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Using the Discount Cash Flow Model in Preliminary Assessment for Gold Mine Projects

Helal H. Hamd_Allh, M.R. Moharram, Mohamed A. Yssin, A. Kh. Embaby

Abstract: ***This study aims to the examination of the economic potential for the Abu Marawat Gold Project (AGP) in the Eastern Desert of Egypt and prediction the decision about go/not-to-go to invest in the deposit location. Discount Cash Flow (DCF) model used to calculate the Net Present Value (NPV) for the proposed gold mine project. NPV calculated by taking the risk and uncertainty produced from geological and technical factors into account. The actual production and cost data for Sukari Gold Mine (SGM) of Egypt used a benchmark for the theoretical calculation for production and cost data of AGP. From the valuation processes for AGP the NPV for the project predominantly positive, so, the project is acceptable to investment. This study aims to the examination of the economic potential for the Abu Marawat Gold Project (AGP) in the Eastern Desert of Egypt and predicts the decision about go/not-to-go to invest in the deposit location.***

Keywords: ***Valuation, Economic potential, Abu Marawat gold project, Discount cash flow, Net Present Value***

I. INTRODUCTION

More than 110 gold deposits and occurrences are known in the Eastern Desert (ED) of Egypt. distributed in the ED, from Umm Balad in the north of ED to Wadi Allaqi in the south of ED. These area covers about 2073.83 km^2 from ED area. Some of important deposits in ED limited to three concession areas which Abu Marawat Concession (1,027km^2), El Fawakher / El Sid Concession (886.83km^2) and EL Sukari Concession (160 km^2). **Centamin** plc [1], **Matt** [2], **Wayne** [3], **Behre** [4].

All these areas one gold mine only is opening in the El Sukari Concession. Sukari Gold Mine (SGM) a successful model for the application of various technologies in the mining industry to create a modern and profitable gold mine.

When evaluating mining investment opportunities, one should consider the risks associated with mineral exploration and development. Risks associated with the valuation processes of the mineral resources contain technical risks, economic risks, and political risks. The technical risks are divided into the: reserve risk, completion risk, and production risk. The economic risks are divided into the: price risk, demand/supply risk, and foreign exchange risk. The political risks are divided into the: Currency convertibility, environment, tax, nationalization **Samis** [5] **Whittle** [6]. This study aims to make a decision about go/ or not for investing in the AGP, therefore, DCF models are proposed to give an economical vision about the project value through NPV for the project with analysis risk and uncertainty.

In this research, applied the income approach to evaluate AGP. Income approach contains the creating cash flow model and NPV calculation. DCF model result from the income approach depends on empirical formula and prediction for cost and production data. Also, in this research, use the actual cost and production data for SGM to know the logicality of calculated results for the AGP.

Study importance is the valuating of AGP in the ED to take a decision about extend in the exploration works and continues to development a gold mine projects in this location or no. Also, study gives the investors an economical vision about the project profitability and loss over the future time. From these valuation processes and the examination of economic potentials of gold deposit in AGP is put the limit for economical or not for the deposit under study and forecast the merit of the proposed gold mine project in AGP.

- GEOLOGY OF ABU-MARAWAT AND SUKARI GOLD DEPOSITS

The Sukari gold deposit is located in the Central Eastern Desert of Egypt at 24º 56’ 50” N 34º42’27” E, about 23 km southwest of the Red Sea coastal town of Marsa Alam. Sukari gold deposits located in the Arabian-Nubian Shield (ANS).

The Sukari felsic porphyry outcrop is located in an easterly dipping sequence of andesite flows, serpentinites and associated volcanoclastic sediments, mainly tuffs and epiclastics. It strikes for 2.3 km and is 100 to 600 m thick. It forms a jagged-toothed, strong topographic high up to 250 m above wadi level (390 m MSL). Wadi drainage plains pass to the east and west of the outcrop, and the sharply incised green – brown Red Sea Hills surround that **Centamin** [1].

Abu-Marawat is accessible by a 26-km long desert track south of the Safaga–Qena asphalt road 400 km south-southeast from Cairo figure 1. The Abu Marawat deposit is situated at 26°30’30” N latitude and 33°39’00” E longitude. **Klemm** et., al. [7]. Abu Marawat area situated in the Central

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* Correspondence Author

Eng/ Helal H. Hamd_Allh*, Mining and Petroleum Dept., Faculty of Eng., Al-Azhar University, Qena, Egypt. Email: helalahmed.2038@azhar.edu.eg

Prof. M.R. Moharram, Mining and Petroleum Dept., Faculty of Eng., Al-Azhar University, Cairo, Egypt. Email: moreda_45@yahoo.com

Prof. Mohamed A. Yassin, Mining and Petroleum Dept., Faculty of Eng., Al-Azhar University, Cairo, Egypt. Email: m_a_yassin@yahoo.com

Assoc. Prof. A. Kh. Embaby, Mining and Petroleum Dept., Faculty of Eng., Al-Azhar University, Cairo, Egypt. Email: abdoembaby_72@yahoo.com

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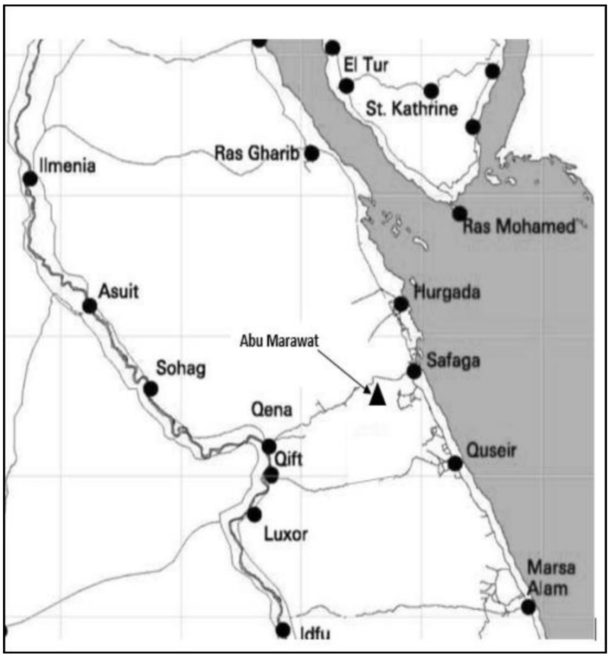

Figure 1. Location map for AGP in Egypt.

Eastern desert, Egypt, and ANS. The Gold mineralization is hosted in finely brecciated quartz vein material.

The area containing the Inferred Resources encompasses parts of the CVZ and FIN veins as showen figure 2 a pair of subparallel, steep and easterly dipping, north-northwest trending, gold-copper quartz veins that are spaced about fifty to a hundred meters apart. The vein system is surrounded by hydrothermally altered, felsic metavolcanic rocks and is located at the contact with rhyolite and a layered ultramafic unit to the east. A north-south trending,

one- kilometre long diorite body has been intruded into the ultramafic **Wayne** et., al. [3].

Ancient Egyptians and Roman geologists have exploited the area for gold. The ancient workings cover an area of about 1 km^2 northeast of Wadi Abu-Marawat, a tributary of Wadi Samna, and the largest workings are located along the eastern part of the old mining site (**Safwat** et.,al. [8], **Hassanein** [9].

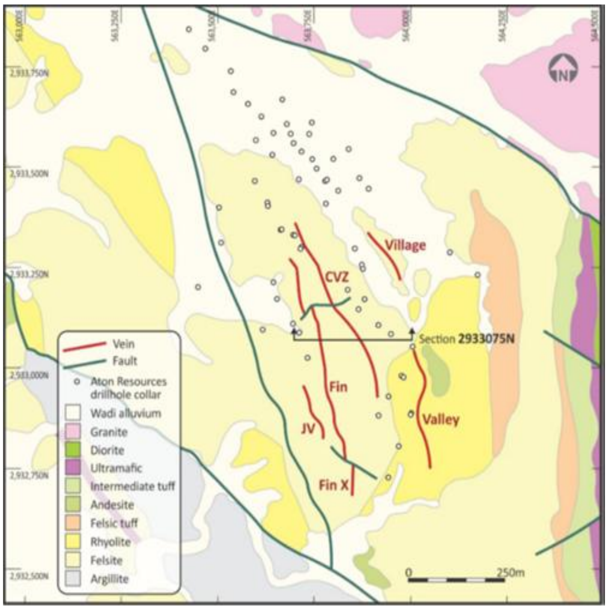

Figure 2. Geologic map of the AGP After Aton Resources Inc.

From the geological condition and geochemistry for Sukari and Abu Marawat gold deposits and similarities between gold deposits in two areas this guide to use the same mining method and the same processing technology used in the SGM. Using the value of operating cost applied to SGM is logical to apply on AGP with a slight difference producing from other factors.

II. METHODOLOGY

➢ DCF model created by using a prediction method to predict cost and production information for the study projects. Steps for DCF Model building for AGP contain:

➢ Calculate the Mine Life (ML) and Production Rate (PR) by using the Taylor-Formula.

➢ Capital Expenditure (Capex) and Operating Expenditure (Opex) Estimates by using multi-methods.

➢ The above-calculated values were compared with the actual value for SGM.

➢ DCF Model building for Abu-Marawat Gold Project using Excel sheet. Finally,

➢ Sensitivity analysis achieved by a change value of the economic factors such as the price of the commodity, capital and operating cost.

III. RESULT AND DISCUSSION

The following section discusses using DCF models to valuation of Abu Marawat Gold Project.

1. Calculation the ML for AGP at base case Cut-Off Grade (COG) 0.5 gr/t

Tonnage of mineral resources for AGP it's have Inferred mineral resources. Inferred Resource: ±25 to 15 % (at 90 percent confidence limits) **Noppé** [10]. Confidence percent taken ±25 to 15 %, according to Inferred mineral resources for Abu Marawat gold deposits. The gold mineral resources in AGP will be increased with continues in the exploration processes. In Sukari gold deposits the mineral resources developed from 26.39 Mt measured and Indicated mineral resources in 2002 to 257 Mt in 2016.

At COG = 0.5 gr/t. ore Resources Tonnage:

2.9 Mt @ 1.75 g/t Au, 29.3 g/t Ag, 1.15 % Zn and 0.77 % Cu, containing 162,000 oz Au, 2.7Moz Ag, 73M lbs Zn and 49 M lbs Cu (Alexander Nubia, 2015)

Calculation of ML using The Taylor-Formula at Base Case COG = 0.5 gr/t

$$\mathbf{ML\ \ in\ Years} = \mathbf{6.5} * \sqrt[4]{\boldsymbol{tonnage}(\boldsymbol{in\ million\ tonnes})}$$

(**Wellmer**, et., al. [11] (1)

Life of Mine in Years = $\mathbf{6.5} \times \sqrt[4]{\mathbf{2.9}} \approx \mathbf{10}\ \boldsymbol{years}$.

The mine life will be increased with increase in the exploration work with taken in consideration the ore body extent in the strike length and depth.

2. Production Rate Calculation

Production rate by ton/year calculated in AGP according to:

$$\text{PR} = \frac{\textbf{Ore Resources Tonnages}}{\textbf{Life of Mine in Years}} = \frac{\mathbf{2,900,000}}{\mathbf{10}} = \mathbf{290,000}\ \boldsymbol{ton/year}$$

According to calculations:

$$\text{PR} \approx \mathbf{290,000}\ \boldsymbol{ton/year} \approx \mathbf{1000}\ \boldsymbol{ton/day}.$$

In the preliminary assessment PR rate as a constant over the mine life. PR is growth over the mine life because in actually PR is changeable according to operating process and PR is growth over the mine life

3. Capex Estimation for AGP Using deferent approach

a. Historical Method

This approach is well described by **O'Hara** [12]. The relationship between the costs can be expressed as follows:

Capex = constant X (production rate) 'power' (3)

$$= \boldsymbol{A} \times \boldsymbol{C}^{0.6} \quad (4)$$

(**Richard**, *et.,al*, [13], **Wellmer**, *et. al.* [11], **Allen** [14].

Where A is constant = 750,000 and "C" is capacity in a t/day.

∴ Capex for AGP = $\mathbf{750,000} \times \mathbf{1000^{0.6}}$ **=USD\$ 47,300,000.**

b. Capacity adjustment (scaling) method based on the SGM criteria

This method proposed to applied scaling method according to the following:

$$\frac{Cos\ of\ SGM}{Cos\ of AGM} = \left(\frac{\text{capacity}\ of\ SGM}{\text{capacity}\ of AGM}\right)^{X}$$

Where (x) is exponential factor is equal 0.6, and capital cost for SGM = USD\$ 265,313,000, according that:

$$\text{Capex for AGP} = \mathbf{265,313,000} \times \left(\frac{\mathbf{290,000}}{\mathbf{5,000,000}}\right)^{\mathbf{0.6}}$$

$$= \textbf{USD\$ 48,063,492.}$$

c. Proposed approach according to stripping ratio criteria

From table 1 a Stripping Ratio (SR) for AGP (1:5.8) and SR for SGM = 1:4.9 according that:

Total material movement from SGM = 30 Mt/y.

Total material movement from AGP = 2 Mt/y.

Total material movement for AGP = 1/ (15) from total material movement for SGM, so the proportional mining capital cost for AGP = $\frac{\mathbf{92,800,000}}{\mathbf{15}} \approx$ **US\$M6.2** Where, US\$ 92,800,000 is the mining capital cost for SGM in 2009.

Also, cost of the process plant, cost of on-site infrastructure, and cost of off-site infrastructure can be estimated by the same method depending on the using the same processing method, from the table 1 PR delivered to a processing plant in AGP = 1 / (15) from PR for SGM. Thus, the cost of the proposed process plant and infrastructure = **193,013,000/15** ≈ US\$**13,000,000** Where US\$ **193,013,000** is the process plant and infrastructure for SGM in 2009.

From the above results which deduced from comparative between two projects:

Total capital cost for AGP = Mining Capital Cost + Cost of Process Plant and Infrastructure = **6.2 + 13 ≈ US\$M19.2** according to year of 2009.

Calculate capital cost for AGP according to year of 2020 using the following formula:

Capex for AGP (2020) = Capex (2009) × (1+average inflation rate)^{n} **Richard** *et.,al*, [13] (6)

Capex for AGP (2020) = 19.2 × 1.08^{11} = US\$M 44.80.

The above calculation for capital cost for AGP there is rapprochement in Capex value produced from the various method.

4. Opex Calculated Using Cut-Off Grade Equation

The main categories of Opex or Cash cost of production are: (i) mining, (ii) processing, and (iii) G&A.

COG × NF ×ε × Price = 0.5 × 0.98 ×0.87 × 40.54 = 17.28 US\$/t

(7)

Where, NF-factors is the Fluctuation of mine returns = 98 % for precious metals.

ε is the recovery percentage of gold from ore. (**Wellmer**, *et.*, al. [15].

Another method for calculation of opex.

COG = *Opex* ÷ price ∴ *Opex* = cut-off × price

***Opex* = 0.5 × 40.00 = 20.00 US\$/t** (8)

Taking Opex (20 US\$/t)

Table 1: Comparative between SGM and AGP according to economic and technical criteria's.

Comparison criteria's	Units	SGM (Actual)	AGP (Prediction)
Mineral Properties	----	Production Properties	Exploration Properties
Resources category	----	Measured	Inferred
Tonnages of resources	Mt	244	2.90
Grade	g/t	Au, 1.02	**1.75** g/t Au, **29.3** g/t Ag, 1.15 % Zn 0.77 % Cu
Mine life	years	+20-year	Proposed: 10-year
Operating cost	US\$/oz	(675-725)	(350-400)
All in sustaining cost	US\$/oz	(890-950)	≈ (850)
Capital cost	US\$M	267.5	47.30
Operating cost	US\$/t Mined	1.98	1.10
Processing cost	US\$/t	12.5	12.5
Stripping ratio	O/w	1:4.9	1:5.8
Total Material Movement	Mt/y	≈ 30	2

From the above calculation and table (1), the operating cost for proposed AGP ranged from 17.28 US\$/t to 20 US\$/t this corresponds (350-400) US\$/oz. Actual cash cost of production for SGM (675-725) US\$/oz in 2019.

Table 2: Predicted Cash flows model before tax for AGP.

Year			1	2	3	4	5	6	7	8	9	10	10
Production	Production	t		300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Grade	Grade	Au, g/t		1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
		Ag, g/t		29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Recovery	Gold Recovery			0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
	Silver Recovery			0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Gold Production	Gold Production	Oz		14,685	14,685	14,685	14,685	14,685	14,685	14,685	14,685	14,685	14,685
Silver Production	Silver Production	Oz		127,174	127,174	127,174	127,174	127,174	127,174	127,174	127,174	127,174	127,174
Gold Price	Gold Price	US$/Oz		1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250
silver Price	silver Price	US$/Oz		18	18	18	18	18	18	18	18	18	18
Revenue, US$m	Revenue, US$m	Gold		18,356,348	18,356,348	18,356,348	18,356,348	18,356,348	18,356,348	18,356,348	18,356,348	18,356,348	18,356,348
		Silver		2,289,136	2,289,136	2,289,136	2,289,136	2,289,136	2,289,136	2,289,136	2,289,136	2,289,136	2,289,136
Total , Revenue	Total , Revenue			20,645,484	20,645,484	20,645,484	20,645,484	20,645,484	20,645,484	20,645,484	20,645,484	20,645,484	20,645,484
Capital Cost	Capital Cost	US$m	47,300,000										
Operating Cost	Operating Cost	US$/t		20	20	20	20	20	20	20	20	20	20
Total Operating Costs	Total Operating Costs	US$m		6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
Royalty		3%		619,365	619,365	619,365	619,365	619,365	619,365	619,365	619,365	619,365	619,365
Gross Profit	Gross Profit	US$m	-47,300,000	14,026,120	14,026,120	14,026,120	14,026,120	14,026,120	14,026,120	14,026,120	14,026,120	14,026,120	14,026,120
PV	PV	US$m	-47,300,000	12,987,148	12,025,137	11,134,386	10,309,617	9,545,941	8,838,835	8,184,106	7,577,876	7,016,552	6,496,807
NPV (USD)	NPV (USD)	US$	46,816,406										
Discount Rate	Discount Rate	0.08											
R (1+r)	R (1+r)	1.08											

The decrease in operating cost/oz in AGP due to Au, grade in AGP more than Au, grade in SGM this increase the gold production from the proposed gold mine in AGP. Also, in the table 1 processing cost for AGP equal processing cost in SGM (12.5 US$/t) based on the similarity between ore types in the two areas and which supposed to using the same processing methods. Hence opex for AGP can be calculated according to the comparison with SGM:

Opex for remove one-ton rocks from SGM = 1.98 US$/t.

According to SR for AGP (1:5.8) ∴Produce 1 ton of ore needs to remove 6.8 tons rocks. ∴ Opex to remove one-ton ore from AGP = 1.98 × 6.8 = 13.5 US$/t. according that:

Total operating cost = 13.5 + 12.5 = 26 US$/t, where is 12.5 is the processing cost. There is variance about 23 % between prediction and compared opex for AGP this is accepted variance because it is less than 25% the percentage accuracy of these valuation processes.

Table 2 shows the DCF model after applied some discounts like royalty on the cash flows. Under the concession agreements, are exempted from customs duties, any taxes, levies or fees or sales taxes so in the cash flow model royalty 3% is discount from the gross profit. The gross profit after discount royalty equal US$M 14 in a year and NPV equal (US$M 46.8). The NPV is positive so the project is accepted.

5. Sensitivity- Risk Analysis

Sensitivity analysis aimed to know the limits of profitability and losses for the studied project by applied the change of economic factors in DCF model likes price, capex and opex. In table 4 the value of economic variables used in risk analysis and its effect on the NPV are summarized. From table 4 the NPV affected by changes in economic parameters like price, capex and opex. Effects produced from the price of the commodity on NPV more than effects from opex and capex. The maximum value of NPV equal (USM$ 87) at price + 30% (1625 / 23.4 US$ / oz of Au/Ag) in sensitivity analysis results, also the minimum value of NPV equal (USM$ 6.4) at price - 30% below the price of the base case. From the sensitivity analysis NPV is positive in all conditions this indicate the AGP is profitable with the changing in the opex and capex by increase and price by decrease.

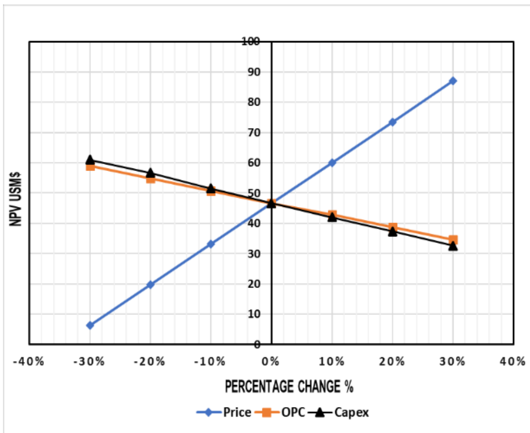

Figure 3. Change in NPV with change in economic parameter.

From figure 3 the relation between the commodity price and NPV is the positive relationship on the figure and the NPV is positive in proposed value of the price.

Table 4: Critical variables applied on the DCF model to calculate NPV.

Sensitivity Area	Percentage Change	Value	NPV USM$
Gold price / Silver price US$ / oz	-30%	875/12.6	6.40
	-20%	1000 / 14.4	19.70
	-10%	1125 / 16.2	33.20
	0	1250 / 18	46.60
	+10%	1375/ 19.8	60.10
	+20%	1500 / 21.6	73.50
	+30%	1625/23.4	87.00
Operating cost US$ / t	-30%	14	58.90
	-20%	16	54.90
	-10%	18	50.80
	0	20	46.60
	+10%	22	42.80
	+20%	24	38.80
	+30%	26	34.70
Capital cost USM$	-30%	33.11	61.00
	-20%	37.48	56.60
	-10%	42.57	51.50
	0	47.30	46.60
	+10%	52.03	42.00
	+20%	56.76	37.40
	+30%	61.49	32.60

6. Economic limits for stripping ratios in AGP

Overall Stripping Ratio (SR) calculated for AGP by using the cross-section method were found

equal 1:5.8 (ore/waste). The following section discusses the relationship between SR, operating cost, gross profit and NPV in AGP. Operating cost predicted in DCF model were found 20 US$/t for mining, processing and G&A costs. Also, for AGP opex equal 26 US$/t when calculated based on a comparison with opex in SGM. In the following section taken opex equal 26 US$/t as a more logic than taking it by 20 US$/t due to SR for AGP is more than SR in SGM.
Mining cost increase with increase the stripping ratio, but processing cost is constant due to the ore tones delivered to processing plant is constant. From SGM data the processing cost per ton equal around 12.5 US$/t and mining operating cost = 1.65 US$/t to remove one ton from open pit at SR = 1:4.9 for SGM. Hence, mining cost in AGP equal (26 US$/t – 12.5 US$/t) = 13.5 US$/t, where (26 US$/t) is the total operating costs for AGP calculated based on a comparison with SGM and 12.5 processing costs at SR 1:5.8 for AGP. Hence extract one-ton rocks from open-pit mine in AGP = 13.5/ 6.8 ≈ 2 US$/t, so when the SR increases the opex increase and decrease in gross profit and NPV. Table 5 explain the values of opex, gross profit and NPV which corresponding difference SR in AGP at the base **case opex = 26 US$/t, SR 1:5.8, and cost per ton removed 2 US$/t**.

From the above table 5 and figure 4 the maximum value of NPV US$M 34.7 at (SR =1:5.8) also, NPV decrease with increase SR and reach to lowest value US$M 2.5 at (SR =1:13.8). From figure 4 NPN transform from positive to negative at SR = 1:14.3. From figure 5 opex increase with increase SR and gross profit, decrease to minimum value US$M 6.2 at SR = 1:15.8.

Table 5: Calculated values of opex, gross profit and NPV which corresponding difference SR.

SR, W:O	OPEX, US$/t	Gross Profit, US$M	NPV, US$M
5.8	26	12.2	34.7
6.8	28	11.6	30.7
7.8	30	11	26.7
8.8	32	10.4	22.7
9.8	34	9.8	18.6
10.8	36	9.2	14.6
11.8	38	8.6	10.5
12.8	40	8	6.6
13.8	42	7.4	2.5
14.8	44	6.8	-1.5
15.8	46	6.20	-5.50

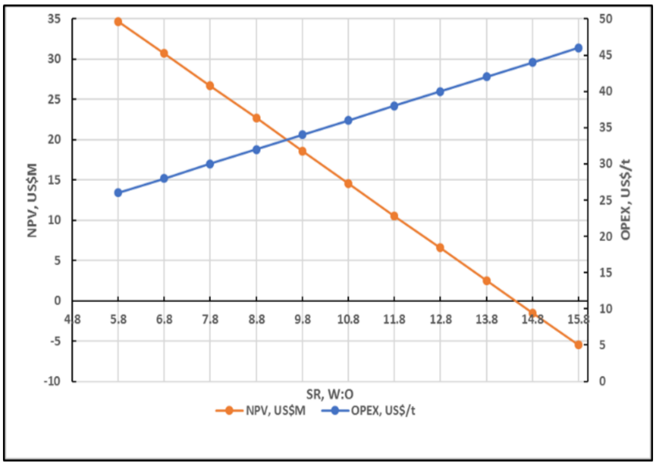

Figure 4. Relation between SR, opex and NPV.

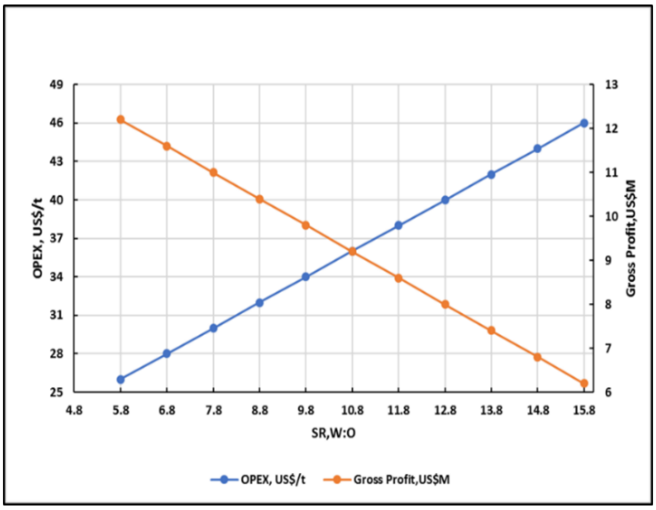

Figure 5. Relation between SR, opex and gross profit.

IV. CONCLUSION AND RECOMMENDATION

The conclusions drawn from the present study can be summarized as follows:

- There is a slight variation in capex value calculated by the multi-methods this gives more accuracy for the proposed model applied to valuation of gold mineral resources in AGP.
- AGP is profitable at the base case i.e COG = 0.5 gr/t, Gold price / Silver price (1250 / 18) US$ / oz, operating cost US$ 20/ t and Capital cost USM$ 47.3 the NPV is positive equal US$M 50.80.
- Sensitivity analysis clarified AGP is profitable in all cases of changing the economic factors for the project. The maximum value of NPV equal (USM$ 87) at price + 30% (1625 / 23.4 US$ / oz of Au/Ag) also the minimum value of NPV equal (USM$ 6.4) at price - 30% below the price of the base case.
- AGP is a profitable project at the stripping ratio (SR) up to 1:14.3. where the NPV equals zero and transforms from positive to negative.

- From the comparison between the SGM and proposed AGP in terms of technical and economic criteria, the AGP is an acceptable project for investment due to of the cost and production values for AGP lies in the range of cost and production values for SGM.
- From the study, we recommend continues in the exploration works in the AGP to increase the certainty in the ore tonnages and grade estimated. Also, extend in exploration works to increase the ore resources to increase the mine life.

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AUTHORS PROFILE

Prof. Dr. Mohamed Reda Moharram is a professor in the Mining and Petroleum Dept., Faculty of Eng., Al-Azher University, Cairo, Egypt. E-mail address: moreda_45@yahoo.com , **Tel. 00201111036342** Former dean of the Faculty of Engineering, Al-Azhar University in Cairo. Professor of Mining Engineering and mineral processing. Supervised and judged many doctoral and master's theses in various universities in Egypt in the fields of mining engineering.

Prof. Dr. Mohamed Abdel Latiff Yassin is a professor in Mining and Petroleum Dept., Faculty of Eng., Al-Azher University, Cairo, Egypt. **E-mail address**: m_a_yassin@yahoo.com , **Tel. 00201118575007**
Founder and former dean of the Faculty of Engineering, Al-Azhar University in Qena. Professor of Mining Engineering and Rock Mechanics Engineering and obtained a doctorate from the state of Hungary in rock mechanics and supervised and judged many doctoral and master's theses in various universities in Egypt in the fields of mining engineering.

Assoc. Prof. Abd El Rahem Khalefa Embaby is Associate Professor in Mining and Petroleum Dept., Faculty of Eng., Al-Azher University, Cairo, Egypt. Holds a master's degree from Faculty of Eng., Al-Azher University, Cairo, Egypt. **E-mail address**: abdoembaby_72@yahoo.com , **Tel. 00201094607168** and Holds PhD from Azerbaijan. He is activity in the mineral resource's valuation using geographical information systems and he publish papers under this area likes "GIS Technology for El-Gedida Iron Ore to satisfy the Requirements of Egyptian Blast Furnace" and "Optimizing Wadi Kalabsha kaolin Ore Grade by GIS for Uses in Egyptian Ceramic and Refractory Industries".

Eng. Helal H. Hamd_Allh. I am an assistant teacher Mining and Petroleum Dept., Faculty of Eng., Al-Azher University, Qena, Egypt from 2007 **E-mail address**: helalahmed.2038@azhar.edu.eg , **Tel.** 00201000263390.
Holds a master's degree from the University of Assiut, Faculty of Engineering, Egypt. And I am a PhD student in the Mining and Petroleum Dept., Faculty of Eng., Al-Azher University, Cairo, Egypt work area at gold mineral resources evaluation and mineral economics. I have published papers in mineral economics under the title "Using the Economy of Sukari Gold Mine to Prove the Potential Economy of Hamama Gold Project, Eastern Desert, Egypt"." and paper under publishing "Valuation Some of Egyptian Gold Mineral Resources Using Market Approach".