Advances in Environmental Biology, 8(7) May 2014, Pages: 3459-3463

AENSI Journals
Advances in Environmental Biology
ISSN-1995-0756 EISSN-1998-1066
Journal home page: http://www.aensiweb.com/aeb.html

Selecting the Major Mine Closure Factors for Choghart Iron Mine of Iran

[1]**Arash Ebrahimabadi and** [2]**Amir Rahimi Ghazikalayeh**

[1]*Department of Mining, Faculty of Engineering, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.*
[2]*Department of Mining Engineering, South Tehran Branch, Islamic Azad University, Tehran, Iran.*

ARTICLE INFO
Article history:
Received 25 March 2014
Received in revised form 20 June 2014
Accepted 15 July 2014
Available online 5 August 2014

Keywords:
Insert keywords for your paper

ABSTRACT
Background: For the past decade or more, the term of “mine closure’’ has firmly entrenched itself into the lexicon of mine operators and regulators, and it is considered as final or "fourth phase" of mine planning. **Objective:** The reasons for mine closing may include economic, geological, geotechnical, regulatory, community and other socio-political pressures. So, premature mine closures decision need to be managed appropriately. **Results:** The aim of this research work is to select the major mine closure factors through application of risk management (Closure risk model) as a powerful managerial tool for assessment of mine closure risk factor. Afterwards, the results achieved from risk assessment were verified using Analytical Hierarchy Process (AHP) approach. With this respect, a case study was carried out in Choghart open pit iron mine.**Conclusion:** The results of application of this model to the mine demonstrated that the mine has low closure risk with closure probability of nearly 30%, however, environmental and community issues need to be considered seriously.

To Cite This Article: Arash Ebrahimabadi and Amir Rahimi Ghazikalayeh., Selecting the Major Mine Closure Factors for Choghart Iron Mine of Iran. ***Adv. Environ. Biol., 8(7),*** *3459-3463, 2014*

INTRODUCTION

Nowadays, the phase "mine closure" is considered as fourth phase of mine planning. This should be treated in a relevant manner to establish sustainable mining development since environmental and sustainable attentions are rising more and more. Premature mine closures can result in significant adverse impacts on the environment and community such as loosing opportunities for operating team to built their careers, having to find other jobs and other places to live by employees, affecting on local business community, low safety issues, subsidence, acid mine drainage, water and land pollution due to improper rehabilitation techniques, etc. Notable attempts to identify why mines close exist in the technical literatures related mine closure concerns. (Laurence, 2001; 2006) developed a risk assessment approach that examines the major risks associated with mine closure. These efforts present a classification system for quantifying mine closure risks for use by mine operators and regulators aiming to minimise the impacts of both premature and planned mine closure[3]. According to Laurence (2006) the reasons why mines close are grouped as following:

Closure due to economic, geological, geotechnical reasons[3], equipment or mechanical failure, regulatory pressure, government policy, community opposition and other reasons.

Under these circumstances, mine closure process needs to be managed appropriately. The aim of this research is to present an approach based on risk management (Application of closure risk model) in order to determine the major closure factors. In the end, results will be verified using Analytical Hierarchy Process (AHP) for higher reliability of the achieved results [5]. After development of this method by Saaty (1980), the method has extensively applied to the majority of multi criterion cases as well as mining problems such as selection of suitable post mining land use [4]. This paper deals with evaluation of the major factors affecting on mine closure process to choose more dominant causes of a mine closure.

1. *Optimisation Of Mine Closure Process Using Closure Risk Model:*

Analyzing the risk:

The Closure Risk Model was developed by Laurence (2001) as a new tool to aid decision-makers in the complex area of mine closure[2]. It uses a simple analytical technique that allows the decision maker to simplify what is often a complex mine closure process into more easily managed sub-components. This systematic approach ensures that critical factors in the closure process are not overlooked. It also allows the most important

Corresponding Author: Arash Ebrahimabadi, Department of Mining, Faculty of Engineering, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran

issues to be highlighted. The model can also be used to produce quantitative estimates of risk to produce the Closure Risk Factor (CRF). A comparison of closure risk factors from various sites will be particularly useful for the larger company with a stable of sites to allow appropriate resources to be dedicated to the locations posing the highest risks. Correspondingly, a government department regulating numerous sites will find the tool useful in applying its limited resources for the best outcome. The technique will assist industry and government\ personnel to achieve the optimum closure outcome in the knowledge that all factors - not solely environmental components - have been adequately considered. The Closure Risk Factor (CRF) is simply a qualitative and quantitative measure that captures the various significant risk components of mine closure. These components can be broadly divided into environmental risks (RE), safety and health risks (RSH), community and social risks (RC), final land use risks (RLU), legal and financial risks (RLF) and technical risks (RT). The Closure Risk Factor is the sum of these individual risks and the relationship can be expressed by the following linear equation:

$$CRF = \sum (RE + RSH + RC + RLU + RLF + RT) \tag{1}$$

The CRF allows the closure risks at each mine site to be broken down into as many individual components as considered appropriate by the decision-maker.

Quantifying the risk:

The science of risk management is continually evolving. Australian Standard (4360) defines risk as ‘‘the chance of something happening that will have an impact on objectives’’[6]. It is measured in terms of the probability of an event occurring and the consequence of that event, or Risk is equal to Probability multiplied by Consequence (ANZSRM, 1999). In the model, the higher the probability or consequence, the higher the number. In other words, if an event has a probability of 10, then, unless timely intervention occurs, the event would certainly occur; conversely, if determined to have a probability of 1, it is unlikely to occur. If the consequence of an event is 10, then the outcome could be catastrophic in the form of a multiple fatality, a major environmental incident, major equipment damage, a major loss to the business, or a ruined community standing. If a consequence of 1, there is an insignificant chance of injury, or a health implication, environmental damage or ongoing liability to the business. The risk matrix is illustrated in Figure 1. Table 1 also shows relationship between closure risk scores and their probabilities[4].

Probability	10 (certain)	9	8	7	6	5	4	3	2	1 (rare)
Consequence										
10 (catastrophic)	100	90	80	70	60	50	40	30	20	10
9	90	81	72	63	54	45	36	27	18	9
8	80	72	64	56	48	40	32	24	16	8
7	70	63	56	49	42	35	28	21	14	7
6	60	54	48	42	36	30	24	18	12	6
5	50	45	40	35	30	25	20	15	10	5
4	40	36	32	28	24	20	16	12	8	4
3	30	27	24	21	18	15	12	9	6	3
2	20	18	16	14	12	10	8	6	4	2
1 (insignificant)	10	9	8	7	6	5	4	3	2	1

Fig. 1: Mine Closure Risk Assessment Matrix.

Table 1: Relationship Between Closure Risk Scores and Their Probabilities.

CRF	Closure risk rating	The range of closure risk probability (%)	Mean probability (%)
> 2000	Extreme	80 - 100	90
1500 - 2000	Very high	60 - 80	70
1000 - 1500	High	40 - 60	50
500 - 1000	Moderate	20 - 40	30
< 500	Minor	0 - 20	10

2. Case Study: Closure Risk Assessment Of Choghart Open Pit Iron Mine Of Iran:

The Choghart apatite-bearing iron oxide deposit (55°28´2″E, 31°42´00″ N) occurs in the Bafq mining district of Central Iran, 12 km northeast of Bafq town and 125 km southeast of Yazd city (Fig. 2). There are more than 80 identified magnetic anomalies in the Bafq mining district, and the region is believed to host over 2 Gt of iron oxide ore [1]. Most of the deposits areunexploited or only partially mined. Choghart is the firstdeposit of its kind exploited in the Bafq mining district.The remaining total reserve of Choghart is estimated to be 200 Mt. The first apatite-rich iron oxide ore was shipped to Isfahan steel mill (the largest mill in Iran) in1971, and since then, Choghart has remained the main supplier of iron ore to this mill. The origin of Choghart iron deposit and other similar iron oxide deposits in the Bafq mining district, like their counterparts in the rest of the world, has been the subject of continuing controversy for local geologists with the difference that the controversy has been fueled by the lack of absolute age determinations, accurate isotopic and fluid inclusion studies, and reliable analytical data. In the following part of study, the procedure of selecting the closure factors are presented[3].

3. Assessement Of Closure Risk Factor For Choghart Mine:

Mine closure questionnaires were distributed to experts and senior engineers and managers working in the Choghart mine. They filled in the questionnaires on the basis of their expertise. It is also asked each respondent to prioritize or rate the relative importance of the major mine closure issues (such as environment, community, safety, etc).

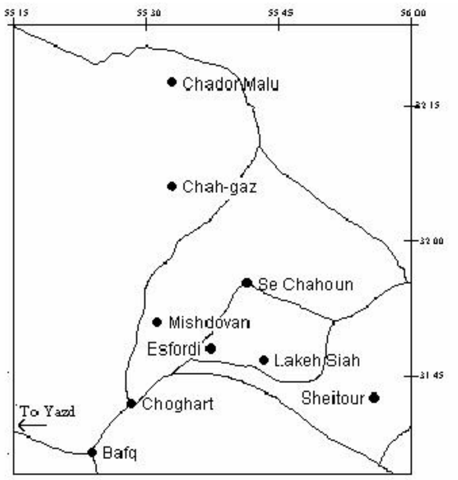

Fig. 2: Location of Choghart Iron Mine.

The remaining questions asked them to list or rate the most important sub-issues under the classifications of environment, community, safety and so on. The calculated risks from the achieved results from these questionnaires are given in Table 2. It should be stated that due to large number of issues and tables, the only overall gained results are shown, as below:

Table 2: Assessment of Closure Risk Factor for Choghart Mine.

Major risks	Risk values
RE	452
RSH	33
RC	127
RLU	25
RLF	51
RT	38
RCF	726

$$CRF = \sum(452+33+127+25+51+38) = 726 \quad (2)$$

With reference to Table 1, the achieved risk score with mean probability of 30% is ranked as "moderate" group. This means the given mine has not high risk and its premature closure probability is very low but environmental and community issues, with the risk values of 452 and 127 respectively, need to be managed properly so that appropriate implementation of reclamation and closure plan will be able to eliminate these risks. Key notes can be comprising:

Adequate control and treatment of surface waters, proper land based construction for tailing dams and waste dumps, decommissioning of construction and infrastructures for increasing aesthetic value of area at primarily stage of closure plan, slope stability analysis of tailing and waste slopes in order to prevention of failure and implementation of reclamation plan over them, negotiation with indigenous land owners to inform them about the future mine's extension plan and next disturbance areas, decision making regarding employment of indigenous workers for accomplishment of closure plan.

4. Verifying the gained results by using ahp method:

One of the most effective methods in a multi variable decision making process is Analytical Hierarchy Process (AHP). This method is able to convert the components of a complex problem from their original qualitative forms to quantitative ones. For gaining this goal, the effective factors on mine closure must be grouped at first step and then at next step, all factors in each group is weighted and scored. Consequently, the decision making methodology will be established multiplying weightings by scores.

All calculated scores are adding up for each broad closure factor. Choosing procedure is terminated by selecting the highest score(s). It should be noted that maybe more than one closure factor is achieved as major mine closure factors. The broad closure issues and sub-issues for this mine are weighted and scored by aforementioned process. Table 3 demonstrates the results. It is evidently attained from the table that environmental and community factors have more effects on Choghart mine closure with the scores of 9.517 and 9.064, respectively.

Table III: The results of score calculation for case study.

Broad closure issue	Sub-issues	Effective score	weights	Calculated score with respect to weight
Environmental	Surface water pollution	10	0.299	2.990
	Ground water pollution	10	0.189	1.890
	Impact on downstream usage	3	0.148	0.444
	Pollution due to waste dumps	15	0.114	1.710
	Pollution due to tailing dams	10	0.135	1.350
	Air pollution (Gas, dust, etc)	15	0.054	0.810
	Contamination of surrounded soils	3	0.041	0.123
	Inappropriate construction	10	0.020	0.200
Sum of the environmental scores				9.517

Table III: THE RESULTS OF SCORE CALCULATION FOR CASE STUDY (Continued).

Broad closure issue	Sub-issues	Effective score	weights	Calculated score with respect to weight
Safety and health	Reduction in safety and security	10	0.633	6.330
	Problems due to open pits, shafts, raises,etc	10	0.261	2.610
	Problems due to subsidence	1	0.106	0.106
Sum of the safety and health scores				9.046
Community and social	Problems related to employees	3	0.608	1.824
	Problems related to land owners	20	0.272	5.440
	General community impact	15	0.120	1.800
Sum of the community and social scores				9.064
Final land use	High value usage such as agriculture	1	0.800	0.800
	Medium value usage such as forest	1	0.200	0.200
Sum of the final land use scores				1
Legal and financial	Government pressure	1	0.750	0.750
	Creditors pressure	1	0.250	0.250
Sum of the legal and financial use scores				1
Technical	Closure plan	1	0.667	0.667
	Exhausted reserves	1	0.333	0.333
Sum of the technical use scores				1

5. *Conclusions:*

The aim of this research is to apply risk management (Closure risk model) as a powerful management tool for assessment of mine closure risk factor and selection of the major mine closure factors; with that regard a case study was carried out in Choghart open pit iron mine. The results of application of this model to the mine demonstrated that the mine has low closure risk with closure probability of 30% but environmental and community issues need to be noticed more than before. Also, in this research the major factors affecting mine closure investigated to choose the closure causes in an appropriate and logical manner. The study followed by establishing an approach based on Analytical Hierarchy Process (AHP) in order to determine the major closure factors and the results obtained from application of closure risk model. The results achieved from application of AHP method for case study showed that environmental and community factors have more effects on Choghart mine closure with the scores of 9.517 and 9.064, respectively. The results of study illustrated the following issues should be considered in closure and reclamation plan: Adequate control and treatment of surface waters, proper land based construction for tailing dams and waste dumps, decommissioning of construction and infrastructures for increasing aesthetic value of area at primarily stage of closure plan, slope stability analysis of tailing and waste slopes in order to prevention of failure and implementation of reclamation plan over them, negotiation with indigenous land owners to inform them about the future mine's extension plan and next disturbance areas, decision making regarding employment of indigenous workers for accomplishment of closure plan.

REFERENCES

Advances in Environmental Biology, 8(7) May 2014, Pages: 3459-3463

[1] Daliran, F., 1999. The Geochemistry of Bafq Apatites, Iran; Implication for the Genesis of Kiruna-type Iron Ores, Eds. Stancly *et al*., Mineral Deposits; Processes to Processing. Balkema, Rotterdam, 631-634.
[2] Laurence, D., 2001. Classification of Risk Factors Associated with Mine Closure. Mineral Resources Engineering, 10(3): 315-331.
[3] Laurence, D., 2006. Optimization of the Mine Closure Process. Journal of Clear Production, 14: 285-298.
[4] Osanloo, M., A. Akbari and H. Hamidian, 2006. Selecting Post Mining Land Use Through Analytical Hierarchy Processing Method: Case Study in Sungun Copper Open Pit Mine of Iran. Proc. of the fifteen Int. Symposium on Mine Planning and Equipment Selection (MPES 2006), Torino: 245-252.
[5] Saaty, T.L., 1980. The Analytical Hierarchy Process, Planning, Priority. RWS publication.
[6] Australian/New Zealand Standard for Risk Management 4360, 1999.