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Original Research

Research On Selecting The Most Suitable Extraction Method For Achin Talc-Magnesite Mine In Nangarhar Province, Afghanistan

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Abstract:

Magnesite is a natural material that has various uses in today's industry, but in the Achin Talc-magnesite mine, only Talc has been mined by underground mining method. And the magnesite has remained intact. However, the magnesite veins are located near the Talc veins, and their thickness is 20-70 meters, which is considered to be completely suitable to be extracted by open-pit mining method.

Global practice data shows that currently 83% of the world's mines are extracted by the open-pit mining method. And about 17% of mines are extracted by underground mining methods.Independently extraction of Talc by underground mining method raises the total mining cost, and it also makes the extraction of the magnesite deposit impossible or difficult in the future.

To select appropriate method for the simultaneous extraction of Talc and magnesite, the average stripping ratio was obtained by the computational method. The average stripping ratio achieved is (K=2.39). Comparing it with global norms, and considering the position of mineral veins, open-pit mining method is proposed for this mine. This makes it possible to extract both Talc and Magnesite with a very lower cost.

Independently extraction of Talc by underground mining method has created underground voids next to the magnesite vein. Which will cause the magnesite vein to slide into these voids in the future and now It causes the price of extraction per ton of Talc to rise.

Keywords: Average stripping ratios, magnesite, open-pit mining, pit, total cost.

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1. Introduction

Achin Talc-Magnesite mine has been active for many years and yet just Talc has been extracted from this mine. Meanwhile, the main part of this mine is magnesite and has an outcrop to the surface with the thickness of 20 to 80 meters[1].

The magnesite mineral is one of the natural beneficial substances that have various uses and is used in different parts of the industry. However, up to date in this mine the attention has been paid to the extraction of Talc and no action has been taken in the field of magnesite extraction. This has caused the Talc to be extracted separately by underground mining method. Undoubtedly, the extraction of Talc alone will create many problems for the extraction of Magnesite in the future. Therefore, it is necessary that with the extraction of magnesite by open pit mining method, Talc should also be extracted at the same time in the future. According to our calculations, extraction of Talc by open pit mining method is much cheaper and more secure than its extraction by underground mining method. Since the veins of Talc are on the footwall of the magnesite vein[2], and among them, there are gobs of various thicknesses. Therefore, separate extraction of Talc in the future will cause breakdown and slippage in the magnesite body, which makes its exploitation impossible or difficult.

What has been researched in this work is the selection of a method to extract both minerals in such a way that their negative effects on each other reach a minimum and still be the most economical method.

By choosing the most suitable method for extracting of Achin Talc-magnesite mine, by considering the minimum total cost and preventing the loss of magnesite, millions of dollars of national capital can be prevented from being wasted.

At present, magnesite economically and industrially has a special place in the domestic and global markets. Simultaneous extraction of Magnesite with Talc can create jobs and also meet the needs of industries in the field of non-combustible materials, thermal insulation, and construction of building partitions.

The aim of this study is to obtain the most suitable method for the extracting of Achin Talc-magnesite mine, because Talc and magnesite veins are located close to each other[1]. Therefore, the independent extraction of each mineral body can have negative and unpleasant effects on each other in terms of the implementation of mining affairs and cause many technical problems.

2. Materials and Study Area

Achin Talc- Magnesite mine is located in the southeastern part of Afghanistan in the northern slope of the Spin Ghar mountain range, which administratively the mine area belongs to Nangarhar province.

This mine is located in geographical coordinates ($34^{\circ}03'$) northern latitude and ($70^{\circ}43'$) eastern longitude. The mine is located 11 km from the village of Achin. It is 72 km away from Jalalabad city and 220 km away from Kabul city[1].(the research area location shown in Figure-1)

The Achin mine was first not only found in 1956-1955 by various geologists, such as Sobat and Nakazoh, but its technical value was also presented[3].
The first geological study of the area was done by K.L. Grisbakh (1980-1992). He was the first to make a geological map of this area[2].
Achin Talc- magnesite mine has been established among Proterozoic dolomitic marbles, connected with 2 km long diabase porphyry dykes of the Talc zone[3].
The zone is composed of closely spaced veins. Its length is from a few meters to 150 meters and its depth is 100 to 160 meters. Talc veins are complex and consist of scaly Talc. It has the white-gray color[3].
The chemical composition of Talc is 95.96-50.22% (average 70.38%), MgO - average 31.6%, harmful CaO mixture is average 7.88% and Talc ore deposit is 1.25 million tons[4].
In this mine, magnesite ore occurred along with Talc vines. The thickness of magnesite is 33-80 meters; the length is 328-765 meters. The shape of the deposit is lens-like and is composed of magnesite with low Talc, dolomite, calcite, and quartz. The composition of the ore body is dolomite-magnesite and the quantity of MgO is 30-38%. Its central parts are composed almost entirely of pure magnesite[1].

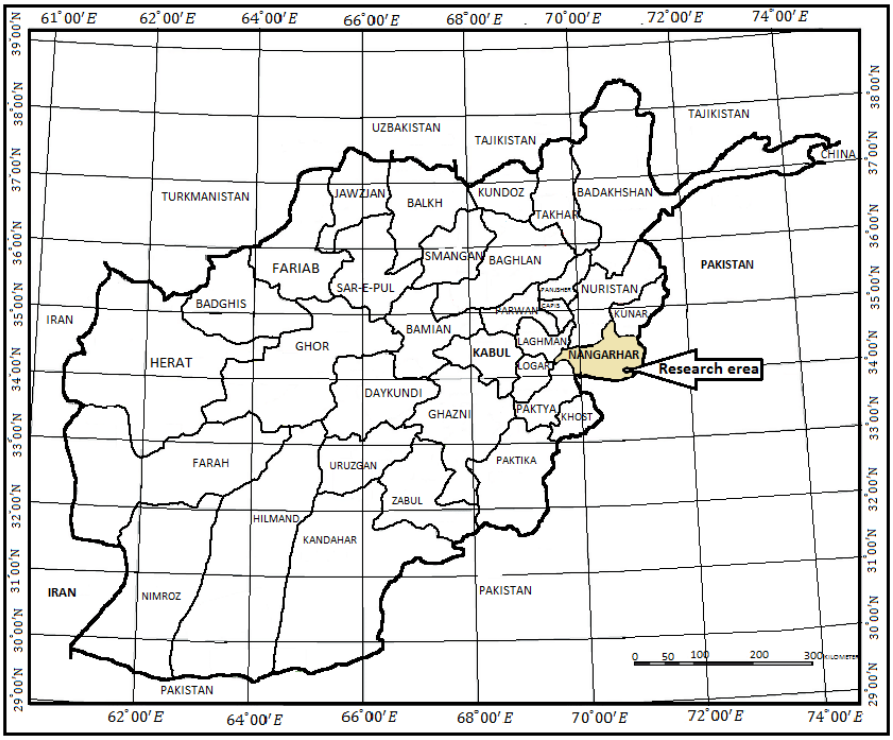


Figure 2- Location of the research area on the map of Afghanistan

The amount of MgO is more than 40%. The amount of Talc is 4.4-3.56%. However, after heating it has the composition of MgO- 83.47-81.94%, SiO2- 12.27-7.77%, CaO- 6.96-3.53%. Magnesite deposit in this mine is 31.2 million tons. The mine was extracted about 85 years ago by locals and about 46 years ago by the Ministry of Mines and Industries. During this period, no suitable extraction system has been selected for the extraction of Talc deposit[5].

In this mine, till now the Talc deposit extracted by underground mining method and magnesite don't extract until today.

Global research shows that currently, 83% of the world's Metal mines are extracted by open-pit mining, and about 17% are extracted by underground mining[6].

If we look at the geological conditions of the Achin Talc-magnesite mine, it is clear that the magnesite veins with the thickness of about 33-70 meters have direct outcrop to the surface. This makes it suitable to be extracted by open-pit mining method, because it will cost less and meanwhile the Talc can be extracted by open-pit mining too.

The economic importance of magnesite in the global market, as well as its uses in industry, is as follows.

1- Magnesite is used in heat and cold insulation industries (especially smelting furnaces), construction affairs, especially in tower buildings for production of the prefabricated walls with low thickness and weight, Chemicals industries, etc.

2- Extraction of Talc independently from Achin Talc-magnesite mine causes several problems during the subsequent extraction of magnesite ore, since their veins are close to each other (about 5-10 meters), the extraction of magnesite in the future will be more complicated or impossible[3].

3 - Using new mining techniques and technologies, the parameters of the pits have evolved worldwide. Currently; pits are designed up to 700 meters depth[7].

Achin Talc-Magnesite mine has been explored to a depth of approximately 100 m. Therefore, we consider the same depth for the pit.

For the first time, comprehensive research has been done on choosing the appropriate method of extraction of magnesite deposit, which Talc could be extracted at the same time.

3. Research methodology:

The current research was done through both library-based methods and field surveys. The first part was performed by reviewing the existing literature, all geological reports and maps available in the archives of the Ministry of Mines and Petroleum have been studied. And the research work previously carried out by the underground mining engineering department in this mine has been studied. The quantity of average stripping ratio that has been considered in the global practice and some mining projects in the world for choosing the extraction method has also been studied. But the second part was done with a distributed questionnaire to the team members, who surveyed the mine, in this section, the following questions have been asked.

Has magnesite ever been mined from the Achin **Talc-Magnesite** mine?

Is there a special extraction method for talc extraction?

Non-combustible materials and heat insulation of smelting furnaces and cement kilns are supplied from inside or imported from outside Afghanistan?
All the answers are summarized and evaluated and the results are listed in the table (5).

The deposit of the main vein of this mine and the waste materials have been calculated, and the average stripping ratios of the pit have been calculated; its results have been analyzed and investigated

4. Subject of research

It is necessary to carry out a research on how to extract the Achin Talc-magnesite mine up to a depth of about 100 meters, with a minimum mining cost and lowest waste and dilution.

The following conditions are considered in mines extraction.

1- The efficiency of open-pit mining is obvious if: Mineral deposits are thick, horizontal, low gradient, with an outcrop or close to the ground surface.
2- Extraction of a mine by underground mining method can be Economical when: the ore deposit is Low in thickness and located at more depths from the surface.
3- The Mineral deposits which are thick and covered by a thick layer of overburden can be extracted by surface or underground mining methods.
4- Mines in which the mineral body outcrops to the surface and has a high gradient and depth, can be extracted by surface or underground mining methods. The upper part is extracted from the surface and the deeper part is extracted by underground[8].

Mineral bodies that are occurs horizontally and slightly sloping and covered with thin layer of gob in the valleys are in this group. Also, the mineral bodies which are covered with thick layer of gob at the foot of mountains are in this group, and are extracted in this way. In the first, second, and third situations, there are no restrictions on the extraction method, but in order to determine the boundaries of the mine area in the first and third cases, the Maximum allowable (break-even) stripping ratio should be calculated.

In fourth situation the open-pit and underground mining methods boundaries are determined.

At present, more than $\frac{2}{3}$ of all minerals are extracted by the opin-pit mining method in Russia.

Researches have shown that from an economic point of view, about 55% of all coal, 75% of Colored metals, and 82% of iron ore are currently extracted by the open-pit mining method. Extensive development of open-pit mining and continuous development of their field of use are explained below due to the numerous advantages of open-pit compared to underground mining method.

Advantages of open-pit mining: High safety and better conditions for maintaining workers' activities. Better working conditions for high-yield machines and mechanisms, resulting in high productivity of workers, low ore waste and high possibility of selective extraction, simpler organization of affairs, more simplicity in organizing affairs and determining the composition of equipment complex.

Disadvantages of open-pit mining: dependence on climatic conditions. Cost of reclamation. Cost of waste material removing in case of a high thickness of overburden[7].

The basic criterion in determining open-pit mining boundaries - is the boundary stripping ratio, based on its comparison with other stripping ratios, we can determine the final depth of the pit, and specify the mine area. Practical experiences show that the use of the method of comparing the final and boundary stripping ratio in the pit is mostly used [9].

Extraction of mineral commodities that involves the removal of waste overburden prior to extraction of valuable ore involves determining the stripping ratio. The stripping ratio is expressed broadly as the ratio of waste to ore. It's simply calculating that, how much waste has to be removed, in order to one unit of ore to be mined. The stripping ratio determines where the pit limit will be.

The units for stripping ratios can vary, and usually depends on the geological properties of the deposit and the commodity mined. It can be expressed in tons (t), or cubic meters (m^3). Usually, for coal, cubic meters (m^3) or tons (t) are used. However, for hard rock mines where the geology is usually complex with the presence of various rock types, tonnage (t) is usually preferred[10].

There are different types of stripping ratios, and here we use the average stripping ratios.

$$\boldsymbol{k}_{\text{гр}} = \frac{\boldsymbol{V}_{\text{в}}}{\boldsymbol{V}_{\text{и}}}$$

Here $\boldsymbol{V}_{\text{w}}$ and $\boldsymbol{V}_{\text{ore}}$ - Are the total volume of west material and the total of ore in the final limit of the pit respectively in (m^3)[11].

To calculate the stripping ratios of the Achin Talc-magnesite mine, in the first step, we calculate the amount of mineral reserve for the main vein.

There are many methods for the calculation of mineral reserves. Three methods are widely used in practice; these three methods are the block method, section method, and statistical method.

It is better to calculate mine deposit in the form of blocks and sections. In both methods, it is possible to use all the geological data to determine the boundaries of the calculation blocks, and also to make the idea of the morphological and natural properties of the minerals clearer. Among them, the sections method can be better for Achin Talc-magnesite mine. The main vein has sufficient geological sections. Therefore, we calculate the mineral reserve in this mine according to the section method.

In this method, first, according to the geological sections of the mineral vein, we receive the area of the mineral body in each section, then multiply it by the length of the cut parts and obtain the volume of the part. For calculating the volume of blocks, different formulas are used depending on the situation[12].

$$\left.\begin{aligned} V &= \frac{S}{3} \times l \ , && 1\\ V &= \frac{S}{2} \times l \ , && 2\\ V &= \frac{S_1 + S_2}{2} \times l \ , && 3\\ V &= \frac{S_1 + S_2 + \sqrt{(S_1 \times S_2)}}{3} \times l \, , && 4\\ V &= \left(S_1 + S_2 + \frac{a_1 \times b_2 + a_2 \times b_1}{2}\right) \times \frac{L}{3} \, , && 5 \end{aligned}\right\} (1)$$

Here:

S- The area of sectional. l- Distance between two sections in a block, A- The large horizontal size of the desired section, B- The large vertical size of the desired section.

In blocks where one section has cut the mineral body and the second section has not cut the mineral body. And the second area for the mineral body does not exist in the same block, considering the characteristic of the disappearance of the side blocks, we act as follows.

If the shape of the section is isometric at the point where it intersects the mineral body, the cone volume formula, (formula (1)), is used. However, If the figure is long, the prism volume formula, (formula (2)), is used.

If the difference between the areas of the two sections of the blocks are about 10%, the prismatic volume formula (formula (4)), is used.

If the difference between the areas of the two sections of the Mineral blocks are about 10-40%, the formula of incomplete pyramid volume (formula (4)), is used.

If the difference between the areas of the two sections of the Mineral blocks are more than 40%, the Obelisk formula (formula (5)) is used.

According to the geological data of Achin Talc-magnesite min, Talc, and magnesite veins are among the marbles that have better stability.

The pit slope angles are mainly related to the physical and mechanical properties of the rocks on both sides and determine the stability of the pit. There are two sides in the pit, working and non-working sides, the size of their angles are listed in Table (1).

Table 1- the pit slope angles size[13].

Slope angle (Degree)	*Type of rock*	*type of pit slope angle*
18-25	Hard rock	Working limit
18-20	Semi hard rock	
10-15	Soft rock	
35-55	Hard rock	Non-Working limit
25-35	Semi hard rock	
18-25	Soft rock	

Achin Talc-magnesite mine is located among the marbles and that marbles have a little seam, they have sufficient stability. According to the table above, the slope angle for the working benches in the pit is 25 degrees, and 50 degrees for the non-working benches[13].

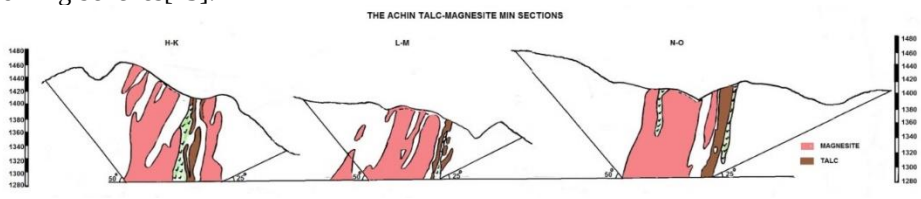


Figure 2- Geological sections of Achin Talc-magnesite mine according to the lines: N-O ، L-M and H-K. (Russian and Afghani geologists.1977 -1974)

From the geological sections presented in Figure (1), the volume of blocks of mineral deposits can be determined as follows.

When calculating the volume of block number (1), after placing the square grid on the section (N-O), we note the number of squares on the mineral deposit and the Waste material in the pit Range and calculate each area According to scale.

The economic value of the Talc and magnesite are not very different, so we assume both as same mineral deposits in the calculations.

The scale of the geological map is 1: 2000, so the area of each square grid with dimensions of 0.5mm × 0.5mm is equal to $100m^2$ in the land.

The area of a mineral deposit in geological sections is calculated from the following formula.

$$S = S_0 \times N$$

$$N = M + \frac{n}{2}$$

Here:

S_O - The area of each square grid.

N- The number of squares occupied by the section of minerals in the square grid.

M- Number of the fully occupied square.

n- Number of the semi-occupied square.

The result of all calculations performed in the blocks of the mineral deposit is listed in Table (2).

Table 2- Calculations of mineral deposit volume and waste material in Achin Talc-magnesite mine.

Volume of block, m^3	**Formula for receiving block volume**	**Ore or Waste material**	**Block number**
1218000	$V_1 = \left(S_1 + S_2 + \frac{a_1 \times b_2 + a_2 \times b_1}{2}\right) \times \frac{l}{3} + S_2 \times \frac{L}{2}$	**Ore**	**1**
4665705	$V_1' = \left(S_1' + S_2' + \frac{a_1 \times b_2 + a_2 \times b_1}{2}\right) \times \frac{l_2}{3} + \frac{{R_1}^2 \times \pi \times \frac{H_1}{3}}{4} + \frac{{R_2}^2 \times \pi \times \frac{H_2}{3}}{4}$	**Waste material**	
1882403	$V_2 = \frac{S_1 + S_2 + \sqrt{S_1 \times S_2}}{3} \times l_2$	**ore**	**2**
4018800	$V_2' = \left(S_1' + S_2' + \frac{a_1 \times b_2 + a_2 \times b_1}{2}\right) \times \frac{l_2}{3} =$	**Waste material**	
2115000	$\mathrm{V}_3 = \frac{S_1 + S_2}{2} \times l_3$	**ore**	**3**
3234600	$V_3' = \left(S_3' + S_2' + \frac{a_2 \times b_3 + a_3 \times b_2}{2}\right) \times \frac{l_3}{3}$	**Waste material**	
631266	$V_4 = \left(S_1 + S_2 + \frac{a_1 \times b_2 + a_2 \times b_1}{2}\right) \frac{l_4}{3}$	**ore**	**4**
2079267	$V_4' = \frac{S_1 + S_2 + \sqrt{S_1 \times S_2}}{3} \times l_4 + \frac{{R_1}^2 \times \pi \times \frac{H_1}{3}}{4} + \frac{{R_2}^2 \times \pi \times \frac{H_2}{3}}{4}$	**Waste material**	
5846669		**ore**	**Total**
13998372		**Waste material**	
2.39	$\mathrm{K} = \frac{V_в}{V_и}$	**average stripping ratios**	

The average stripping ratios in this pit is as follows.

$$\mathrm{K} = \frac{\boldsymbol{V}_\mathrm{w}}{\boldsymbol{V}_\mathrm{o}} = \frac{13998372}{5846669} = 2.39$$

The research data that is used in the global practices show, if the average stripping ratios of the pit are consistent with the limit listed in Table 3.The extraction of the mine must be by open-pit methods.

Table 3- Depth and size parameters of some surface coal mines[11].

Length of pit, km	***Depth of pit, m***	***stripping ratios. m^3/ton***		***Depth angle (deg)***	***Thickness of deposite. m***	***pit***
		boundary	***average***			
7,6	352	10-11	4,8	65-90	18-35	***Krasnabrud***
8,0	370	10-11	6,31	45-90	14-30	***Novasirgiev***
6,5	215	10-11	6,4	-	-	***Casey Leaf***
9,8	550-600	12,0	4,2	45-90	14-68	***bachat***
3,0	120	4,0	1,35	-	20-120	***komertaw***
4-6,5	70	-	1,0	-	18-42	***Irsha-Brodin***

Table 4-Depth and size parameters of some surface metallic mines[11].

Depth of pit, m	***Stripping ratios m^3/m^3***		***Depth angle (deg)***	***pit***
	boundary	***average***		
420	15,7	8,8	0-40	Sibayesk
255	15,0	6,2	70-80	Ochalin
280	12,0	7,24	7-10	Zolotost Beloff
285-360	12,0	8,2	60-80	Carathylin
385	12,0	1,97	65-80	Olynigoresk
135	-	4,60	Horizontal	Stovilin
460	12,0	4,3	70-80	Sokolov
650	12,1	5,78	40-55	Sirbi
236	10,0	4,5-5,0	0-50	KaraJal
720	12,0	4,4	40-50	Kachar
360-560	13,0	3,6	90	Korshonof

According to global practices, coal is extracted with an average stripping ratio of 8 by the open-pit mining method. While the value of magnesite ores is more than twice the economic value of coal in the world market. Based on this; in the Achin Talc-magnesite mine, the magnesite mineral body that has been explored at a depth of 100 to 150 meters, with an average overburden stripping ratio of (2.39) for overall pit, can be extracted openly together with the Talc mineral.

5. Results and discussion:

For safe and economical extraction of talc and magnesite Achin mine. Frequent contacts have been made with the Ministry of Mines and Petroleum, and questionnaires have been distributed to the members of the survey team at the Achin talc-magnesite mine, the answers provided are listed in Table (5).

Table 5- Questions and answers provided by members of the Achin Talc-Magnesite Mine Survey Team.

number	***Asked Questions from members of the survey team at the Achin Talc-Magnesite mine***	***Summary of answers provided by the survey team at the Achin Talc-Magnesite mine***
1	Has magnesite ever been mined from the Achin Talc-Magnesite mine?	So far, the Ministry of Mines and Petroleum has not proposed a comprehensive plan for magnesite extraction.
2	Is there a special extraction method for talc extraction?	Extraction during all this time is done in a local, unscientific way and inside the mining cave and there is no special extraction system.
3	Non-combustible materials and heat insulation of smelting furnaces and cement kilns are supplied from inside or imported from outside Afghanistan?.	All non-combustible materials and heat insulation of metal smelting furnaces and cement kilns are imported from outside Afghanistan

Table (5) shows that despite the existence of abundant reserves of magnesite in this mine, the country's essential materials concerning non-combustible materials and heat insulation of metal smelting furnaces and cement kiln dash are imported from outside Afghanistan. This issue will inflict an irreparable blow on the body of the national economy of the country because cash will be paid for the purchase of these materials. Unfortunately, no plan has been proposed for mining so far at the level of the Ministry of Mines and Industries. Unfortunately, no plan has been proposed by the Ministry of Mines and Industries for extraction so far. Accordingly, with a sense of responsibility, for the first time, the issue of economic and safe extraction of this mine has been discussed in this research.

Calculations show that the average stripping ratio up to the explored depth (140-100 m) in the Achin magnesite mine is low (k=2.3), The result of calculating the average stripping ratio in blocks is shown in figure (3).

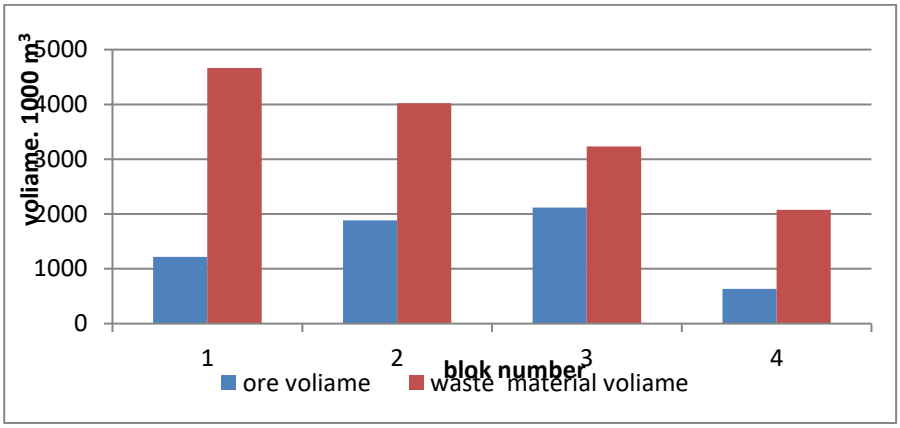


Figure 3- Volume of waste material and ore in the pit.

The Talc and magnesite mineral bodies with a High thickness has an outcrop to the surface So, Open-pit mining method will be suitable for the extraction of this mine, For the first years of mining, the magnesite can be extracted directly on the surface without removing waste material.

By open pit mining of talc-magnesite at the same time, both minerals can be obtained at a lower cost and more secure.

Independent extraction of Talc has been done in the last few decades without defined and designed mining methods.

In the past, Talc was extracted from caves, which is unprofessional and non-technical, and in the future will create many technical problems to extract the remaining Talc.

The vacancies created by Talc extraction will cause the magnesite mineral body to slide in the extracted zone in near future and Make it technically difficult to extract magnesite in the future.

6. Conclusion

Considering the data in the global practice and the importance of magnesite and Talc in the world Market and data obtained from the calculation of the average stripping ratio, Achin Talc-magnesite mine should be extracted by open-pit mining method.

The underground extraction of only Talc from the Achin Talc-magnesite mine raises the extraction cost per ton.Talc and magnesite minerals in Achin Talc-magnesite mine should not be extracted separately at different times because these two mineral veins are close to each other, and by extracting one of these mineral bodies separately, another mineral vein will be slide in the future.

The magnesite deposit in Achin min has good quality and economic importance and its extraction cause the production of non-combustible materials and heat insulation for metal smelting furnaces, Cement factory kilns, producing prefabricated walls of buildings and increasing exports nationally. The voids created by extraction of Talc in the past must be filled by blasting waste material.

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