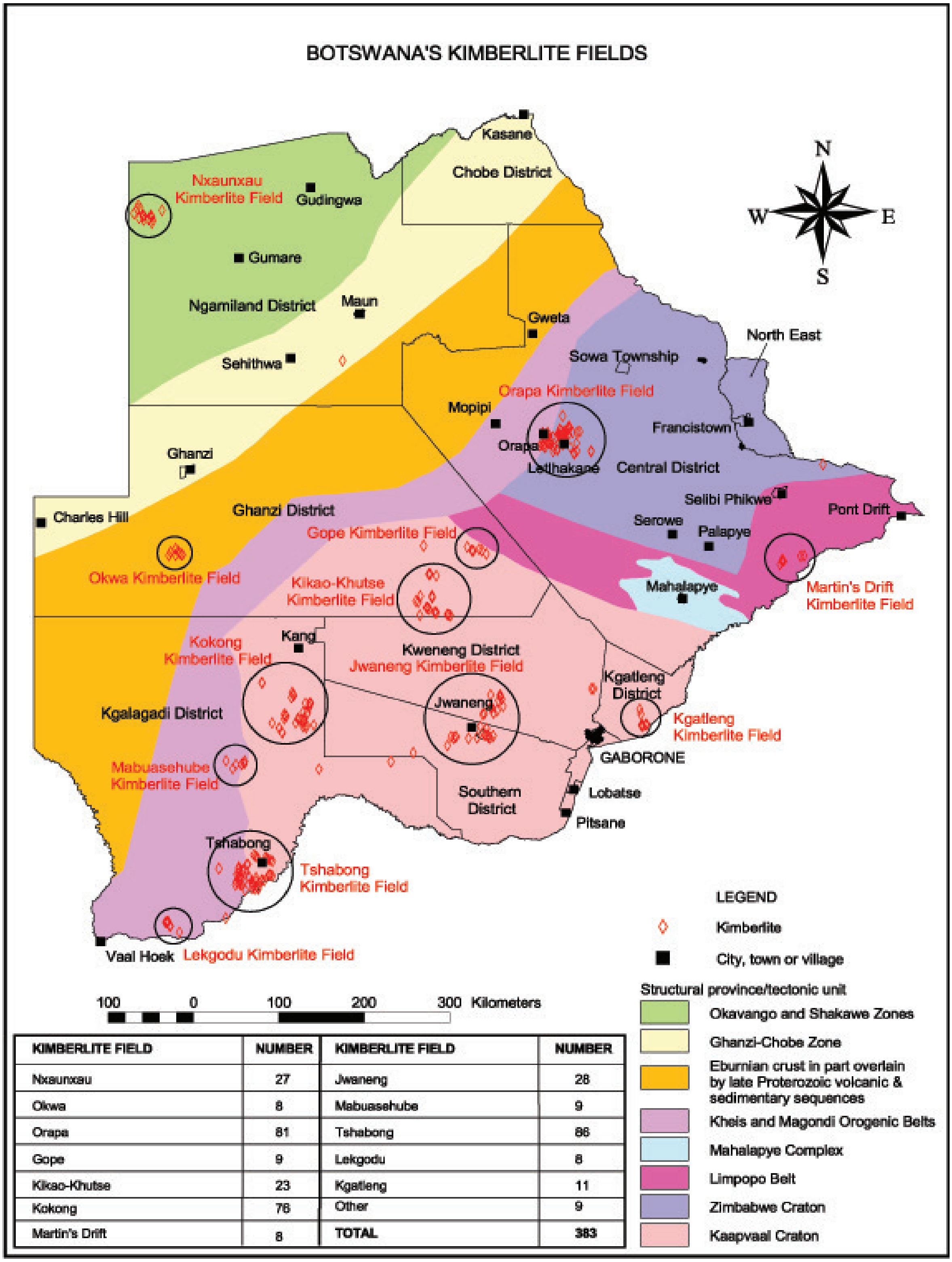
colonial rule over the then Bechuanaland Protectorate.

However, the first recognised diamond find in Botswana, in alluvial deposits, was made by Consolidated African Selection Trust (CAST) prospecting geologists in 1955, on the gravel banks of the Motloutse River at Foley siding, some 250 km east of Orapa Town and about 50 km south of Francistown. This discovery also gave rise to the commencement of diamond exploration in Botswana by De Beers, in the same year.

In terms of their initial discovery, it is of significant interest to note the fact that six out of the eight Botswana diamond mines in operation today were found between 1967 and 1974 (Map 1), a period which I have termed the wonderful discovery era (Table 1).

Map 1: Botswana's Kimberlite Fields and Craton Geology



KIMBERLITE FIELD	NUMBER	KIMBERLITE FIELD	NUMBER
Nxaunxau	27	Jwaneng	28
Okwa	8	Mabuasehube	9
Orapa	81	Tshabong	86
Gope	9	Lekgodu	8
Kikao-Khutse	23	Kgatleng	11
Kokong	76	Other	9
Martin's Drift	8	TOTAL	383

Source: Brook (2016)

Table 1: Botswana's Seven Diamond Periods from 1954 to present

DATE	PERIOD	ACTIVITY
1954 - 1966	The Lean Mean period	Preparing to prospect, rudimentary methods, poor success rates
1967 - 1974	The Wonderful Discovery era	Numerous diamondiferous kimberlites discovered – all of today's major mines discovered during this incredibly successful prospecting period
1971 - 1982	A decade of Mine openings	Orapa, Letlhakane and Jwaneng Mines opened
1980 - Present	Prospects re-visited	Old De Beers prospects re-visited by newcomers who achieved success through improved technology and methods
2003 - Present	The smaller Mines	Damtshaa, Lerala, B/K11, A/K6 opened and Ghaghoo under construction
2006 - Present	Valuation and Trading Consolidation	Improvement and consolidation of Diamond sorting, valuation and retailing
2008 - Present	Towards Greater Diamond Beneficiation	The new road to added value from downstream activities – polishing, cutting, Jewellery and sales

Source: Brook (2012a)

In the same year that Botswana's first diamond mine at Orapa was commissioned, 1971, the government of Botswana established the Botswana Diamond Valuing Company (BDVC). Up until it was replaced by the Diamond Trading Company Botswana (DTCB) in 2006, BDVC had a staff compliment of more than 500 people. Today, DTCB employs a similar number, including the staff transferred from Global Sight-holder sales from London to Gaborone in 2013.

Botswana's first diamond polishing and cutting factory was established by Diamond Manufacturing Botswana in Broadhurst, Gaborone, in 1976. However, from the mid-2000s, given Botswana's strategy to develop more aspects of diamond beneficiation within the country, it became obvious that there was an urgent requirement to develop a dedicated Diamond Technology Park to house all the new players that would be expected to arrive in Botswana to be part of the country's 'Diamond Dream'. There are now 13 Botswana based sight-holder companies registered to cut and polish rough diamonds in Botswana, complying with the Diamond Cutting Act 66:04 of 1979.

The final stage of the diamond pipeline in Botswana is the manufacture and retail of diamond jewellery, both locally, regionally and internationally. Botswana's downstream diamond industry currently employs over 3,000 people. Diamond jewellery manufacturing is still in its infancy in Botswana, having really only developed in the past 10 years. Diamond jewellery manufacturing is extremely important to the diamond beneficiation process in Botswana, since jewelled diamonds accrue as much as three times more than the value of the mined, rough stone.

All the stages of the diamond pipeline are now performed in Botswana and development in the downstream activities of cutting, polishing and diamond jewellery manufacture and retail is now also gathering pace. We now turn to the stages in the diamond pipeline.

Prospecting Stage

With more than 80% of Botswana covered by often thick sands and other sediments of the great Kalahari Desert, De Beers Consolidated Mines (DBCM) in Kimberley, South Africa, always knew that diamond prospecting would have its challenges here. Unperturbed, DBCM applied for their first diamond prospecting license way back in 1932. After obtaining permission to actually prospect in the late 1930s, it was only in 1954 that DBCM, under the leadership of the late Dr Gavin Lamont, eventually commenced preparations to enter the territory in 1955 to prospect for diamonds. The delay was due to the fact that DBCM had been extremely busy already mining diamonds in South Africa at seven mines, including Kimberley mine where it all started in 1871.

However, over the years, perseverance by DBCM and other prospecting companies has now led to the discovery of 383 kimberlites and two lamproites by the end of 2013.

For the first quarter of a century of prospecting, geologists relied on tried and tested soil sampling methods to discover kimberlites. The diamond host rock contains a number of trace minerals, such as ruby red garnets, apple green chrome diopsides, jet black ilmenites and pale yellow olivines (collectively named 'indicators') which, when found in the gravitating screens, brought much excitement back to the old De Beers prospecting bush camps. Dr Lamont, undisputed leader of the discovery of most of Botswana's diamond mines, pioneered the soil scooping method of sampling along sampling routes which spanned lengthy baselines which were cut throughout the Kalahari Desert. Some baselines were over two hundred kilometers long.

Whilst it was Dr Lamont's leadership that directed all the prospecting operations, it was left to hard working and conscientious Batswana, from all over the country, to man the arduous soil sampling campaigns and ensure samples were properly processed and labelled for dispatch to the laboratory. The 'Docs' right hand field officer was Eleven Malema who controlled all labour in the base camps. Quietly spoken, he commanded so much respect from the youngsters fresh and keen to make an impression. His brother, the late Brot Kemang Malema, equally as competent, managed the gravitating or 'jigging crews'. Dr lamont was awarded the Presidential Order of Honour in 1976 by Botswana's fouding president, Sir Seretse Khama while Bot Malema was awarded the Presidential Certificate of Honour in 1992 by the second president, Sir Ketumile Masire. Other senior Batswana field crew who were also instrumental in helping to find the diamondiferous kimberlites were Rexon Saranyana, Setekia Wasanena and Jacob Ramorwa.

Geophysical techniques are also often very effective in diamond exploration. The most cost-effective and successful geophysical reconnaissance technique used in Botswana has been airborne magnetics, flown by either fixed wing aircraft or helicopter. With evidence that a major contribution to kimberlite and lamproite magnetic anomalies is often remnant magnetisation, local anomalies may be of normal or reversed polarity compared to a non-magnetic background. It is common that Botswana kimberlites have reversed magnetic polarity.

Airborne electromagnetics is also extensively used in diamond exploration. While its cost is a factor of three greater than magnetics, it is particularly effective in the detection of weathered or crater facies pipes and is extremely rapid to execute.

Gravity and resistivity surveys, which depend on density differences between the different country rocks of the Botswana craton environments, have also been used to successfully earmark kimberlites for drilling and delineation. Between 2005 and 2007, De Beers operated a German crewed Zeppelin, one of only three in the world at the time, in the Jwaneng and Orapa Mine lease areas to try to discover new kimberlites using high resolution gravity surveying. The Zeppelin, which weighed only 700kg, flew at less than 50 m above ground and was successful in finding a small number of pipes in existing mine leases.

I have termed the period from 1967 to 1974 'The Wonderful Discovery Era' in which no fewer than six of the current eight diamond mines were discovered. The Orapa Field, with the discovery of 81 kimberlites, contains five of today's eight operating diamond mines, and is the most significant Field to date. However, the Tshabong Field, contains 86 discovered kimberlites, and along with the Kokong Field with 76 kimberlites, represent the best potential for future finds. The Orapa and Tshabong Fields are the most prospected areas at the moment.

In the order in which they have been explored, the twelve kimberlite fields (see Map 1) currently existing in Botswana are: 1) Kgatleng Field, 2) Orapa Field, 3) Jwaneng Field, 4) Kikao-Khutse Field, 5) Kokong Field, 6) Tshabong Field, 7) Lekgodu Field (Middlepits), 8) Gope Field, 9) Mabuasehube Field, 10) Martins Drift Field, 11) Okwa Field, and 12) Nxaunxau Field.

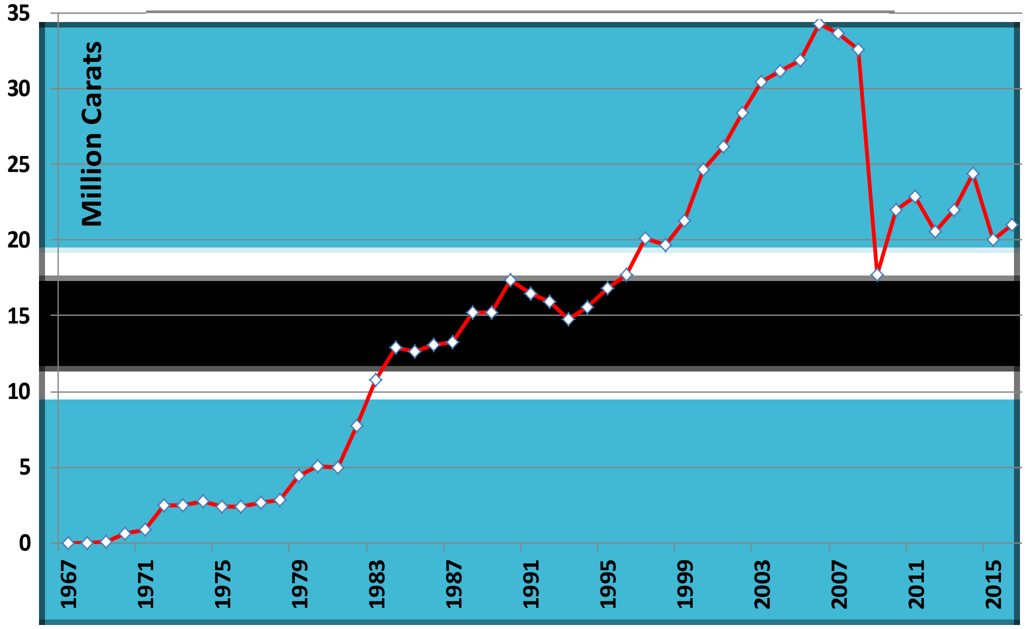
Mining Stage

Diamond mining in Botswana commenced on 1 July 1971, with the official opening of Orapa Mine in the Boteti region of the Central District, 240 km west of Francistown, by President Sir Sereste Khama, in the presence of Harry Oppenheimer from De Beers and John Richards, General Manager of Orapa Mine from 1970 to 1973. The most recent diamond mine to be commissioned in Botswana is Boteti Diamond's A/K6 Karowe Mine which opened in 2012 by the Canadian company Lucara. Karowe mine is located some 10 km west of Debswana's Letlhakane Mine.

There are currently eight operating diamond mines in Botswana, and in order of opening these are; Orapa, Letlhakane, Jwaneng, Damtshaa, Lerala (formerly Tswapong Mine), B/K11, Karowe and Botswana's first underground mine Ghaghoo (previously called Gope Mine). Currently, Damtshaa, Lerala, Ghaghoo and B/K11, all marginal mines in terms of profitability, are managed on a care and maintenance basis.

Diamond production in Botswana has increased year on year, with the exception of two periods, 1990 to 1993 and 2008 to 2009, because of a planned reduction in output to match lower sales caused by global financial crises (Figure 3). In 1967, production amounted to 1000 carats only, from the Orapa Mine bulk sampling plant, but rose to a maximum annual production of 34.4 million carats in 2006.

Figure 2: Botswana Diamond Production from 1967 to 2016



Source: Brook (2016)

In diamond mining, the mine planning process involves the optimal exploitation of the kimberlite resource. The mine plan involves designing progressive 'cuts' into the ground, which are developed in a series of 'benches', usually 12-16 m in height. The slope angle of the cut depends on the strength of the country rock mass –the stronger country rocks, eg Basalt, at the Debswana northern mines, may have slopes of up to 60 degrees, whereas the weaker rocks, such as mudstones, have much gentler slopes, of the order of 30–45 degrees. Since most kimberlite diatremes are carrot in shape, with the resource tapering at depth, there is usually a requirement to mine several successive cuts before reaching the end of open pit mine life and considering underground mining as further cuts are less or even uneconomical. The next cut to be mined at Jwaneng will be cut 9.

Let's take a closer look at Botswana's eight diamond mines, commencing with Debswana's four mines, which currently produce 99% of total diamond output in Botswana. Debswana is currently the world's second leading producer of gem diamonds by value, after Russian company AlRossa.

Table 2: Details of the Botswana Diamond Mines

Mine (oldest first)	Latitude	Longitude	Size (Hectares)	Typical annual production (carats)	Life of Open pit Mine (year)
Orapa (1971) A/K1	25 22 08.73	21 18 30.63	118	14,000,000	Cut 3 to 2044, thereafter mining tailings from 2043 to 2057
Letlhakane (1977) D/K1 & D/K2	25 41 22.01	21 31 12.24	15.2	1,000,000	To 2016, thereafter mining tailings from 2017 to 2040
Jwaneng (1982) D/K2	24 42 07.12	24 31 25.77	54	12,000,000	Cut 9 to 2035, thereafter cut 10 or underground to beyond 2050. Mining tailings from 2015 to 2034
Damtshaa (2003) B/K9, B/K12, B/K1, B/K15	25 31 57.67	21 18 29.04	24.5	230,000	B/K12 to 2017 B/K9 to 2026
Lerala (2008) K002,003,004, 005, K006	27 45 21.78	22 46 06.65	6.33	330,000	To 2021
B/K 11 (2010)	25 30 28.25	21 28 13.77	8	225,000	To 2020
A/K 6 Karowe Mine (2012)	25 28 14.00	21 29 59.00	3,3 to 7 at depth	350,000	To 2026
Ghaghoo (formerly Gope – GO-25) 2013 – underground mine	24 46 40.64	22 37 14.12	10.3	600,000	To 2038

Source: Brook (2016)

Orapa Mine ('Resting Place for Lions')

Orapa is the largest conventional open pit diamond mine in the world and the world's largest diamond mine producer by carats. The mine is situated about 240 km west of Francistown. It began production in July 1971, and it is the oldest of Botswana's diamond mines. The mine had to be linked to Francistown with a new gravel road and power supply. Fortunately, ample and good quality was water was available locally from the regional groundwater system comprising the Ntane sandstone aquifer.

A new town also had to be built from scratch at the mine; it originally had 162 houses for married employees and single quarters for 210 m en, a hospital, clinic, two schools, an adult education and training centre and full recreational facilities. By 2016 the town's population was about 9,500 and both Orapa and Letlhakane have expanded significantly.

Justification for commencing mining at Orapa was arrived at from bulk sampling shallow pits across the whole kimbelite pipe, named A/K1. A bulk sampling plant was constructed on site in 1968 and the kimberlite ore grade was evaluated to be about 50 carats per hundred tons (cpht) but now stands at 80 cpht. Today, the area of excavation at surface measures about 120 hectares and the 290 m deep pit measures 1.25 by 1.8 km. The planned life of the current open pit is to the year 2044 with a cut No. 3. But this does not include processing of the old tailings dumps, which have significant potential still for further diamond recovery because recovery methods have improved. Therefore, the planned life could be extended to between 2043 and 2057.

In August 1996, representatives of Botswana Government, De Beers Centenary AG and Debswana Diamond Company signed an agreement to double production at the Orapa Mine. The expansion increased Orapa Mine's annual production from 6 million carats to 12 million carats from the No. 1 and No. 2 plants from the year 2000 and raised Debswana's total production to about 26 million carats in that year.

Letlhakane Mine ('Little Reed')

Letlhakane Mine is situated 40 km south east of Debswana's Orapa operation and 190 km west of Francistown, in central Botswana. The mine which was first discovered during the sampling and evaluation process at Orapa, became Debswana's second mine when it opened in 1975. The mine has been managed from the larger Orapa operation. Two kimberlite pipes are mined, D/K1 (13 hectares) and D/K2 (2.2 hectares).

The D/K1 pipe has a 'trouser leg' morphology and the area of excavation on surface measures 88 hectares. The current pit depth below ground level is about 400 m and the pit dimension is 1.1 x 1.1 km. Ore grade was about 30 cpht before the mine came to the end of its planned life in 2014, after which there is potential for mining underground. At its peak in 2011, Letlhakane Mine produced 1 million carats. The pit at D/K2 was closed in 2017, when the total Letlhakane Mine tailings resource began to be mined up until the year 2040.

Damtshaa Mine ('Water for a Tortoise')

Four small diamond pipes (B/K1, B/K9, B/K12 and B/K 15) were discovered between 1967 and 1972 in an area 20 km east of the Orapa kimberlite pipe. These pipes were grouped to form the Damtshaa Mine, the youngest of the Debswana mines which began operation in 2003, and are managed along with Letlhakane Mine from the Orapa operation.

The ore grade for B/K9 and B/K12, the kimberlites currently mined, is about 29 cpht and annual production is a maximum of about 330,000 carats. B/K9, at 11.5 hectares, is the larger of the two mined pipes and has a current area of excavation of about 21 hectares, and a depth below surface of 50 m.

B/K 12 pipe area at surface measures 3.2 hectares and the current area of excavation is 7 hectares, with the pit bottom 63 m below ground level. The mine was on care and maintenance during 2017 and scheduled to be brought back into production during Q1 2018.

Jwaneng Mine ('Where a Small Stone is Found')

The Jwaneng pipe was discovered in the Naledi River Valley ('Valley of the Stars'), southern Botswana, in 1972. At that time there were a mere 63 dwellers in the region called Jwana, the site of the present day Jwaneng Town. The mine is located on the fringe of the Kalahari Desert. When the mine started 1,345 employees were recruited. The township of Jwaneng, like its sister at Orapa, was developed from scratch and today has a population of just over 18,000.

Jwaneng Mine is the richest diamond mine in the world by value. It contributes about 60-70% of Debswana's total revenue**.** The Jwaneng mine Aquarium plant is the first of its kind in the diamond mining industry. It has the completely automated diamond recovery plant (CARP), and the fully integrated sort house (FISH). This project brought to an end the hand sorting of diamonds in Botswana. High tech x-ray scanners used at this facility ensure quick and accurate diamond recovery and maximised profit. After sorting the diamonds from all Debswana operations are cleaned by a process of acidisation at DTCB in Gaborone.

Currently Jwaneng is mining to a depth of about 350 m and is expected to reach 624 m at the end of Cut 8 mining. The resource consists of three separate volcanic pipes/vents namely north, south and centre pipes and a small kimberlite sill in the south east which erupted through Transvaal strata and the overlying Karoo sediments about 245 million years ago. This is much older than the Orapa kimberlites at around 90 million years, but younger than the oldest mined kimberlites at Lerala, that have an age of around 1.3 billion years.

The area of the D/K1 pipe at surface was 54 hectares and the area of excavation at surface is 355 hectares. The central pipe is the richest while larger diamonds are thought to be associated with the southern pipe. The average diamond grade is 140 cpht. The pit currently measures 1.6 km by 2.4 km and the life of open pit is currently scheduled up to 2035 (Cut 9), after which there is further potential for either a cut 10 or underground mining. Processing of the tailings resources commenced in 2015 and is currently planned to end in 2034.

Lerala Mine

The five kimberlites which make up this mine in the Central District were originally discovered by De Beers in 1991 but it was only in 2008 that the mine was established. Originally known as the 'Martin Drift Kimberlites', the 330,000 carat per year diamond mine, originally owned by DiamondEx limited, was fully commissioned in June 2008 at a cost of US$ 24 million.

The five kimberlite pipes have a combined size of six hectares. The pipes are exposed at the surface and the indicated resource is 13.5 million tons of kimberlite at a grade of about 25.5 cpht. Life of mine is put at 10 years, but could possibly go deeper after that. The mine was put on a care and maintenance basis during the 2008 global financial crisis and has yet to re-commence mining. In 2011, Lerala Mine was bought by Mantle Diamonds UK for US$3,250,000 and then re-sold to Kimberley Diamonds in 2016.

B/K11 Mine

B/K11 is located approximately 10 km north-west and 20 km south-east of Debswana's Letlhakane and Orapa mines, respectively, and is within five kilometres of Karowe Mine. The surface area of BK11 is estimated to be eight hectares, and overburden is shallow at less than 20 m. The pipe was originally discovered by De Beers in 1970, but was deemed to be uneconomic at the time.

Mining of this single kimberlite by Firestone Diamonds commenced in July 2010. Full production of about 10,000 carats per month was reached in 2011. Its diamonds are valued at $175 per carat and with an 11 million ton resource at 8.5cpht, the value of the resource is estimated at about $150 million. The first auction sales of BK11 diamonds were held in Gaborone in 2011 and grossed $1.35 million for the first quarter. The second quarter's diamond auction attracted 31 companies and grossed $2 million. The largest diamond recovered to date is a high quality 13.74 carat stone. The mine has been on a care and maintenance programme since 2012, but when re-opened, is expected to have a life in excess of 10 years.

A/K6 (Karowe Mine)

The Boteti A/K6 Karowe Mine is located in the Orapa kimberlite field. It is owned by the Canadian company Lucara Diamond and was commissioned in 2012. It consists of three lobes, South, Centre and North, of which the South Lobe makes up approximately 75% of the kimberlites' resource potential. The pipe has an area of 4.2 hectares at ground surface which expands to seven hectares at a depth of 120 meters. With a grade of about 16 cpht, the reserves will be mined over a period of 11 years.

Instead of using conventional scrubbers to disaggregate the kimberlite ore in order to liberate the diamonds, this mine uses an AG or autogenous mill (self –generating mill). The AG mill acts as a high intensity ball which produces acceleration fields 40 to 50 times stronger than gravity, producing rapid and intense breakage of kimberlite ore through high intensity tumbling, just like a washing machine.

Production for the last four years has ranged between 350,000 to 380,000 carats annually, recovered from 2.2 to 2.4 million tonnes of ore per year. In 2011, the mine was given the name of Karowe mine, a Sesarwa name meaning a precious stone. The autogenous mill process has generally resulted in preserving the original size of the rough diamonds; Karowe mine is now famous for recovering exceptionally large stones.

In November 2015, the world's second largest diamond, measuring 1109 cts, was found at the Lucara's Karowe Mine. This was the largest stone found since the discovery of the Cullinan diamond in South Africa in 1902, more than 110 years ago, which measured 3106 cts. It was quickly followed by the discovery of two other large stones, measuring 813 cts (6^{th} largest stone in the world) and 374 cts. The cutting and polishing of these stones is still to be undertaken. The largest cut and polished stone in the world is the Golden Jubilee, cut from the Cullinan diamond, and weighing 545.67 cts. The Karowe gem therefore offers a perfect opportunity to be cut into the largest ever finished diamond, carving Karowe mine and Botswana firmly into the diamond history books.

Indeed, this became the case when the mine unearthed an even larger diamond of 1,758 which was given the name 'Sewelo' ('Rare find') in 2019.

Ghaghoo Mine (Formerly Gope Mine)

Gope is named after the region of the Central Kalahari Game Reserve (CKGR) where the Gope 25 kimberlite pipe is located 45 km within the eastern border of the CKGR. Gem Diamonds acquired the company Gope Exploration from De Beers and Xstrata in May 2007 for US$34 million. In 2011, the name of the mine was changed from Gope – 'Nowhere' to Ghaghoo –the Sesarwa name for the locally abundant tree – *Acacia Leuderitzii* –False Umbrella Thorn.

A mining license was approved in 2011 and production at Botswana's first underground mine commenced in 2013 with the life of mine currently estimated to be in excess of 30 years. Gope's total resource is estimated at 20.5 million carats with a total average in situ value of US$3.3 billion. The average resource diamond price has been increased to US$162 per carat at a grade of about 22 cpht. Two blue diamonds were also recovered from the historical diamond samples during the course of valuation work. In late 2016, the mine was put on a care and maintenance programme and is currently being considered for sale by owner Gem Diamonds.

Diamond Processing

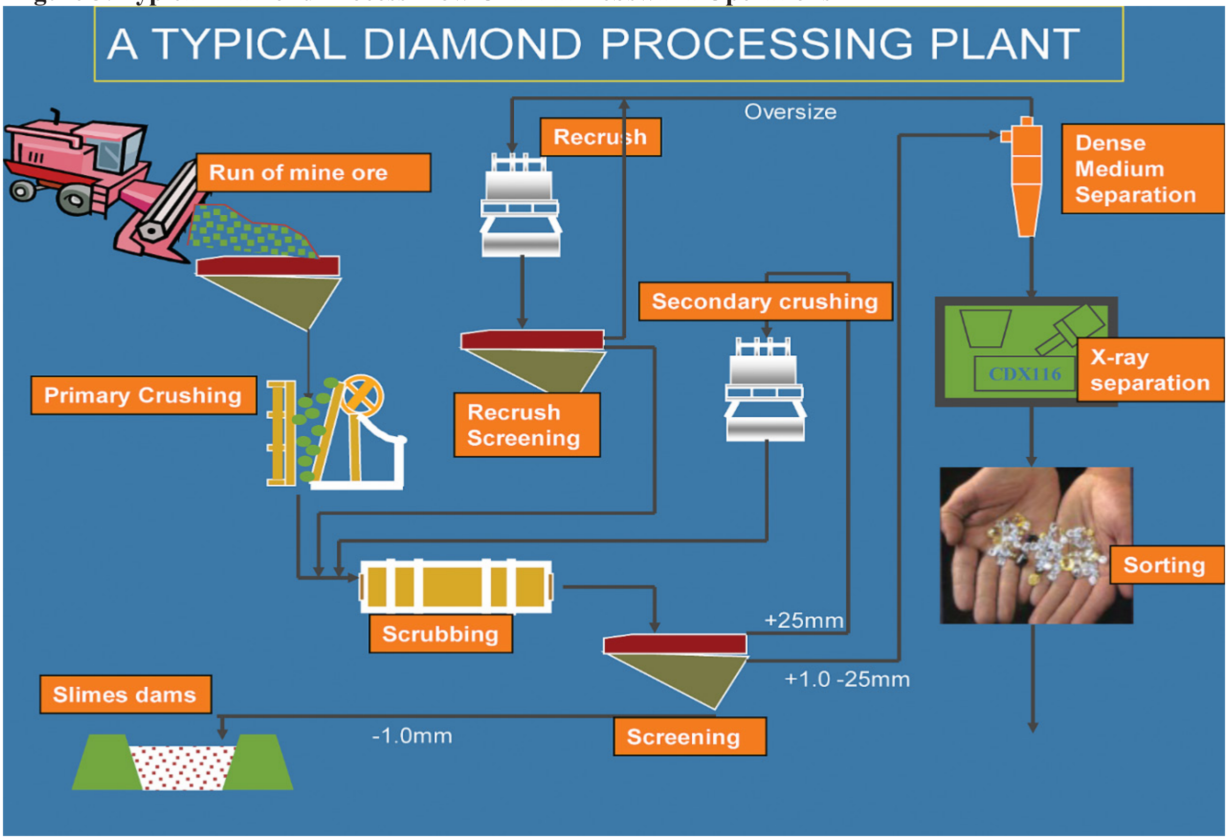
The methods of processing the kimberlite ore and recovering diamonds are based on processes and technology which take advantage of some of the unique properties of the diamond mineral itself. The first, being the hardest and most robust natural material on earth, means that the mineral is very resilient and can survive the first rigorous process of primary, secondary and re-crushing the kimberlite ore into smaller fragments in order to promote diamond recovery.

The second property of the diamond which metallurgists use in the recovery of the stones, is that of its heavier specific gravity –at 3.52 g/cm3, it is 3½ times heavier than water and also heavier than most other minerals and as such, diamonds sink to the bottom of the chamber called a dense media separator, where they can be concentrated before undergoing X-ray processing.

This brings us to a third property of the diamond which is the fact that it is transparent to X-rays and luminesces or emits light when exposed to X-ray radiation. When the above dense media separator concentrate is passed through beams of X-rays, diamonds show up as white objects (Figure 3). The X-ray technology, upon detecting the diamonds, then jets a forceful spray of air which ejects the diamonds, and some surrounding concentrate, into metal containers which are then sorted further for the recovery of the diamonds.

ISSN: 0525-5090

Figure 3: Typical Diamond Process Flow Chart at Debswana Operations



Source: Brook (2012a)

In some smaller diamond processing plants, and diamond sampling plants, a 'grease table' belt is still utilised which exploits another interesting characteristic of the diamond –the fact that it repels water, but rather sticks to the layer of grease coated on the conveyer belt where it is recovered by melting the collected grease once all the ore has been processed.

A state of the art recovery and sorting building at Jwaneng, known as the 'AQUARIUM', was commissioned in 2000. This tall set of four building structures contains a Completely Automated Recovery Plant (CARP) which is a completely 'hands-off' process and therefore maximises security while optimising diamond recovery through the use of the latest X-ray machine technologies.

CARP produces concentrate with > 50% diamond by weight. The CARP was designed to treat concentrate from the Jwaneng Main Treatment Plant (MTP), and the Jwaneng Recrush Plant, and tailings from the Jwaneng old recovery tailings dump. Within the same 'AQUARIUM' buildings, diamond sorting, cleaning, packing and weighing takes place in a fully integrated sort house (FISH) which is also completely 'hands–off' and maximises diamond security while optimising diamond sorting through the use of laser technology. FISH is more efficient than hand sorting for certain product categories.

Single Particle Sorting (SPS) is undertaken using laser technology. The feed is CARP concentrate (>50% diamond by weight) and particles are presented one at a time and detected using a laser beam. The resultant SPS product is a concentrate in excess of 95% diamond by weight.

Acid cleaning of the final SPS product is now done at the DTCB building in Gaborone using nitric and hydroflouric acid to dissolve silicates or minerals attached to the diamond surface; silicates dissolve in acid but diamonds do not dissolve.

The final product (>99% diamond by weight) is then sent to the DTCB in Gaborone for final sorting and valuation. Having successfully liberated the diamonds, the next stage in the diamond pipeline is to sort and value all the diamonds recovered.

Diamond Sorting and Valuation

In the same year that Botswana's first diamond mine at Orapa was established in 1971, the Government of Botswana formed the Botswana Diamond Valuing Company (BDVC). In 1982, the BDVC sorting building, known as Orapa House, was opened in Gaborone and was the tallest and most sophisticated building in Botswana at the time. After sorting and valuation, diamonds were sold to the De Beers Central Selling Organisation (CSO) in London, which was replaced by the De Beers Global Sight-holder Sales (DBGSS) in 2013.

The DTCB, a 50:50 joint venture partnership between the Botswana Government and De Beers, replaced BDVC in 2006. Today, DTCB currently sorts diamonds into around 14,000 categories. The DTCB new headquarters, which opened in 2008, has the capacity for sorting and valuing up to 45 million carats per year and is able to accommodate up to six hundred employees. The sorting process ensures the correct valuation of all production. It also ensures that a consistent supply of rough diamonds can be delivered to the DTCB's customers (called Sight-holders), who are among the world's leading diamantaires. Once diamonds from the individual producer countries have been valued they are carefully blended with like for like diamonds from the DTC's other producer countries to create a selling mixture. This process is called Aggregation. The DTC currently has around 110 selling mixtures or boxes.

The Sight-holders purchase boxes of rough stones which have been aggregated by DBGSS. The diamonds may have been sourced from any De Beers operation anywhere in the world. Today, diamonds are sold by five different entities in Botswana. DBGSS is the primary rough diamond sales arm of De Beers, and it is the world's largest supplier of rough diamonds by value. They moved from London to Gaborone at the end of 2013. Ten sales gatherings, called sights, are held per year, with 73 sight holders currently attending, of which 18 are registered as local (Botswana based) sightholders.

Secondly, the Okavango Diamond Company (ODC), established in 2012, is a rough diamond distribution company that is 100% owned by the Government of Botswana. While DBGSS aggregates Botswana production together with diamonds from other De Beers mines, from countries such as Namibia and Canada among others, before sale, ODC is the largest source of uniquely Botswana diamonds in the market. They sell through on line auctions, also with 10 viewings per year. ODC currently receives 15% of the run of mine from Debswana annually.

The other companies which sell rough diamonds by auction are Firestone Diamonds from their BK/11 mine, currently standing on a care and maintenance basis, and Boteti Mining, from their very successful Karowe Mine. In 2015, Gem Diamonds also began sales by auction from the Ghaghoo Mine.

Sightholder sales work differently: Parcels of each of the categories corresponds to a certain price in the DTCB diamond price book. Once there is agreement on categorisation, the purchase process is complete. In February 2007, the DTCB Diamond Academy was launched and on 18 March 2008, the new DTCB building opened on the Sir Seretse Khama International Airport road adjacent to the Debswana Corporate Centre formerly known as the Technical Support Centre and became the largest rough diamond sorting and valuation facility in the world. Today diamonds from De Beers mines worldwide are sorted and valued in Gaborone depending on size, shape, quality and colour, otherwise commonly known as the 4 C's –carat, cut, clarity and colour, a grading system which was invented by the Gemological Institute of America (GIA) back in 1953.

The first step in the sorting process is to consider the size of incoming diamonds from the so called 'Run of mine' production which arrives in specially sealed metal canisters. Diamonds weighing more than

10.80 carats are classified as 'Large Stones' or 'Special Stones'. There are three main size groups namely 1) >10.8; 2) 0.66 carats to 10.79 carats; and 3) < 0.66 carats, which are further divided into a further six categories using sieve plates.

Diamond Cutting and Polishing

Botswana's first diamond polishing and cutting factory was established by Diamond Manufacturing Botswana in Gaborone in 1976. In 2007 the Botswana Diamond Manufacturers Association was established with its main objective being to represent the cutters throughout all facets of Botswana society and government, and to assist with government policies such as labour and employment.

A strategy for the development of diamond cutting/polishing/jewellery making skills has also been launched. This strategy supports the introduction of institution based diamond cutting and polishing training in Botswana. Diamond cutting/polishing and jewellery is a fast growing industry of great strategic importance to Botswana. There are now 13 factories in Botswana specialising in the cutting and polishing of rough stones. These companies also benefit from being registered local De Beers sightholders and are, therefore, guaranteed a constant and reliable supply of product.

Botswana Diamond Jewellery

The ultimate stage of the Botswana diamond journey is the manufacture and retail of jewelled diamonds. Some 65% of the world's diamonds come from African countries and the $8.4 billion African diamond industry is one of the key pillars of the African economy. Today, Botswana diamonds are also valued, cut and polished and turned into wonderful pieces of jewellery which can be sold all over the world. Diamond jewellery manufacturing is extremely important to the diamond beneficiation process in Botswana, since jewelled diamonds accrue as much as three times more than the value of the mined, rough stone.

The history of diamond jewellery manufacturing and retail in Botswana dates back to 1990 when local company 'Private Collections' started its hand-made, classic diamond jewellery business in Botswana and became the first company to manufacture in Botswana, albeit on a very small, and exclusive basis. 'Private Collections' has also established a wholly owned mini-factory within the Diamond Technology Park trading as 'Fine Jewellery Manufacturing (Pty) Ltd'. They procure polished diamonds from Botswana based diamond cutters. In 2012, they launched 'the SWANA Diamond'. The 'SWANA Diamond', cut and polished by Dalumi Diamonds Botswana, is a patented unique diamond cut featuring 89 facets displaying a perfect eight-pointed star in the heart of the diamond, revealing the indescribable brilliance and internal fire.

Located in the African Mall in Gaborone, Classic Jewellery is a privately owned domestic company that began its operations in 1997. The company manufactures bracelets, wedding and ear rings made out of gold and silver. There are also a small, but increasing, number of shop based jewellery manufacturing workshops in Botswana, mostly located in the capital city, Gaborone. One such is Schonberg jewellers, who opened in 2005, who have produced some unique necklace pieces of Botswana diamond encrusted agate.

In 2010 the Botswana Training Authority carried out a study which showed that jewellery manufacturing together with diamond cutting and polishing are amongst six vocational areas identified as critical players in strategies meant to increase economic growth while at the same time creating employment for Batswana.

As for public training and education, the new College of Applied Arts and Technology, which opened in Oodi in 2012 (Kgatleng District), now offers, for the very first time in Botswana, a certificate, advanced certificate and Diploma in Jewellery Design and Manufacturing. The course lasts between 12-

18 months. In 2015, one of its first 15 student intake, Mpho Mokgatle, won the prestigious shining lights wards 'Development Award' and a two year's apprenticeship with the Keith White Jewellery design and manufacturing enterprise in South Africa.

A Diploma programme in Jewellery Management and Design is also now available at the Botho University in Gaborone. In 2011 Shrenuj Botswana commenced Botswana's first commercial jewellery manufacturing unit, located in the 'Diamond Technology Park' in Gaborone and in 2013, they opened a jewellery retail outlet within their diamond cutting and polishing factory in Broadhurst (Gaborone). They also produced some interesting iconic pieces, including a Botswana flag lapel pin and ladies broach and their 'Love' pendant. In 2016, however, due to financial difficulties associated with their parent company, they closed operations in Botswana.

Local ex-sight-holder, Chow Thai Fook, established their diamond cutting and polishing factory in Gaborone in 2012, and benefited greatly from having access to thousands of jewellery outlets in Mainland China, Hong Kong and Macau, with a heritage of over 80 years and their beautiful Botswana cut round brilliant diamonds are found in gem-set jewellery, gold products, platinum/karat gold products and watches. However, due to high prices associated with local production, they also closed their Botswana factory in 2016.

The Botswana Diamonds brand was launched in Europe in 2008 and is distributed by local sightholder, Taché. They assure consumers of a stone of exceptional quality and conveys the beauty and mystique of its country of origin. Botswana Diamonds are distributed through partnerships with major distributors throughout the world.

Botswana's diamonds feature in most of the Shining Lights Diamond Jewellery Design Awards; a prestigious, Southern Africa based, biennial diamond jewellery design competition, founded by De Beers in 1996.

Diamond Beneficiation

In the diamond industry the term beneficiation refers to downstream activities in a producer country such as Botswana that adds value to locally mined rough diamonds and creates local employment. It includes the art of sorting and valuing rough diamonds, their subsequent cutting and polishing, and the manufacture of diamond jewellery. This strategy of turning natural resources into shared national wealth is anticipated to stimulate the development of a new industry in Botswana and create many more jobs in the country. The jobs, primarily in diamond cutting, polishing, jewellery manufacture, sales and marketing, will account for a 30% increase in diamond industry jobs in Botswana and result in a 10% increase in the country's total number of manufacturing jobs. In addition, job creation in secondary business sectors such as banking, security and information technology will support Botswana's economic vision to generate jobs and drive maximum value from the country's diamond resources. The following efforts have been made by the government to assist in the overall development of the Botswana diamond industry:

- In 2008, the Botswana Government clustered a number of major development projects into six hubs to attract internal and external investment. A Diamond Hub was established to facilitate beneficiation and promote Botswana as one of the world's major diamond trading centers.
- The construction a new Debswana Corporate Centre in 2007.
- The formation of the Botswana Diamond Manufacturer's Association in 2007.
- The construction of a Diamond District incorporating a Diamond Technology Park in 2008.
- The 2008 construction of a Diamond Trading Company Botswana sort house, the largest sorting and valuation facility in the world.

- A strategy for the development of diamond cutting, polishing and jewellery making skills, launched in 2009.
- The construction of a Secure Transfer Facility (STF) at Sir Seretse Khama International Airport in 2011.
- The 2012 agreement by DTC International to move all of its sales and other operations to Botswana before the end of 2013 with DBGSS in Gaborone.
- The formation in early 2012 of the De Beers Aggregation Company in Botswana to undertake the aggregation of all De Beers worldwide diamond production in Botswana for the first time.
- The formation of Botswana's first state diamond trading company, the 'Okavango Diamond Trading Company', in 2012 and their diamond auction house in 2013

Conclusion

For over 100 years diamonds have left Africa to be sorted, valued and sold in London. However, the signing of the 2011, 10-year Botswana Government–De Beers agreement meant that Botswana diamonds will stay in Botswana for longer to have more value added and to enable Botswana to derive more from what is essentially a finite natural resource. The agreement saw the Diamond Trading Company (DTC) relocate its Sights and sales operations –including professionals, skills, equipment and technology –from London to Gaborone before the end of 2013. From its new base in Botswana, DBGSS has now commenced aggregate production from De Beers' mines, and its joint venture operations worldwide, and to sell to international Sight-holders.

Diamond Trading Company Botswana (DTCB) will continue to sort and value Debswana's production before selling it on to the DBGSS. All the stages of the diamond pipeline are now performed in Botswana and development in the downstream activities of cutting, polishing and diamond jewellery manufacture and retail is gathering pace. The scene is at last now set for Botswana to potentially become one of the most important diamond centres in the world.

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