

Angola Diamonds Alluvial Deposits Cut-off Exploitation Value

Adriano Cauanda Xavier

Adrianoxavier1989@gmail.com

Instituto Superior Técnico, Universidade de Lisboa

Dezembro, 2017

Abstract

The factors of economic and operational analysis, are fundamental to assess the feasibility of a mining project. On the other hand, the economic horizon tax in operational terms is short term for planning, not taking into account the time value of money.

The economic evaluation of a mining project is a process ever more demanding and multidisciplinary approach. The activities involved are exposed to greater risk, due to the high capital to invest and the uncertainties associated with reservations. In the case of diamond projects, the existence of a general summary indicator of profitability (cut-off value) is essential for a preliminary assessment of the economy of a project, since it allows you to make forecasts of costs and revenues.

The thesis dissertation aims to estimate the value of a general summary indicator of the profitability of the exploitation of alluvial deposits of diamonds in Angola. Since the deposits of diamonds contain their own populations of diamonds, the average value of the diamonds contained a reservoir varies naturally, a tighter range (Mitchell, 1986).

To reach the desideratum, you will need to compile existing data and available for each project chosen to check if an overview, it is economic to exploit a determined alluvial reservoir in Angola. At the end will be the validation of results obtained with other projects and international alluvial mining on kimberlite (for example the mine of Catoca-Angola).

According to the results obtained, the cut-off value in a typical alluvial diamond mine in Angola is situated around 100 USD/m³, a value that compares to the 80 USD/m³ prevailing in the kimberlitic Catoca mine (a mine with high operational costs when compared with other kimberlite mines).

In fact, the SOMILUANA mine has cut-off values higher than 100 USD/m³, an apparent contradiction. This mine's cut-off values are higher the suggested typical value, as its costs are unusually high due to the high overburden removal costs (typical of Calonda Formation deposits). It is even possible that

a rational, complete and sustainable exploitation in deposits with lower overburden thickness (e.g. flood plains and riverbed deposits) attains cut-off values of 50 or even 40 USD/m³, as the prices of gravel and sand sold outside Luanda seem to suggest.

Key words: cut-off value; economic evaluation; profitability; uncertainty; investment.

1. Introduction

The discovery of the first Angolan diamond occurred in November 1912 in Rio mussulala - Lunda North. In the same year was constituted the PEMA (Companhia de Pesquisas Angola Mining). The first explorations had place in the river Chicapa and its tributaries. In October 1917 was created the Diamond Company of Angola (Diamang), with the aim of discovering and exploring diamond deposits. From that date the bet in exploration has to be a priority, having resulted in the discovery of several diamond deposits. These findings allowed a rapid growth of the Angolan diamond production, until the constitution of Endiama in January 1981, which replaced totally and definitively the Diamang in 1988. Angola is today a major worldwide producer of diamonds.

This dissertation describes the Angolan diamond industry, with emphasis on their cost of production, the current market situation of diamond, its perspective and opportunities. It shall be calculating the cutoff value of alluvial mines (secondary deposits - Somiluana mines), analyzed.

The rational exploration, complete and sustainable use of alluvial deposits of diamonds (for which this thesis aims to contribute) is an opportunity for the creation of employment, development of infrastructure, training of human resources and wealth creation in the interior of Angola, fostering social and economic balance in the country.

1.1. Formulation of the Problem

We are witnessing today in Angola, a wave of alluvial exploration projects of small and medium-sized enterprises, with very limited technical and economic capacity (cooperatives). The existence of a summary indicator (cutoff - value) general profitability is useful for a preliminary assessment of the economy of a project. Taking into account the reality of projects of exploration of alluvial diamond the question that arises is: What is the threshold (cut-off value) from which is, in a general way, economic to explore an alluvial reservoir in Angola?

The need to use the cutoff value (and not the classic fat cut, *cut-off grade*) is due mainly to the fact that the deposits of diamonds contain their own populations (specific) of diamonds and therefore have very different valuations. As the individual stones, the average value of the diamonds contained a reservoir can also vary greatly, for example:

- (Catoca kimberlite): 80 to 90 USD/ct (Catoca data);
- Lulo (alluvial, very near to the primary source): > 2,500 USD/ct;
- Some primary deposits (Ex: kimberlite of Camatchia) contain more than one population of diamonds in zones or distinct facies, with very variable values;

2. Variety and Applications of Diamonds

The first classification of diamonds - based exclusively on its weight, since this was the only important factor in trade. However, with the advance of science and technology and the need to preserve the "rarity", other physical criterion were adopted with the passing of time. The formulation of the criterion of classification or valuation to be followed by traders, then became essential. In addition, the unification and standardization of the nomenclature of these criterion or rule were decisive for that they become practical and reliable.

The more simplified classification divides the diamonds into two groups, namely:

- 1) **Diamonds gemstones:** are endowed with special properties appropriate to be stoned. Levinson et al (1992, apud Zolinger, 2000, p.147) formalized this classification into diamonds Cuttable and industrial type.
- 2) **Diamonds Industries:** which gathers all the stones devoid of quality to be used as gemstones.

The Price (USD/ct) of diamonds on the market in addition to the correlation between demand and supply, it has been determined by four essential factors of evaluation, called 4C, namely:

- ❖ **Carat** weight: weight is the simplest and most characteristic old to determine the value of the diamond, is a valuable factor for a diamond, the greater the diamond, the greater is the unit price proportional to weight. The unit of measurement used is the carat (ct) equivalent to 0,2g.
- ❖ **Color** (Color): The evaluation of the color involves decisions on how the color of the stone approaches *colorless*. However, the majority of diamonds have traces of the colors yellow and brown, yellow being the color more frequent among natural diamonds, except the fancy color (blue, pink, violet, orange and red), the colorless are the most valuable (M.King, Moses, & Jmes e.shigley, 1994). During the assessment must observe the color depth, which is a combination of tone and saturation.
- ❖ **Clarity:** small traces of other minerals covered during the training process, designated as inclusions. The inclusions interfere with the visibility of certain optical properties of yolk, such

as reflection and refraction, inclusions are detrimental to the purity of a diamond, diminishes the value of the rock once that determines its final use. The impact of the imperfections in the value of the diamond depends on its position, being irrelevant if you are located in the irregular surface of the gem (will be easily eliminated during the process of stoning), (Chambel, Caetano, & Reis, 2013)

- ❖ **Cut** (stoning): The stoning allows you to remove the diamond maximum brightness and better dispersion. The value of the impact of a specific form is directly related to its impact on the yield of stone in the process of stoning. It is the form of stone which, in conjunction with its dimensions and their internal imperfections, determine the final utilization of the diamond after the stoning, and consequently its value to be used in jewelry.

2.1. Angolan Diamond Sector

The bet on agriculture and secondary sectors (industrial) and tertiary sector (retail and services) is important and fundamental to the development of the country, but it is, however, the mining sector in special sub-diamond industry which, in the first phase (next decade) presents the potential immediate and sufficient for sustainability of the Angolan economy and help leverage other sectors aiming at economic diversification, which the country so urgently needs. It is in this sector that there is already an important human and material basis on which the country can develop relatively quickly, an additional production capacity (at least partially) to minimize the impact of the decrease of revenues of oil extraction.

Angola has an extensive diamond reserves estimated at 180 million carats. They are located mainly in the provinces of Lunda North and Lunda South and northeast of the country. The Angolan diamond sub-sector is led by the Society mining of Catoca, with a share of 84.4% in volume and 61.7% in value, this mine is in a mature phase of your life (SM Catoca, 2015).

2.1.1. Present situation

The Angolan economy depends on the exploration of petroleum resources and diamond. The diamond production has evolved successively given the control of concessions by the Ministry of Geology and Mines in Angola. We have to bear in mind that the Ministry only controls, in this case, approximately 70% of holdings, given that the gold miner control the remaining percentage, probably with more than 350 thousand prospectors, although the tendency is the decrease in the control of the gold miner. During the last years the Angolan production was growing, even with fluctuations in average price of diamonds, gross revenues amounted to 1.08 billion dollar and the tax revenues from commercialization of diamond in 2016 was 77 million dollars, having as exporting countries: United Arab Emirates, Israel, Belgium, Switzerland and China - **Table 1** Presents the indicators of marketing

and production in the year 2016.

Table 1 - Production and marketing indicators during the year of 2016 (Endiama, 2017).

Description	Carats	Average Price	Gross revenue (US\$)	Taxes & Fees
Industrial production	8,662,586.75	114.81	994,572,894.73	74,592,967.10
Artisanal production	358,880.30	236.40	84,838,464.84	2,120,961.62
Total	9,021,467.05	119.65	1,079,411,359.57	76,713,928.73

It is necessary to mention that the diamonds explored in Angola have an excellent quality, transforming the country into a key player in the world market of diamonds, being already placed worldwide in fifth position in the ranking in terms of value.

The **Figure 1** illustrates the behavior of the price of the diamonds in Angola over the past ten years, having its lowest value in the year 2009, a difficult phase for the market of diamonds in the world due to the economic recession.

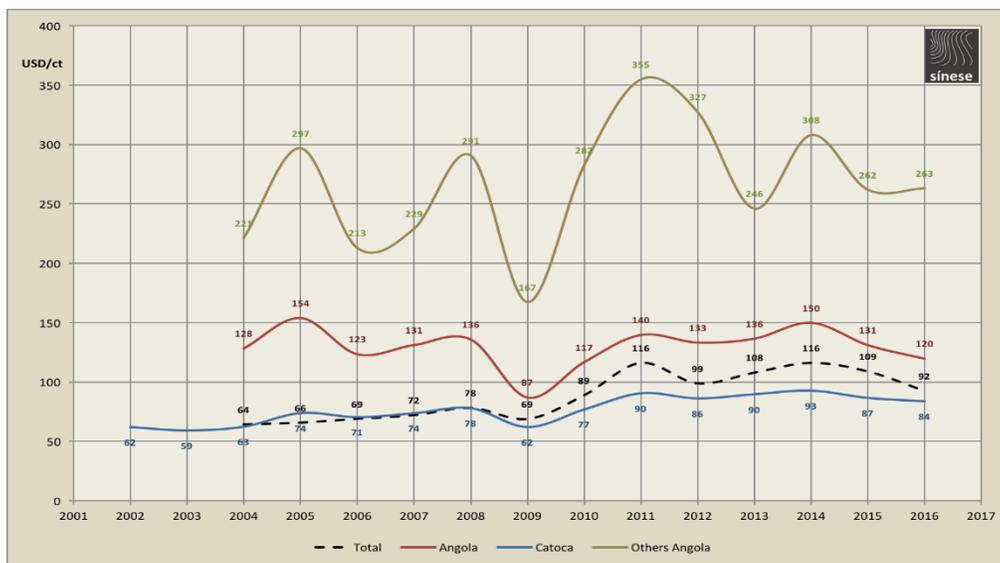


Figure 1

The exploitation of Angolan diamonds have two stages, one stage having the Diamang as monopoly (1917-1976), and the other phase with the Indiamina (state company) with responsibility for giving the follow-up to the work developed by Diamang is prospecting work, and the reactivation of mines. The Indiamina was created in 1976 in **Figure 2** - Shows the behavior of the cut-off grade content over the years.



Figure 2 - Evolution of cut-off grade (ct/m3) over the years (Diamang (1917-1976), Catoca (2003-2012) and Camatchia (2005-2012) (Chambel, Caetano, & Reis, 2013).

3. Methodology and data

Is not a simple task to estimate a general cut-off value for the alluvial deposits of diamonds in Angola:

- ❖ Scarcity of data, especially in alluvial deposits
- ❖ The variety of characteristics of deposits (waste/ore, for example)

In addition to the analysis of the results of Angolan alluvial mines (inferring the respective cut-off values), compare and will validate the results obtained with other Catoca - kimberlitos (Angola). To help calibrate the estimate of the cut-off value of alluvial deposits of diamonds, may have recourse to the value of sales of aggregates (gravel) in Angola. The data collected for this work include:

- ❖ Historical information (Angola):
 - Cutting content used in the definition of blocks of DIAMANG-0,20 ct/m3 (in situ);
 - Production Data and demonstration of DIAMANG results;
- ❖ Current Data (Angola):
 - Somiluana project (Trans Hex)- ALLUVIUM
 - Kimberlite (example - Catoca)

- ❖ For calibration and validation:
 - The average sale price of diamonds;

3.1 Results and Discussion

The comparison of technical and economic parameters between two mines that explored diamonds in different fields, is decisive for the understanding of the differentiation of the volume of iron ore produced, cut-off grade, operational costs, price and finally the cut-off value. From the comparative analysis it will know or identify the reasons for the existence of technical and economic bottlenecks and their nature.

The production indicators are important to the process of analysis of performance of a mine, but this performance is subject to factors of operational costs such as: technological factors, geological factors, economic factors.

The cut-off grade of the Catoca mine are clearly more height Somiluana - **Figure 3**.The production scale of the Catoca mine 15 times more than the mine of Somiluana- **Figure 4**.

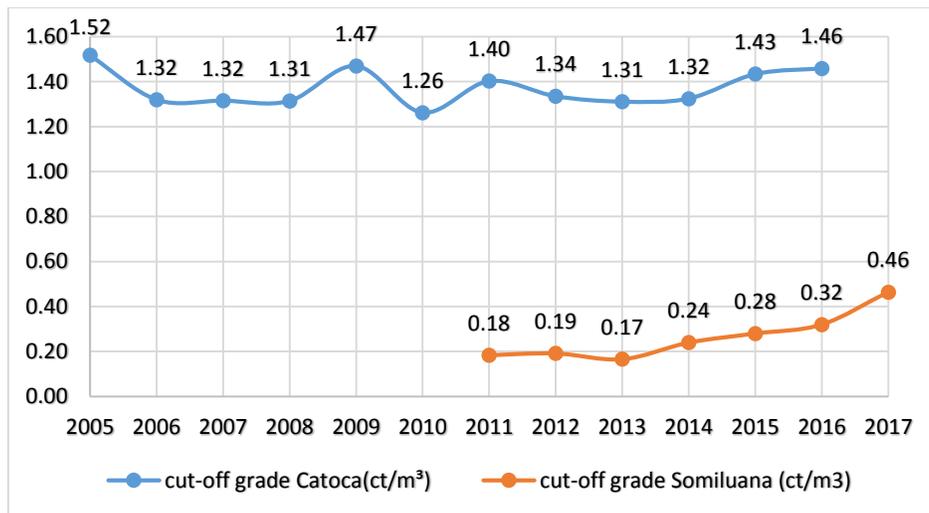


Figure 3 - Comparison between the cut-off grade of the mine of Somiluana and Catoca.



Figure 4 - Comparison between the ore extracted from the mine of Somiluana and Catoca.

Having regard to the scale of production and the type of reservoir from the Catoca mine total operating costs are much higher than those of the mine of Somiluana - **Figure 5**. The unit operating costs (per ton or m³ produced and processed), however, are much lower than in the case of Catoca.

The price of diamonds from alluvial mines has been very high in relation to the diamonds of mine kimberlítico. Due to the process of transportation that diamonds are suffering by water from rivers until your deposit, is a selective process, and the greater the distance at deposition of material, the greater will be the natural selection of the initial population of diamonds and, the less will be the proportion of diamonds with structural defects, and also greater will be your unit value of this natural phenomenon that at the base, the unitary value of alluvial diamonds as the mine of Somiluna than diamonds of kimberlite - Example Catoca - **Figure 6**.

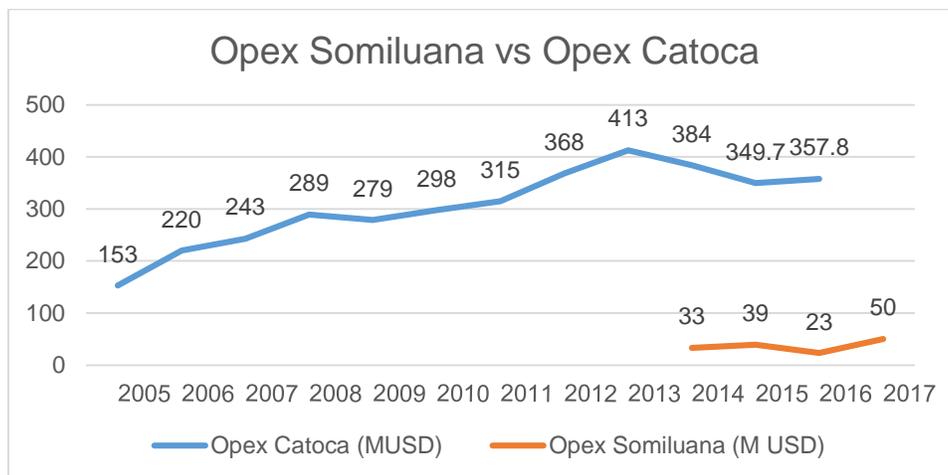


Figure 5 - Comparison between the operational costs of the mine of Somiluana and Catoca.

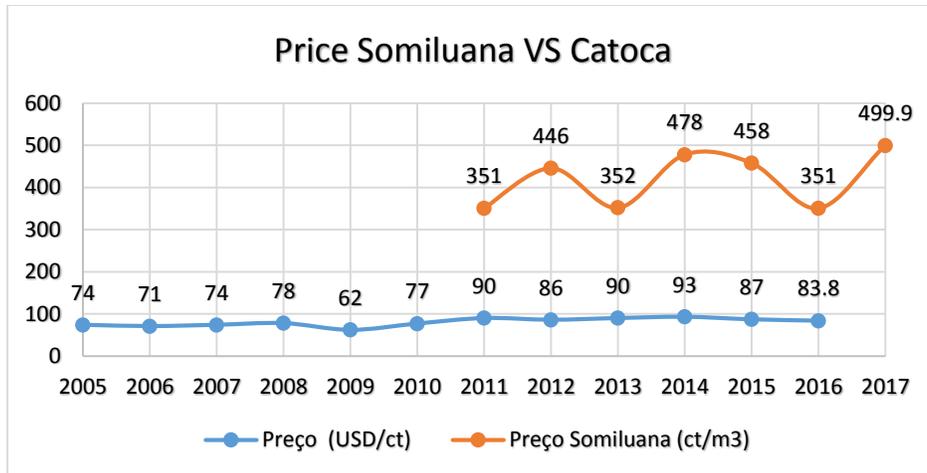


Figure 6 - Comparison between the prices of diamonds extracted from the mine of Somiluana and Catoca.

The cut-off value as a summary indicator of profitability is higher in the mine of Somiluna than in the Catoca mine as shown in **Figure 7** Due to geology and technology. These factors had a strong influence on the high cost for production of 1m³ of gravel mine of Somiluana. The Somiluana is to move their exploration to areas of high thickness of overlying cap rock in Calonda Formation. On the other hand, the technology that has been used to explore the diamonds in these areas is of high costs a lot. But even with very high costs in the extraction of diamonds, it is rewarding the extraction of diamonds in these zones, because the diamonds extracted in these deposits, are diamonds of quality and as a result have high prices in relation to the diamonds from the Catoca.

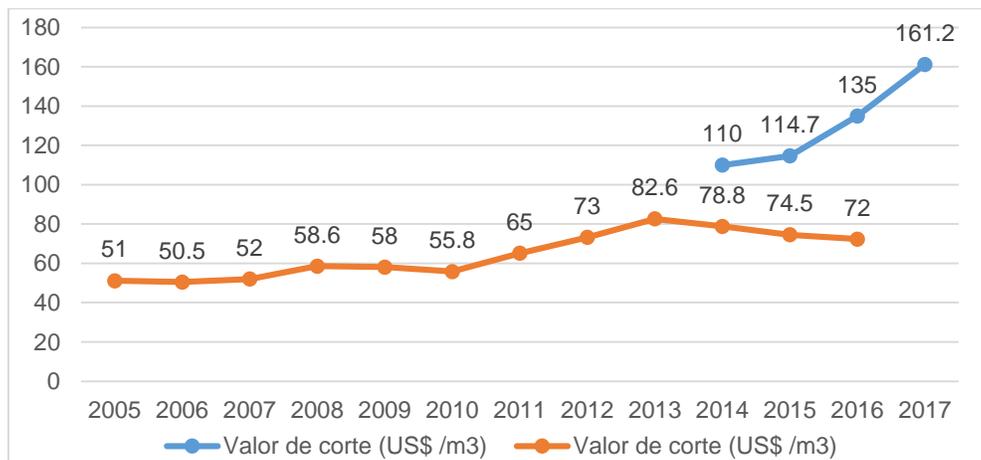


Figure 7 - Comparison between the cut-off value of production of diamonds from the mine of Somiluana and Catoca.

3.2. Final Considerations

According to the results obtained in this study, the cut-off value of an alluvial mine in Angola is around 100 USD/m³, which compares with around 80USD/m³ kimberlitic the Catoca mine (mine with operational costs high in international terms).

In reality the mine Somiluana has cut-off values superior to 100 USD/m³, which is an apparent contradiction. The cut-off value of this mine is higher than the suggested value as general already has very high costs of removal of waste (typical of exploration of Calonda Formation). It is even possible that a rational exploration, complete and sustainable reservoirs with lower coverage of waste (in the marshlands of rivers or in the riverbeds) has cut-off values were significantly lower, and may even be in cases ideals at values close to 40 to 50 USD/m³, as seem to suggest the values of sales of aggregates in the region of Luanda.

To evaluate the profitability of a mining project is not an easy task, because it is a demanding process and multidisciplinary approach, it is, in addition, a dynamic study, since the project variables change continuously. By means of economic evaluation techniques or economic indicators it is possible to assess the profitability of an investment.

The existence of a general summary indicator of profitability (cutoff value) was essential for a preliminary assessment of the economy of diamond projects studied, since it allows you to make forecasts of costs and revenues. The technical and economic constraints experienced by alluvial mines in Angola, can not viable the mining projects of this nature, the reason of survivals of alluvial mines, is the high price of diamonds extracted from this mine, guaranteeing them the compensation of the high costs of extraction.

References

- Chambel, L., Caetano, L., & Reis, M. (2013). *One century of Angolan diamonds*. Sínese & eaglestone. Lisbon: Sínese & eaglestone.
- Endiama, A. S. (2012). *Business opportunities in the SUB-SECTOR OF DIAMONDS IN ANGOLA* Luanda - Angola.
- M.KING, J., Moses, T. M., & Jmes e.shigley, Y. L. (1994). *Color Grading of colored diamonds in the GIA groans trade laboratory*. New York.
- Mitchell, R. H. (1986). *Kimberlites. Mineralogy, Geochemistry, and Petrology*.
- SM Catoca. (2015). *Annual Report*.