Republic of Botswana

Economic Accounting of Mineral Resources in Botswana, 2015/2016

Technical Report

Prepared by the Botswana Geoscience Institute

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WAVES Wealth Accounting and the Valuation of Ecosystem Services

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Abbreviations

BIDPA	Botswana Institute for Development Policy Analysis
CBM	Coal Bed Methane
DoM:	Department of Mines
GDP	Gross Domestic Product
GoB	Government of Botswana
Mcts	Million carats
Mt	Million tonnes
RRoC	Rate of Return on Capital
SB	Statistics Botswana
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WB	World Bank

Acknowledgements

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[1] The Mineral Accounts are coordinated by Dr. Gomotsang Tshoso, the Mineral Resource and Hydrocarbon Manager, and Ms. Dineo Florence Sefemo, the Mineral Accounts Officer at Botswana Geoscience Institute.

1. Introduction

This report follows previous work by Dr. Keith Jefferis (2016) and is supported by the Government of Botswana (GoB) and the World Bank (WB) through the Wealth Accounting and Valuation of Ecosystem Services (WAVES) Global Partnership. The objective was to develop natural capital accounts using the System of Environmental and Economic Accounts (SEEA) Central Framework, which was approved by the United Nations Statistical Commission (UNSC) in February 2012. The report is structured in a similar outline to Dr. Jefferis' earlier work, but with some new findings for the 2015 mineral accounts for five commodities, namely diamonds, coal, copper-nickel, soda ash, and gold.

Mining is still an important component of Botswana's Gross Domestic Product (GDP). It generates the majority of export earnings, and makes a major contribution to government fiscal revenues. Therefore, the revenues generated by the mining sector are of critical importance for sustainable development. The decision to include mineral accounts in the WAVES project reflects the importance of the mining sector and the need to ensure that appropriate decisions are taken regarding the investment of mineral revenues to provide for future economic growth. This study has the following objectives:

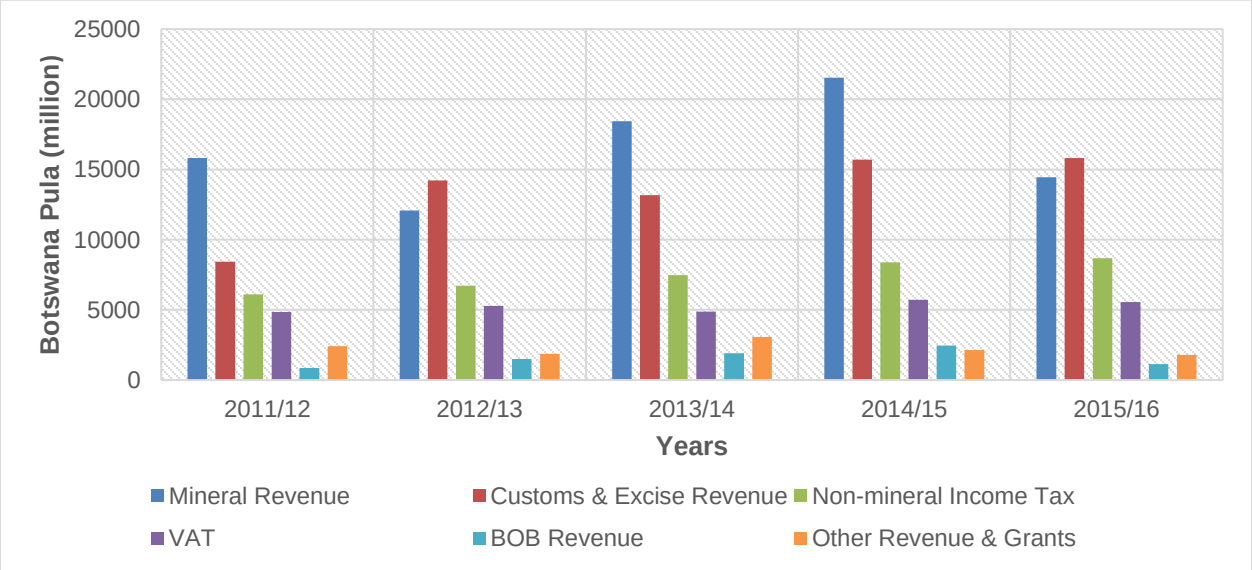
- Quantify the major physical trends in resource stocks for major minerals;
- Quantify the major monetary trends in resource stocks for major minerals;
- Estimate the rent generated by each of the major minerals;
- Produce estimates of mineral depletion.

NOTE*: Actual values have been sourced from previous reports by the Department of Mines, Statistics Botswana, and Econsult.*

2. Minerals, the mining sector, and the economy of Botswana

The mining sector has long dominated Botswana's economy. Admittedly, its contribution to GDP has been volatile, registering 15.3% in 2009, then 19.2 in 2010 before rising to 23.4% in 2011. The long-term trend has been one of decline, from 25.5% in 2004 to 17.7% in 2015 (See Table 1). Nevertheless, the mining sector remains a significant contributor to government revenues (See Figure 1) and export earnings, occasionally surpassed by customs and excise revenues. Contributions from mining are frequently influenced by global trends, particularly the global markets for diamonds. In short, when the global economy is experiencing weaker growth, demand for diamonds normally goes down, resulting in a decline in production and sales of diamonds, and hence the contribution of mining to the economy goes down. For instance, in 2009, the world economic recession depressed global demand for diamonds, and so mining's contribution to GDP was only 15.3% in 2009, down from 25.0% the previous year. Weak recovery in the global markets contributed to the mining sector's low real value added, which declined 22.2% in 2014 to 17.8% in 2015.

Figure 1: Total revenue by source (2011/12 to 2015/16)



Source: MFED 2016

Table 1: Contribution of gross value added to GDP by type of economic activity, at current prices, 2004-2015

Calendar year	Agriculture	Mining	Manufacturing	Water & electricity	Construction	Trade, hotels & restaurants	Transport & communication	Finance & business service	General government	Social & personal services	Value added	Taxes on imports	Other taxes on products	Subsidies	Total GDP
2004	2,3	25,7	5,6	1,9	5,7	12,2	3,4	12,7	14,6	5,0	89,0	6,5	5,0	-0,5	100,0
2005	1,8	31,7	4,9	1,4	4,8	10,8	3,6	11,7	14,2	5,0	90,0	6,3	4,3	-0,5	100,0
2006	2,0	32,2	5,3	1,3	4,8	11,9	3,8	11,3	13,2	5,0	90,8	5,8	3,9	-0,5	100,0
2007	2,2	29,1	6,3	1,1	5,3	12,3	4,0	11,4	13,2	4,8	89,8	6,4	4,3	-0,5	100,0
2008	2,5	25,0	5,7	0,9	5,0	13,4	4,4	12,5	14,6	5,1	89,1	6,3	5,1	-0,5	100,0
2009	2,8	15,3	6,3	0,4	6,1	15,2	5,4	13,2	16,8	6,3	87,8	6,2	6,6	-0,6	100,0
2010	2,5	19,2	6,4	0,5	5,8	15,1	5,1	13,4	15,4	6,0	89,4	5,1	6,0	-0,5	100,0
2011	2,5	23,4	5,8	-0,1	6,0	14,9	4,9	13,3	14,1	5,6	90,3	4,8	5,3	-0,4	100,0
2012	2,7	17,6	5,9	-0,6	6,8	15,4	5,8	15,0	15,4	6,1	90,1	5,1	5,3	-0,4	100,0
2013	2,3	19,4	5,8	-0,1	6,4	16,9	5,5	14,2	14,2	5,9	90,4	5,1	4,9	-0,4	100,0
2014	2,1	22,2	5,3	-0,4	6,0	17,9	5,3	13,2	13,7	5,6	90,9	4,9	4,6	-0,4	100,0
2015	2,2	17,8	5,8	-0,2	6,6	16,2	5,9	14,7	15,4	5,9	90,3	5,2	4,9	-0,4	100,0

Source: Statistics Botswana

2.1 Mineral Production

Historically, the main driver of mining sector growth and earnings has been diamonds, although there have been smaller contributions from base metals (copper, nickel, and cobalt) as well as from soda ash and gold. This situation has been changing in recent years. In 2015, diamond production decreased by 15.6% compared to a 6.6% increase realized in 2014 (compared to the previous year). Copper/nickel production declined by 35% that same year. The Mowana and Thakadu copper mines were put on provisional liquidation in the fourth quarter of 2015. Boseto copper mine (Discovery metals) was liquidated in the second quarter of 2015 (Statistics Botswana, 2016). Mineral production information for the five primary commodities is summarised in Table 2.

Table 2: Botswana mineral production, 2015

Mineral	Units	Physical production	Value of production (Pula million)
Diamonds	carats	20,823,643	135,568
Copper-nickel	tonnes	40,157.0	0
Soda ash (natural)	tonnes	243,369	4,172
Coal	tonnes	2,065,778	0
Gold	kg	754.1	392

Source: BGI, Mineral Accounts

2.1.1 Diamonds

Diamond production in 2015 reached 20.8 million carats (mcts). The Debswana mining company accounted for 20,368,000 carats, making it the largest contributor, followed by Boteti mining (364,314 carats) and finally Gem Diamonds (91,330 carats). Due to the weak recovery of global markets, overall production in 2015 was lower than in 2014, which registered 24.7 mcts. Additional information on diamond production in past years is detailed under the physical accounts section in this report.

Diamonds in Botswana are produced from six mines: Orapa, Jwaneng, Letlhakane and Damtshaa, operated by Debswana (a joint venture between the Government of Botswana and De Beers); Karowe, operated by Lucara Diamond Corp.; and Ghagoo, which is operated by Gem Diamonds. Ghagoo, in the Central Kgalagadi Game Reserve, is the newest, and Botswana's first underground diamond mine, while all of the other mines are open pit operations. Two very small mines (BK11 and Lerala) are mothballed, although Lerala is expected to re-open in late 2015.

For many years, all diamonds were exported in rough form, with sales and marketing largely taking place outside of the country. However, this situation has changed over the years. Around 20 diamond cutting and polishing operations have been established, which partly use diamonds.from Botswana. Furthermore, as of 2013, De Beers's global sales operations have been relocated from the United Kingdom to Botswana, which means that diamonds from all of the De Beers Group mines are sold from Gaborone. There are also other diamond marketing platforms, including the GoB-owned Okavango Diamond Company, which sells

a share of Debswana's production outside of De Beers's channels, and Lucara Diamonds. All of these operations are helping to establish Botswana as a global diamond marketing hub.

2.1.2 Base metals

As of the end of 2015, base metals (copper-nickel) production took place at three mines in Botswana: Selebi-Phikwe (operated by BCL), Phoenix (BCL/Tati Nickel), and Mowana (African Copper). The situation has since changed because BCL was liquidated. A new mine is due to be opened in Western Botswana by Khoemacau Copper Mining, who have also taken over the bankrupt Discovery Metals. There are three mothballed mines: Thakadu (African Copper), Boseto (Discovery Metals), and the underground nickel mine at Selkirk (Tati Nickel). BCL also operate a smelter at Selebi-Phikwe, which processes concentrate from the mines and produces semi-refined copper-nickel matte, to be exported for final refining elsewhere. Copper-nickel production has been declining in recent years, being significantly affected by the closure of the BCL mine and fluctuating copper prices. In 2015, the total production amounted to 40,154 tonnes from BCL, Messina Copper, Discovery Metals and Boseto, with some minor production of silver as a by-product (Table 3). Historical production estimates are provided in the physical accounts section.

Table 3: Base metal mineral production statistics, 2015

BCL	Messina Copper Botswana (Mowana and Thakadu-opened 2008)	Discovery Metals Boseto Copper	Discovery Metals Boseto Copper
Total metal (Cu, Ni, Co) in matte (tonnes)	Copper (tonnes)		Silver (kg)
30,992	5,977	3,185	2801

Source: BGI, Mineral Accounts

Until 2015, BCL was the largest contributor of base metals in terms of production (Table 3) and value. Sales of copper and silver metal from Messina Copper, Discovery Metals, and Boteti only occurred in January and February, while Khoemacau may increase their contribution should their production start in the near future.

2.1.3 Soda ash and salt

Soda ash and salt are produced from brine deposits located at the Makgadikgadi salt pans, through an evaporation process. During the past five years, the production of soda ash averaged 250,000 metric tons a year, while salt averaged 440,000 metric tons a year. Small quantities of salt are sold domestically, while soda ash is exported. Botswana is the fourth largest producer of natural soda ash in the world (after the United States, Turkey and Kenya), although it has the second-largest reserves (Jefferis, 2016). In 2015, soda ash production reached 243,369 tonnes and salt production reached 404,295 tonnes (Mineral Production Statistics, 2015).

2.1.4 Coal

Coal is produced in small quantities in Botswana, mainly for domestic consumption, with the main usage being power generation. Historical production has been just under 1 million metric tons per annum (mtpa), from a single mine at Morupule, although output has now risen to 2–3 mtpa to supply the new coal-fired Morupule B power station. Botswana's coal resources have previously been estimated at 212 billion tonnes (Chatupa, 1991). This tonnage includes demonstrated (measured and indicated), inferred, hypothetical and speculative coal resources, based on Coal Exploration Reports from previous and current exploration licenses. It should be noted that 77% of the estimated resource remains in the hypothetical or speculative category. African Energy estimated that the total coal resource amounts to 28,539 metric tons in the measured, indicated and inferred category (BIDPA, 2012).

2.1.5 Gold

Gold has, in the past, been intermittently mined in northeast Botswana, although at present there is only one mine in operation (Mupane), which commenced production in 2005. Production is relatively low at just 754.1 kg in 2015, and is declining as reserves become depleted, although the exploration of satellite deposits around Mupane is helping to extend the life of the mine.

2.2 Prospects for the mining industry

Botswana's mining sector is likely to become more diversified over the next two decades as diamond production declines in relative terms and other minerals develop.

2.2.1 Diamonds

The Debswana mines at Orapa and Jwaneng, which represent the mainstays of Botswana's diamond production, can keep producing for another 50 years based on current investment levels (Department of Mines, 2015). Other mines have been opened in recent years but they are much smaller than Orapa and Jwaneng and are more less economically significant. There are reserves that can be exploited beyond this time, although this will require significant investments to deepen and broaden the pits, or to go underground. With an anticipated upward trend in real diamond prices over the next two decades, driven by emerging supply-demand imbalances as major deposits are worked out, such investments should be worthwhile. The large tailings dump at Orapa, Letlhakane and Jwaneng can also be processed.

2.2.2 Base metals

Botswana's base metals mines have been adversely affected by low prices (especially for nickel), declining reserves and ore quality (especially at Tati Nickel), production problems, and difficulties in achieving anticipated ore processing volumes (especially for African Copper and Discovery Metals). However, it has been established that there are unexploited base metal deposits around Selebi-Phikwe and in Northwest Botswana (the Ghanzi district and Ngamiland). Additional base metal mines will likely open in the coming years as the government has plans to put up infrastructure for transport and power. However, this will all depend on price improvements.

2.2.3 Coal

The main potential for large-scale development within the mining sector in Botswana lies with coal because of its huge reported reserves. The extensive deposits are spread throughout eastern and central Botswana (BIDPA, 2012 and Chatupa, 1991). A significant ramp-up in production requires an export market, whether for coal itself or for products derived from coal, such as electricity or chemicals. Developing a significant coal export market will, in turn, require the provision of dedicated rail infrastructure, either to the east coast of Africa (via Zimbabwe, Mozambique, or South Africa), or the west coast (via Namibia) (Wood, 2011). These are large and expensive projects, and various options are under consideration by the Government of Botswana. Mining coal for export also comes with substantial water

requirements for washing, and the availability and cost of sufficient water is another factor to consider when developing large-scale coal production.

There are also substantial deposits of CBM (similar to shale gas), which could be exploited as an energy source (liquid petroleum gas), a fuel for power generation, or a chemical feedstock. The viability of exploiting CBM deposits is under investigation.

2.3 Downstream processing

The majority of Botswana's minerals are exported in unprocessed or semi-processed form. However, there has been a gradual upward shift along the value chain, at least for diamonds. While rough diamonds have long been sorted and valued in Botswana, in recent years some diamonds have also been cut and polished locally. Since 2013, the entire production has also been marketed locally, with the relocation of De Beers Global Sight Holder Services (DBGSS) from London to Gaborone. In addition, the newly-established Okavango Diamond Company (ODC) is marketing a portion of Debswana output in Botswana (but outside De Beers' channels), and other diamond mining companies (e.g., Lucara) have also established marketing operations in Botswana. There is also some jewellery production going on.

Coal is already processed locally to produce electricity. Other possible downstream processing activities using current mineral products include copper-nickel refining, fabrication of metal products, and glass production from soda ash. Coal may also be used for much larger-scale electricity production for export, or for chemical or liquid fuel production. Future CBM production can also be used as the basis for a variety of downstream products.

3. The framework for mineral accounts

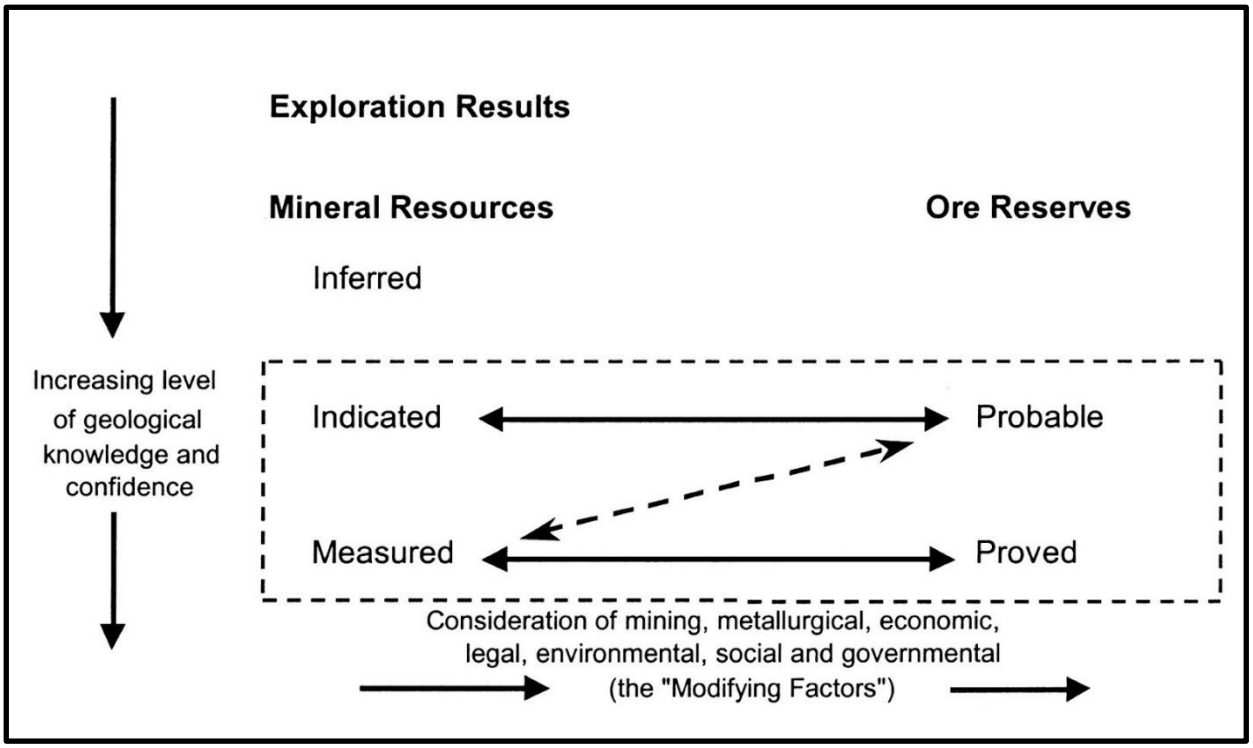
Mineral accounts represent a contribution to the broader task of calculating Botswana's level of national wealth, its changes in wealth, and its genuine net savings. National wealth includes produced, human, natural, and financial capital that can be used to generate income and livelihoods. From a sustainable development perspective, it is important to track changes in national wealth over time. The extraction of minerals can easily lead to a reduction of national wealth if declining mineral assets are not compensated by increasing assets of other forms (produced capital, natural capital, and financial assets). If national wealth is not sustained or increased, real incomes will decline in the long term (Jefferis 2016). Indeed, most of Botswana's minerals have historically been exported in unprocessed or semi-processed form, with few linkages between the mining sector to other economic activities in the country. However, this is gradually changing.

3.1 Mineral resources and reserves

In constructing mineral stock accounts, one of the most important starting points is the classification of mineral deposits in the ground. Essentially, any mineral deposit can be classified according to the level of confidence regarding the geological structure of the deposit. The latter will depend on both the nature of the mineral, and the type of prospecting and exploration that has been carried out. In addition to the level of geological confidence, a deposit can be classified according to its economic viability. For instance, there may be a high level of geological confidence regarding a certain deposit, but it may be of low grade or difficult to extract, making it economically unviable to extract given existing mining and processing techniques and market prices. A deposit's level of economic viability will be less stable than the level of geological confidence, given that price expectations can change considerably.

Any mineral deposit can therefore be evaluated across these two dimensions, as shown in the "McKelvey" diagram below. Identified (i.e., discovered) resources can be divided into Measured, Indicated, and Inferred, with progressively lower degrees of confidence as to the geology of the deposit. In terms of economic classification, deposits are either economic (i.e., mineable) or sub-economic.

Figure 2: McKelvey classification of mineral deposits showing the difference between mineral resources and ore reserves



Source: McKelvey, 1976

Deposits that are both economically viable and identified with a reasonably high degree of geological confidence (measured or indicated) are classified as "reserves," which may be further subdivided into proven and probable categories. Identified deposits that either fall into the geological inferred category and/or are considered sub-economic, are classified as "resources." Mineral reserves are of primary economic interest, although mineral resources can be moved into the reserves category over time, either due to changing economic conditions (such as higher prices), or to further geological assessment or exploration work. In this report, we focus on reported reserves, except in the case of diamonds where—for reasons of differences in geology between diamonds and other minerals—we also include inferred resources. Where data on reserves are not published by mining companies, we use measured and indicated resources instead.

3.2 Measuring resource rent and valuing mineral assets

The economic value of a mineral resource is measured by the *resource rent*. This is the economic return earned from the sale of a mineral, over and above the costs of extracting the mineral. Resource rent occurs because of the scarcity of a resource. Unless there are specific policies to recover resource rents from mineral producers, much of it will accrue as "windfall" or "super-normal" profits to mining companies—i.e., a profit that is over and above that which would be normally required to reward the mining company for the capital employed in the mining operation and the risks incurred in mining investment and operation (Jefferis, 2016).

In many countries, the law prescribes that minerals belong to the state. Mining companies are then given licences entitling them to exploit (mine and sell) the mineral resource. However, as the owner of the resource, the government is entitled to a return on it. From an economic perspective, sustainable and equitable resource management requires that the resource rent be recovered by the government through appropriate taxes, and be used for the benefit of all citizens. Non-renewable resources like minerals will eventually be depleted, and the employment and incomes generated by this activity will come to an end. It is especially important that the resource rent from minerals be invested in other kinds of economic activity, which can replace the employment and income from the mineral-based industries once they are exhausted. In this way, exploitation of minerals can be *economically* sustainable—because it creates a permanent source of income—even though non-renewable resources are, by definition, not physically sustainable, and the revenues derived directly from minerals are consequently unsustainable.

Most countries, including Botswana, levy special taxes and royalties on minerals to capture resource rent. But while the principle of capturing resource rent is well established and widely accepted, doing so in practice is quite difficult, for several reasons (Jeferris 2016):

1) There is room for disagreement between what is an acceptable rate of return on capital (RRoC) for the investor, including an allowance for risk.
2) The taxation regime should have a relatively low or normal rate of tax on profits when profits are low, but a higher rate of tax when profits are high, to capture any windfall gains—thus a variable profits tax rate is required, which must be carefully designed.
3) There is scope for transfer pricing because investors can transfer profits out of the mining jurisdiction (where taxes may be high) to tax havens or lower-tax jurisdictions.

4) Mineral royalties on the gross value of production are by far the simplest kind of tax to impose on mining companies but have the disadvantage of making some mineral deposits sub-economic because they raise the costs of mining.

The value of natural capital is the present discounted value of the stream of income (rent) that it is expected to generate in the future, or what is called the present value. There are two steps to calculating the present value of mineral assets:

1. Calculate the rent per unit of output generated by current production and estimate future rents
2. Calculate the economic value of the mineral deposit as the discounted value of future rents.

4. Mineral accounts update

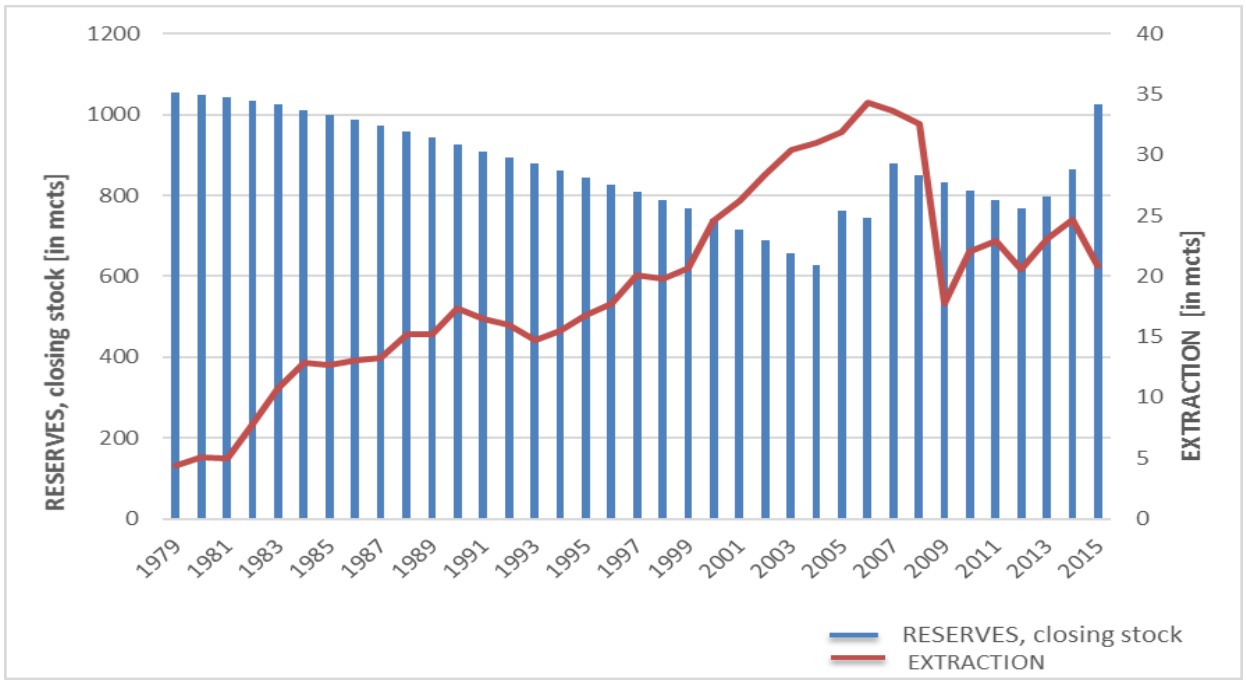
4.1 Physical Accounts

The construction of physical accounts for minerals is an important step in building economic accounts, whereby the changes in the economic value of the country's natural capital can be tracked. Extraction levels and estimated reserves over the years 1979-2015 are presented in Figures 2 -6 below, for diamonds, copper-nickel, coal, soda ash, and gold.

4.1.1 Diamonds

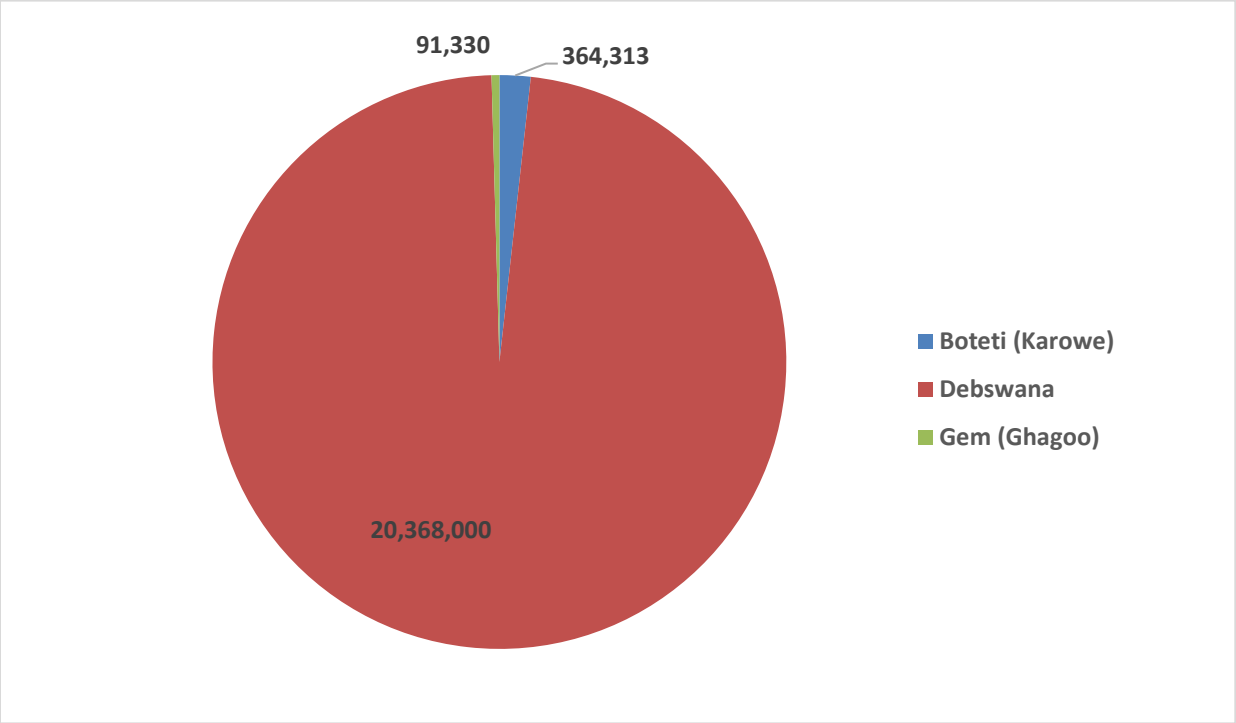
Since 2015, most of the diamond production in Botswana has been concentrated in Debswana operating mines (Department of Mines, 2015). Commercially viable diamond deposits are also found at Karowe, Ghagoo, Lerala, and BK11 (Firestone/Tango) mines. However, the latter are relatively small compared to Debswana, with their combined resources totalling less than that of Debswana tailings dumps, which are also included in reserve estimates. Figures for historical production (1979-2015) are presented in Figure 3 and results for 2015 production are summarised in Figure 4.

Figure 3: Diamond extraction and stocks in million carats, 1979-2015



Source: BGI, Mineral Accounts

Figure 4: Diamond extraction and stocks in million carats, 2015



Source: BGI, Mineral Accounts

Debswana mines were the largest producer of diamonds in 2015, followed by Boteti (Karowe) then Gem Ghaggoo diamonds. BK11 (Firestone/Tango) and Lerala did not have any production in 2015.

An increase in reserve size is observed in 2015 (Figure 3) due to the following:

- A revised resource estimate, informed by new drilling information from Debswana on the Jwaneng and Orapa resource extension projects, was introduced in 2015.
- Classification of new indicated resources resulted in a substantial increase in the diamond reserve, and an associated decrease in the exclusive diamond resource.
- The life of mine plan approved in 2015 includes the Cut-8 estimates of 84 metric tons of material to be treated from Jwaneng mine and an increase in the exclusive diamond resource in Orapa due to the addition of new inferred resources at depth (Anglo American, 2015).
- Anglo American's 2015 reserve statement indicates that there is still a significant amount of inferred resources, suggesting that the reserves will continue to increase in 2016.

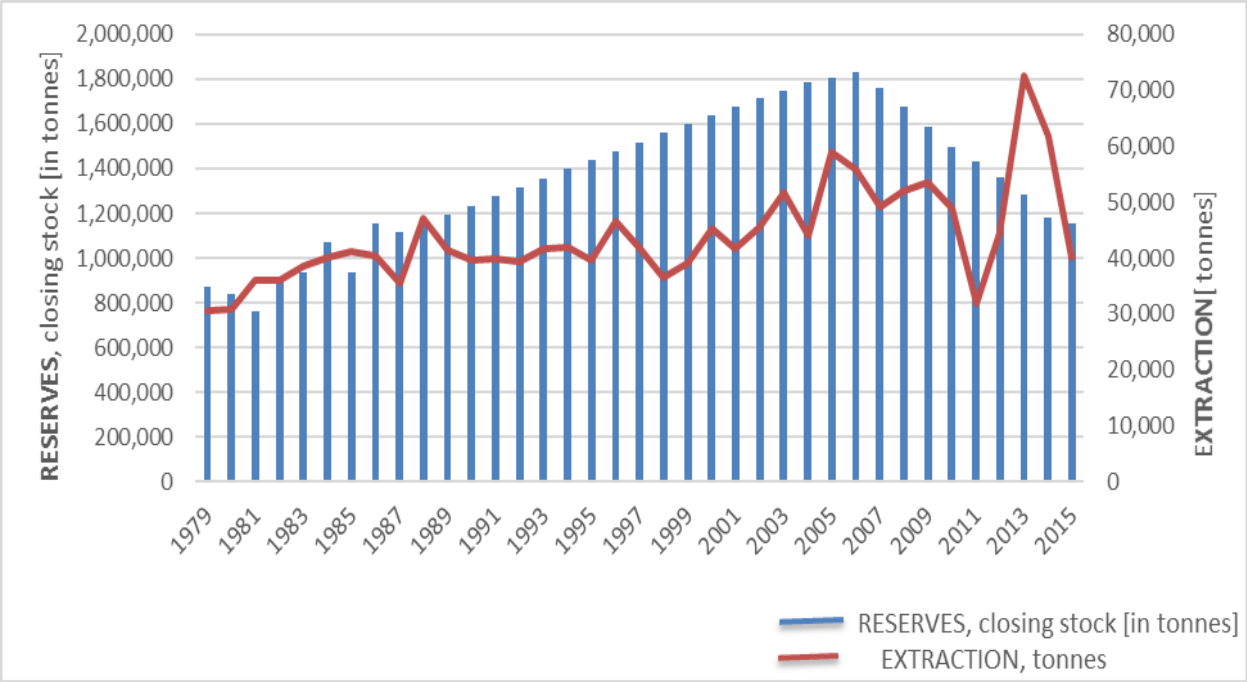
Note: Information on diamond extraction/production was obtained from the Department of Mines (DoM). In Botswana, the mines are owned in equal share by De Beers and the Government of the Republic of

Botswana through the Debswana Diamond Company joint venture. Anglo American, which has some shares from DeBeers Holdings Company, is listed on several major international stock exchanges. Therefore disclosure rules require that figures on mineral reserves be provided to investors and published as part of the annual accounts. Therefore, since 2012 Anglo American annual reports on mineral reserves and resources have included figures for all four Debswana mines. It is also obtainable from Debswana website (insert website). According to Anglo American reports Debswana Diamond Reserve and Diamond Resource estimates are reported in accordance with The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (The SAMREC Code, 2007 Edition as amended July 2009).

4.1.2 Copper-nickel

The BCL mine has been at the forefront of copper-nickel mining in Botswana. Khoemacau has recently completed its exploration phase and is likely to have a positive impact on the growth of copper–nickel production. In principle, the 2015 reserve figures would cover some 20 years of extraction, based on current rates. However, this may not practically be the case, as some of the reserves (especially those at Tati Nickel) are of very low grade, and continued mining may not be viable (depending on copper and nickel prices). In due course, a portion of the identified resources may be converted to reserves as the quality of prospecting data is upgraded, which could further extend the life of the reserves. A summary of base metal historical production is shown in Figure 5 below.

Figure 5: Copper-nickel reserve and extraction, 1979-2015



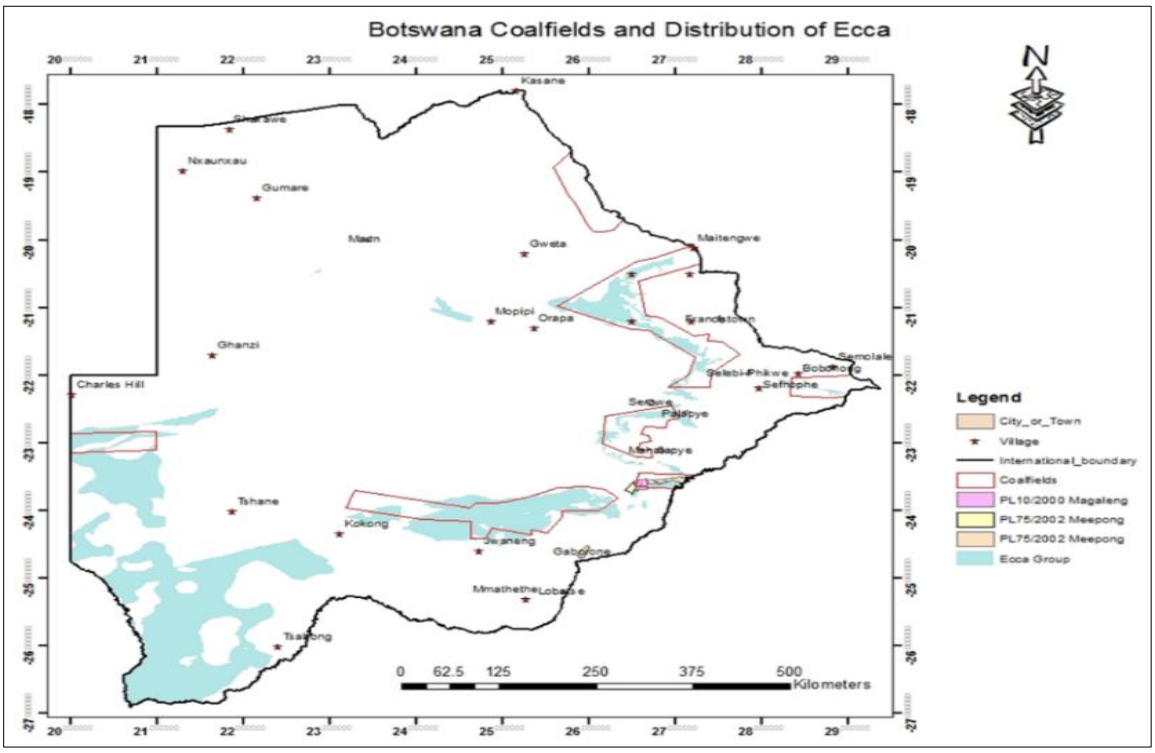
Source: BGI, Mineral Accounts

Generally, copper-nickel reserves have decreased since 2006 because the BCL mine was approaching the end of its life, while production levels also declined because of low-grade ores.

4.1.3 Coal

Botswana's coal resources are available in the 11 areas, primarily in the eastern part of the country (See Table 4 below). These coalfields include: Pandamatenga, Eastern (Dukwi, Foley and Sese), Tuli, Morupule and Moijabana, Mmamabula, South Eastern (Dutlwe and Letlhakeng) and Ncojane. However, there has been little development of these resources. Only Morupule is currently being mined, although Mmamabula has been granted a mining lease. BIDPA (2012) has reviewed the coal resources and concluded that 11 billion tonnes of coal are within the measured and indicated reserves. This varies greatly from previous reports of 212 billion tonnes (Chatupa,1991), which include inferred, hypothetical and speculative coal resources.

Figure 6: Coalfield distribution in Botswana



Source: Gwandu 2017

Table 4: Indicated and measured resources from all coal studied blocks (BIDPA, 2012)

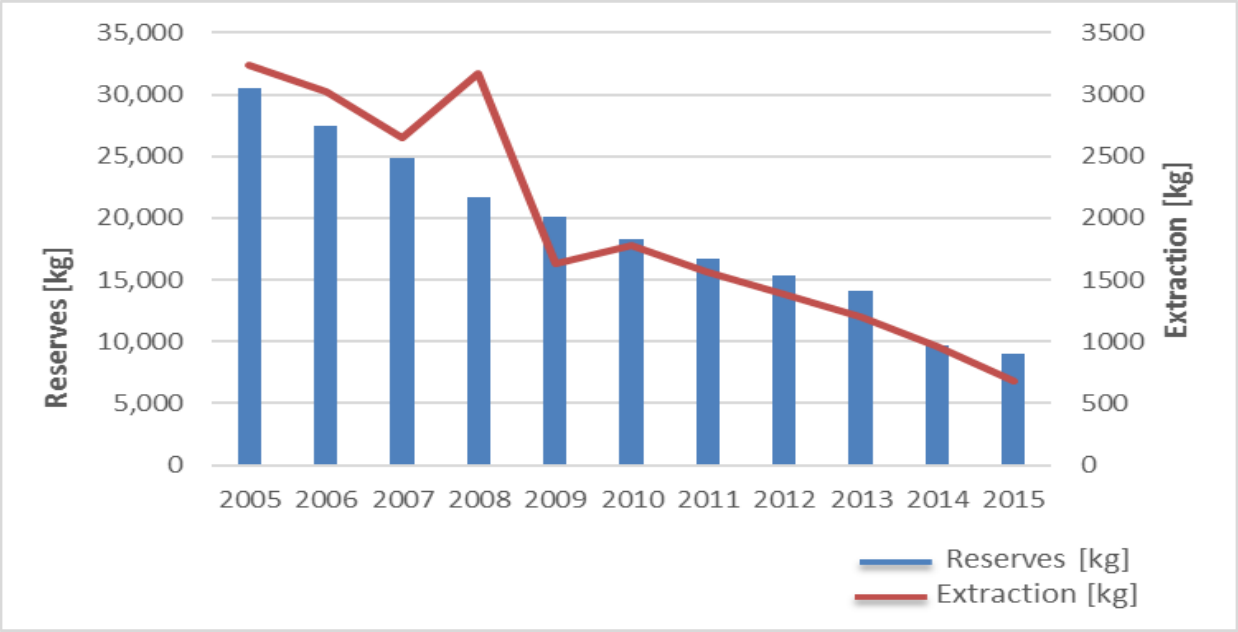
2012 TOTAL TONNES (IN-SITU) AFTER GEOLOGICAL LOSSES, Top 200-300m only (all in Mt)						
Coalfield	**Deposit**	**Company**	**Total Tonnes**	**Measured**	**Indicated**	**Inferred**
Dukwe	Dukwe	Asenjo	922		508	414
Foley	Sese	African Energy	2,800	500	2,200	109
Foley Sese NW Daheng 85	Sese NW	Daheng	850		850	
Serule	Sechaba	Shumba	968			968
Serule	Lechana	Asenjo	830		103	727
Serule	Tshimoyapula	Asenjo	1,174			1,174
Morupule	Morupule	Debswana	2,900	425		2,483
Morupule	Morupule South	Hodges	2,330		1,916	414
Moiyabana	Moiyabana	Hodges	1,500			1,500
Mmamabula	Mmamabula	CIC Energy	2,346	2,313	2	31
Mmamabula	mmamabula West	Asenjo	5,364		573	4,791
Mmamabula	Mmamabula South	Under Tender	617	553	57	7
Mmamabula	Mmamabula Centr	Under Tender	408			408
Letlhakane	Mmamantse	Aviva Corp	1,300	895	405	
Dutlwe	Takatokwane	Nimrodel	4,230			4,230
Total			**28,539**	**4,686**	**6,614**	**17,256**
Measured and Indicated	**11,300**				**11,300**	

Source: BGI, Mineral Accounts

4.1.4 Gold

Mupane is the only gold mining company whose information on gold reserves can be obtained from corporate publications and the Department of Mines. The resource information was compiled by Jefferis (2016) and shows that reserves and extraction levels have been declining over the last 10 years. Unless new reserves are identified, the anticipated life of the mine is about 13 years based on the 2015 production rates (See Figure 7).

Figure 7: Gold reserve and production, 2005-2015

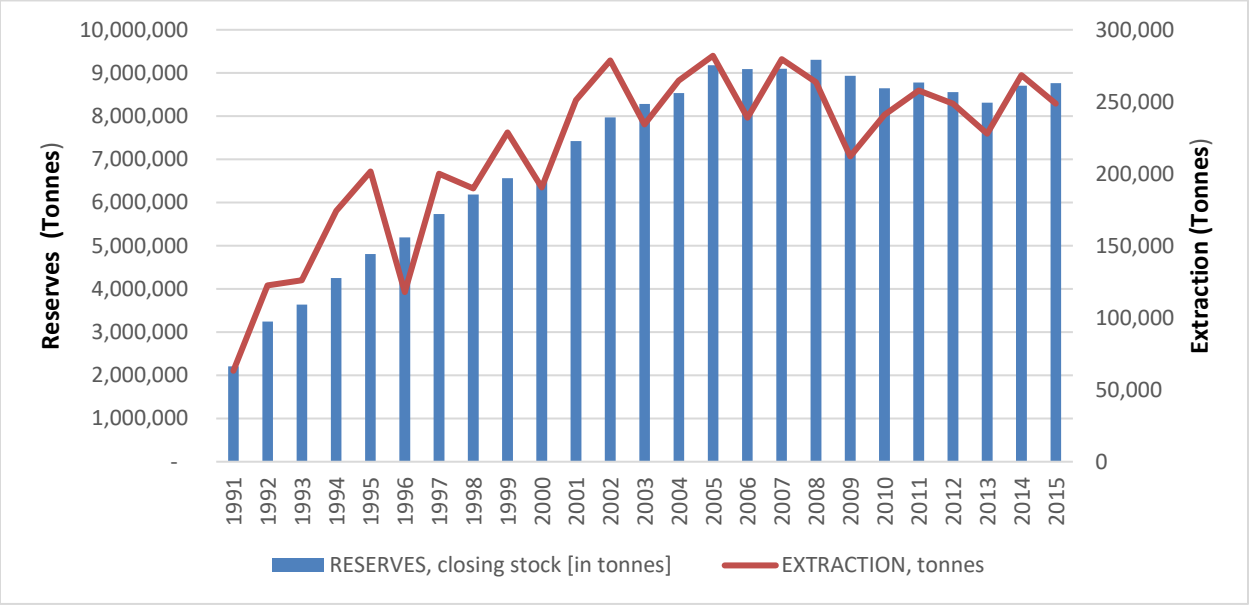


Source: BGI, Mineral Accounts

4.1.5 Soda ash

Production of soda ash started much later than for other commodities, around 1991. Soda ash has generally shown significant growth over the years, both in terms of production and reserves (Figure 8). Extraction was 248,764 tonnes in 2015 on the estimated reserve size of 8,761,802 tonnes. Soda ash production was not adversely affected by the global financial crisis of 2008/2009.

Figure 8: Soda ash reserve and production, 1991-2015



Source: BGI, Mineral Accounts

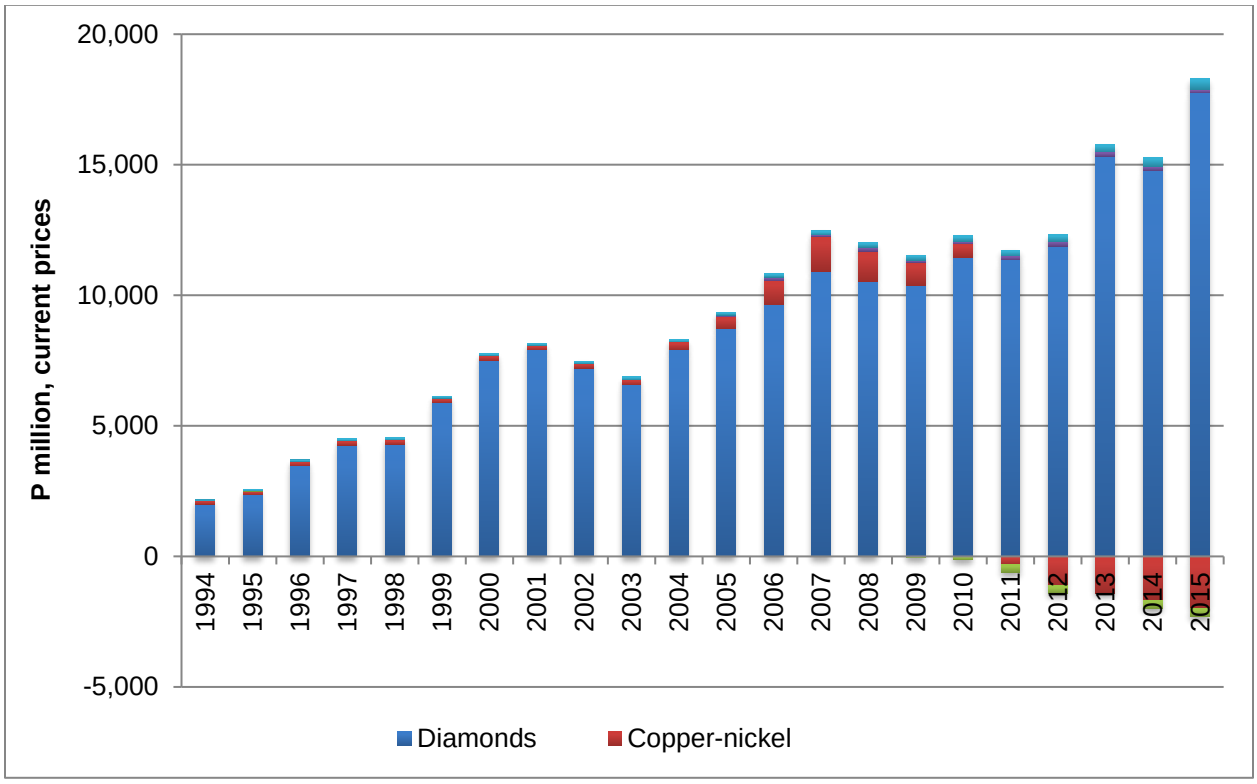
Soda ash is an unusual mineral in that it is, to some extent renewable. The brine extracted from Sua Pan - from which soda ash and salt are produced - is replenished by water inflows. Based on modelling reports of extraction and recharge flows, and discussions with Botash management, it is projected that current rates of soda ash extraction can be maintained for 35 years. Reserve figures are derived indirectly, with the closing stock calculated as the level needed to keep production at current rates for 35 years.

4.2 Resource rent and monetary accounts

Monetary accounts are reported as the value generated by the various commodities that are being mined, while the resource rent is the surplus value after all costs and normal returns have been accounted for. The value generated and the resource rent have been calculated for the five major minerals mined in Botswana - diamonds, copper-nickel, coal, soda-ash, and gold - for the period 1994–2015, with forecasts until 2017. Since gold production only started in 2005, its values are reported from that year onward.

4.2.1 Mineral rents

Figure 9: Resource rent by mineral, at current prices, 1994 – 2015



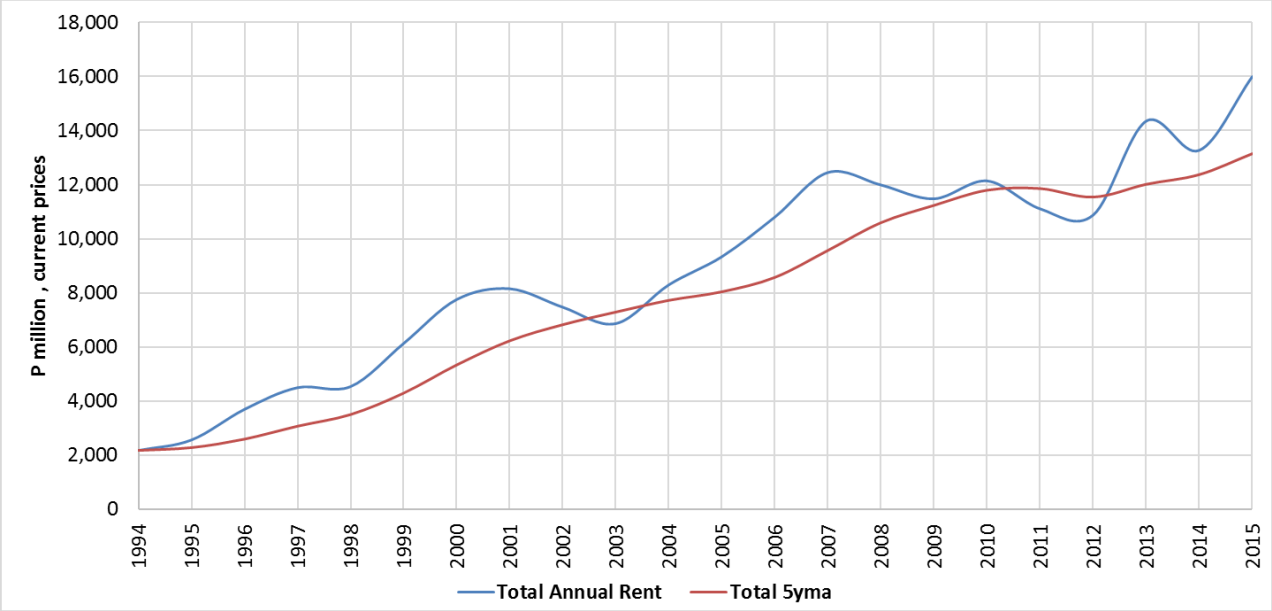
Source: BGI, Mineral Accounts

Diamonds play an important role in the contribution of resource rents, as evidenced by the following results:

- Between 2011 and 2015, diamond rents made up 97% of the total mineral rents. Rents from copper-nickel have been much smaller, and were actually negative for 2008 through 2015. Rents from coal have consistently been negative from 2011 through 2015. Soda ash and gold showed small but positive contributions in 2015, at 2.98% and 0.28% respectively.
- The global financial crisis of 2008–9 led to a sharp fall in resource rents, although diamonds, being by far the largest contributor to rents, were also much more stable during this period.
- Since 2004, rents from soda ash have been small but positive, and lately they have been increasing, mostly supported by replenishing reserves and the fact that its selling price was revised in 2015.

- Annual resource rents have been quite volatile due to mineral prices and production volumes. A 5-year moving average of rents gives a more representative long-term trend, as shown in Figure 10 below.

Figure 10: Total resource rent vs 5-year moving average



Source: BGI, Mineral Accounts

One of the uncertainties in resource rent calculations is the assumed rate of return on capital (RRoC). Return on capital is conceptually part of the costs of production, but is not normally calculated and published as part of financial accounts. Most of the calculations carried out here use a 20% RRoC, in line with previous exercises (Jefferis, 2016). This is justified as follows:

> *Given that all figures are presented in nominal (current price) terms, an appropriate RRoC must take into account inflation in order to arrive at an appropriate real rate of return. Inflation averaged 8.1% a year during the period 1994-2014,as measured by the GDP deflator, yielding a real return on capital ,in Pula terms, of 11%.*

In choosing an appropriate RRoC, a trade-off needs to be made between simplicity and accuracy. The appropriate RRoC may vary across time and projects. A real, pre-tax rate of return of 11% would probably be considered too low by private investors in risky, new mining projects, but may be too high for a mature mining project with little geological uncertainty and stable offtake agreements. For example, a coal mine

selling to a power station under a long-term, take-or-pay contract with an agreed pricing formula faces lower risks than a copper mine selling into the global spot market. For present purposes, simplicity is favored, with a single RRoC of 20% used for all years and all minerals except coal, where the rate is 15%. In future calculations of mineral rents, it may be appropriate to use a lower RRoC, given that Botswana's inflation is now significantly lower than in the past. It may also be appropriate to use different RRoCs for different minerals.

In practice, the choice of RRoC does not make a great difference to the overall rent calculation. This is because diamonds account for the majority of mineral rents, and in the diamond sector, the rent makes up a large part of operating surplus while the deduction for return on capital is relatively small. However, for other minerals, the rent calculation is more sensitive to the assumed RRoC.

Table 5: Calculation of total resource rent, all mining activities, 1994–2015 (Pula million)

Year	Operating surplus	Consumption of capital	Capital stock	Return on capital	Total resource rent
1994	2,881	260	1,442	286	2222.01
1995	3,374	265	1,461	290	2344.16
1996	4,494	271	1,425	283	2669.66
1997	5,146	283	1,378	273	3142.60
1998	5,164	300	1,477	293	3557.17
1999	6,970	316	1,655	328	4348.23
2000	8,813	333	1,894	376	5391.49
2001	9,123	379	2,289	455	6267.95
2002	8,737	451	2,869	570	6882.07
2003	8,377	518	3,512	699	7372.99
2004	9,252	625	4,435	883	7713.80
2005	14,212	829	5,985	1,193	8544.06
2006	17,044	1,097	7,374	1,470	9860.73
2007	17,283	1,476	9,953	1,978	11207.75
2008	16,559	1,974	13,182	2,618	12263.55
2009	8,710	2,135	12,989	2,576	11523.21
2010	13,681	2,339	13,863	2,737	10969.93
2011	23,324	2,800	17,879	3,506	11103.41

2012	18,792	3,498	20,694	4,066	10156.34
2013	23,798	4,011	23,543	4,635	10440.74
2014	27,947	4,702	27,107	5,349	13639.81
2015	21,687	2,928	18,741.1	3,683.6	14565.73

Source: BGI, Mineral Accounts

Table 6: Resource rents from major minerals (Pula million, current prices)

	Diamonds	Copper-nickel	Coal	Gold	Soda Ash
1994	2,000.4	176.6	3.1	n/a	169
1995	2,359.3	234.5	1.8	n/a	270
1996	3,467.7	286.6	2.1	n/a	86
1997	4,257.2	180.2	6.3	n/a	90
1998	4,296.6	125.8	5.6	n/a	112
1999	5,883.1	233.5	3.9	n/a	124
2000	7,498.7	347.3	2.9	n/a	106
2001	7,909.5	167.6	1.2	n/a	121
2002	7,206.8	241.0	-0.1	n/a	131
2003	6,571.8	294.8	0.1	n/a	90
2004	7,097.4	754.2	-1.1	n/a	81
2005	10,783.3	1,104.6	2.8	66.5	142
2006	11,915.2	2,540.3	1.2	135.6	181
2007	11,783.7	2,226.1	-0.4	66.4	229
2008	12,979.7	-1,105.5	-9.7	151.1	219
2009	5,134.4	-1,085.2	-50.5	-2.6	218
2010	10,086.6	-972.0	-121.5	176.7	154
2011	17,261.0	-2,082.5	-284.7	257.3	289
2012	11,421.1	-2,230.9	-294.2	326.5	347
2013	15,202.7	-2,061.0	23.4	50.9	441
2014	22,215.6	-2,143.0	-309.4	-56.2	509
2015	15,078.9	-1,417.8	-308.8	11.7	588.9

Source: BGI, Mineral Accounts

4.2.2 The value of mineral assets

One of the important outcomes of mineral rent calculations is the ability to value unexploited mineral assets. The economic value of any mineral in the ground is equal to the flow of future income that it can generate. Income, in this case, is the rent that will be generated, over and above the costs of producing the mineral (i.e. the costs of turning it from a sub-soil deposit to a marketable commodity). Making such a valuation depends on many unknowns, including: future mining costs and minerals prices; the pace of future exploitation (production); and the proportion of saleable reserves.

The formula for calculating the net present value of the mineral deposit is as follows:

$$NPV = \frac{R.X((1+r)^n - 1)}{r(1+r)^n}$$

where: *R*=per unit rent; X=annual output; r=real discount rate; and n=lifetime of deposit.

Thus, the following resource valuations are derived:

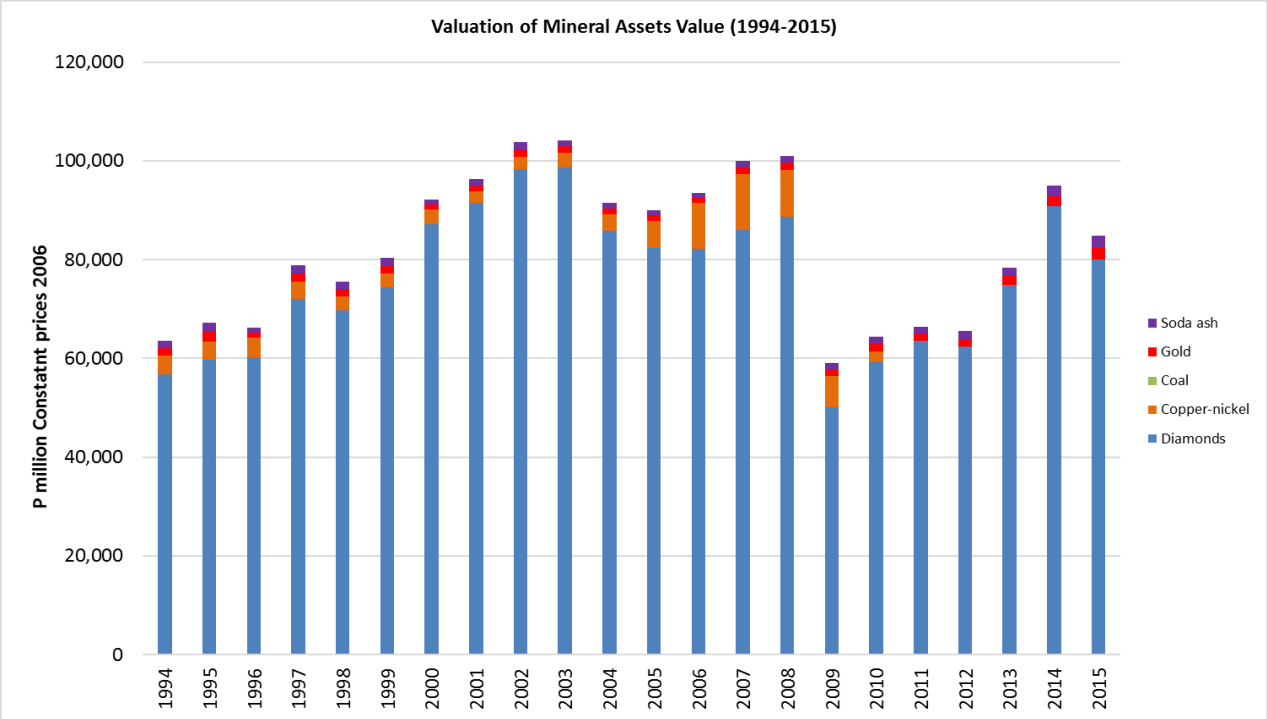
Table 7: Net present value of mineral reserves (2015)

Mineral	Resource rent per unit of production (5yma, P)	Life of mine (years)	Net present value of reserves (Pula million)
Diamonds	15,078.9	49.3	135,568
Copper-nickel	-1,417.8	28.8	0
Coal	-308.8	19,756	0
Gold	11.7	11.8	392
Soda ash	588.9	35.8	4172
Total	**13,952.9**		**140,132**

Source: BGI, Mineral Accounts

Coal and copper-nickel reserves are valued at zero because of the negative calculated resource rent. This illustrates the point that the economic value of an unexploited mineral asset is zero if it cannot be mined profitably. The mineral asset value from 1994 until 2017 is shown in figure 11 below.

Figure 11: Valuation of mineral assets, 1994- 2017 (constant 2006 prices)



Source: BGI, Mineral Accounts

The value of unexploited mineral assets rose steadily from 1994 until the time of the global financial crisis in 2008, which caused a sharp drop in the value of mineral assets due to the impact on prices. Since that time, there has been some recovery but the value of mineral assets remains below the peak in 2003. This is partly due to price effects as well as reduced production levels. A sharp rise in 2014 is due to additional diamond resources in Orapa, after which the value goes back to normal in 2015.

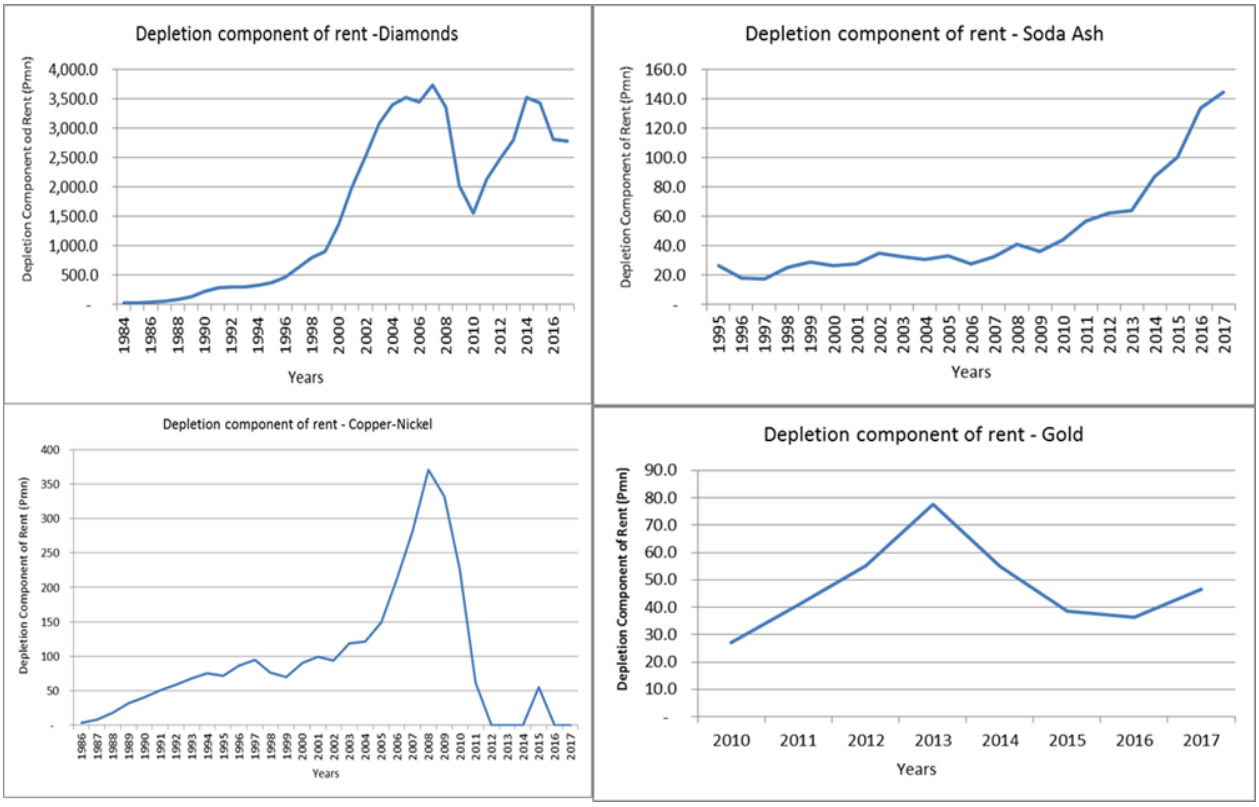
5. Mineral depletion

Notwithstanding the fluctuation in the value of mineral assets from year to year, the extraction and sale of minerals necessarily involves the depletion of an asset. This may or may not be offset by other developments, such as new discoveries or price changes. However, it is necessary to calculate the depletion component of mineral consumption as part of the mineral accounts, in order to provide input data for the calculation of Adjusted Net National Savings (ANNS) under the SEEA. In this methodology, resource rents in a given year are divided between a depletion component and a return (income) component, according to the following formula:

$$Depletion = \frac{RR}{(1+r)^n}$$

where *RR* = annual resource rent, r = chosen discount rate, and n = lifetime of mineral deposit (to exhaustion). The remaining portion of the resource rent is the income component. Hence the depletion component gets larger as the remaining lifetime of the deposit gets shorter. The depletion component by commodity is shown in Figure 12.

Figure 12: Depletion component of rent by commodity

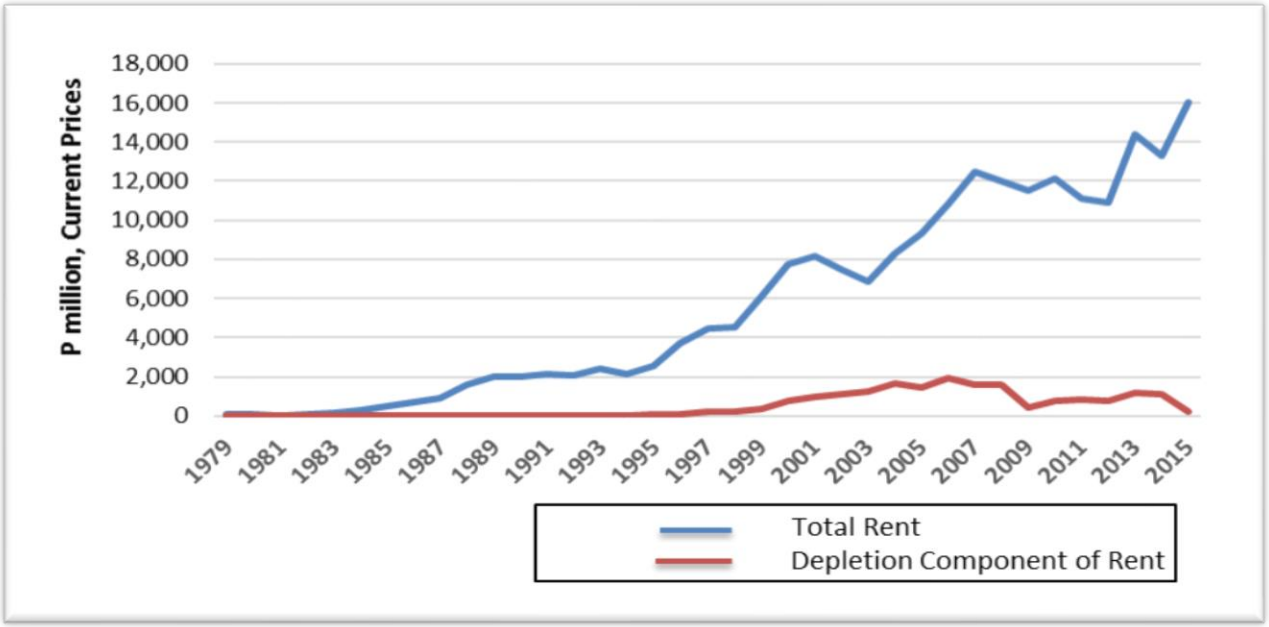


Source: BGI, Mineral Accounts

Diamonds exhibit an increasing depletion component from 1994 through 2007, in line with the highest extraction period. Thereafter, the depletion component decreases until 2010, which corresponds to the decreasing extraction rate and increasing reserve size. The depletion component then rises sharply until 2014, mostly because of increased extraction resulting in decreased reserves. After 2014, the depletion component decreases, reflecting an increase in reserves until.

Soda ash maintains a nearly constant depletion component between 1995 and 2009, clearly showing that the reserves are being replenished. From 2009 until 2015, however, there is an increasing depletion component, indicating declining reserves due to increased production. Copper-nickel shows an increase in the depletion component between 1986 and 2008, even though its reserves were increasing. This could be due to volatile copper-nickel prices. The depletion component then drops to zero along with the net present value, except for a slight increase in 2015. With coal, the depletion component cannot be measured because the mineral value is zero. Meanwhile, gold has the shortest time series and very little can be derived from it. Generally, gold reserves are decreasing and the depletion component is increasing. In aggregate, the lifespans of Botswana's mines (notably diamond mines) are relatively long, while the depletion component is relatively small (Figure 13).

Figure 13: Total rent versus depletion component of rent



Source: BGI, Mineral Accounts

6. Conclusions

The following conclusions can be derived from the 2015 mineral accounts report:

- Diamonds contribute the most to the country's mineral assets, making up by 97% of its value, followed by soda ash at about 3% and gold at less than 1%. The contributions of copper-nickel and coal are not significant compared to other mineral assets.
- Diamond mining reached maturity in 2006 with the highest production level. In 2015, there is a decrease in production despite an increase in reserves. An increase in production will clearly depend on favorable commodity prices and increased demand.
- The life of diamond mining in Botswana has been extended to more than 50 years due to the new discoveries made by Debswana in 2015.
- Soda ash mining is estimated to continue for the next 35 years, provided the extraction is kept constant relative to the available reserves. Should production increase, its reserves will be depleted faster.
- Gold reserves are being depleted and mining of this mineral will only go on for the next 13 years.
- Irrespective of its huge resources, coal is not generating any value.
- Copper-nickel has been mined without any profit between 2008 and 2015, as it is very sensitive to changing commodity prices. However, the situation may change if the newly established Khoemacau copper silver mine in the northwestern can perform better once mining begins.

7. References

Anglo American (2015). Ore Reserves and Mineral Resources Report. Anglo American plc.

Chatupa, J.C., (1991). Notes accompanying the revised inventory of the coal resources of Botswana. Geological Survey of Botswana, Unpublished report.

Department of Mines (2015). Mineral Production Statistics.

Jefferis, K. (2016). Economic Accounting of Mineral Resources in Botswana. WAVES Technical report.

McKelvey, V. E. (1976). Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey. United States Government Printing Office, Washington.

Statistics Botswana (2016). Gross Domestic Product. © Statistics Botswana.

Grynberg, R. (2012). Coal Exports and the diversification of Botswana's Economy. BIDPA Publication Series.

Wood Mackenzie, W. (2011). Government of Botswana –Coal Resource Monetization Strategy Options Study –The paths to monetizing the coal resource. Consulting government related advisory.

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