Justification of Longwall Mining Technology for the Development of Kieselguhr Deposit in Sig Mine, Algeria

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Abstract. The improvement of mineral extraction technology in underground mines to increase productivity has become an important objective of the mining industry in Algeria in the race for price competitiveness, especially after the sharp decline oil prices as the main income of Algeria. But the increase production in underground mines where the deposits do not have good mechanical characteristics is a major challenge for the decision-makers, as the case of the kieselguhr mine of sig (Western Algeria) which uses the Room and pillar mining method that do not fit the condition of soft deposits and do not have sufficient strength, which causes a lot of collapses from time to time. The only way to ensure the increase of production, by improving the method of extraction and efficiency of the equipment used. In this article, we will combine the Room and pillars mining method and use the technology of the longwall mining method to increase the production of the mine and ensures the safety of workers during operation.

1. Introduction
Kieselguhr is a siliceous sedimentary rock of biogenic origin as formed by the accumulation of diatom skeletons (unicellular brown algae). Size generally between 10 and 50 microns [1], the skeletons (or frustules) consist of amorphous hydrated silica (opal). Other constituents are present in variable proportions, such as organic matter, conventional elements, or even clay minerals. Diatomite is also called "kieselguhr", or "diatomaceous earth" in the Anglo-Saxon world; in Denmark "molar" refers to diatomaceous clay containing up to 30% smectites. There is a wide variety of diatoms, some are sponge-type to small more or less fragmented element, others are instead more or less elongated type and consists of small rod-shaped elements.

Currently geologists identify more than 12000 diatomite species [2]. And because of its diversity and versatile uses, which are one of the mineral resources of Algeria, and given the growing demand for this mineral that has put the kieselguhr extraction units in a situation of insufficiency in the face of local needs.

The ENOF (National Company of Non-Ferrous Mining Products) has written in its specifications to increase the exploitation of the kieselgurh deposit of the mine of Sig from 3 000 T per year to 130 000 T [3] to answer to the growing demand for this material. So obviously we will have to improve the extraction technology and the working regime (the workstations and loading and transport ... etc) to ensure the desired goal of production, taking into account the problems related to stability.
2. Methodology

In this article, we have made the combination of the room and pillars mining method with the technology used in coal mines by the longwall mining method to increase the productivity of the mine. And put the new sizing and all the necessary equipment. With the change of regime of work in the mine and until the loading and the transport of mineral towards the development plant.

3. Use of kieselguhr

Our kieselguhr can be used to filter aid [4,5], all kinds of liquid such as beer, wine, all kind of oil, as filler, such as plastic, rubber, paper, ceramic, cement production [6], insulating materials [7,8], fertilizers, coatings, cosmetics, pesticides, toothpaste, building materials, glass ... etc.

3.1 The characteristic of kieselguhr

The physical characteristics of the kieselguhr produced by the national the company ENOF are illustrated in (Table 1).

4. Case study

In the Kieselguhr mine in the Sig region for several years, uses the underground mining mode. This in the light of the fact that the cover layers reach 84 meters [3]. The open or mixed mode of operation cannot be considered since the stripping coefficient exceeds the norm, and economically very expensive.

4.1 The extraction method used

The choice of the operating method was based on a combination of two methods, that of room and pillar mining method and that of drifting and stoping. And this has been called:room and pillars with stoping and caving on residual keels.Drifting and stoping is a method used for the exploitation of deposits with a lenticular morphology and a thickness of less than 5m [9].

Driftingis an operation that consists of digging one or more horizontal or inclined tracks. And stoping is a major phase of the operation, involving the slaughtering and removal of most of the ore. This has been adopted at the level of different districts of exploitation because the layer of kieselguhr exploited is in plateau and that the disposition is very simple. It is based on the proper choice of dimensions to be given to the pillars so that they can withstand without weakness, cause of the pressures of the ground. But the problem lies in the resistance of the mineralized layer that is rather weak and causes the falling of the stones and the collapse of rooms sometimes because of the recovery of the mineralized pillars.

4.2 Principle of the method

This method consists of drilling parallel galleries 4 m wide, called "Drifting" as shown in (Figure 1), and spaced from each other by about 4 m, which is the width of the pillar. These pillars are then
partially recovered as shown in (Figure 2), only the residual pillars 2 m aside are abandoned and struck down [9].

![Figure 1. Drifting: Opening of the tracks [10]](image1)

![Figure 2. Stoping, cross-cuts, long pillar to Exploit the Pillars. [10]](image2)

4.3 Current production of the mine with the extraction condition used

The production of the mine in the last years does not exceed the 3000 t/year as illustrated in the (Figure 3), and that because of several factors affecting on the increase of the productivity of the mine that they are the following ones.

- The extraction technology used is not suitable for mechanical deposit conditions.
- The resistance of the rock is very weak causes instability of roof of the mine especially when to use the instruments, which cause the vibration.

![Figure 3. Production in tons the last years [3]](image3)

5. Optimization extraction technology

The longwall room and pillar mining method, is a method that combines room and pillar mining technology with the longwall mining technology [11]. The principle of this method with moving roof supports to extract the ore throughout the long panel (from 50 to 250 m) [12], and can be up to 5 km in length [13]. On varying heights (about 3 m), the ore is sliced down using a mechanised shearer on a front moving parallel to itself in the vein (mineralized layer), with an armored face conveyor (AFC), The AFC is connected to outbound belt conveyor. An aisle is kept open at the face of the waist, and let the roof fall at the back, at a safe distance for the miners and their equipment as shown in (Figure 4). The preparatory work includes the tracing of access tunnels to ore and the transport of ore to the extraction pit. The layer to be exploited being of reduced thickness and of great horizontal extension, it is generally possible to exploit it by a rather simple network of galleries. The rolling galleries are drawn in the same layer. The distance between two adjacent taxiways determines the length of the face [14].
5.1 Mode of opening and sizing of structures

✓ Sizing of the main gallery:
A main gallery identifies the door that allows access to the deposit, as a communication route, circulation and arerage. In the mine of sig the main gallery was already drilled before by mechanical slaughter as shown in the (Figure 5), since the base of the ground are marly limestones (low stability).

✓ Calculation of the surface and the volume of a panel:
The width = 2,5 m, thelength = 50, the height = 3m
Sp = 2,5. 50 = 125 m2, Vp = 125 .3 = 375 m³
Knowing that the mineralized rock does not exceed 3m

✓ Reserves of mineralized rock in a panel:
Rrm = Vp D (t/p)
Rrm: reserves of mineralized rock in a panel (t/p), Vp: volume of the panel, Vp = 375 m³D: density of kieselguhr D = 0.7 t / m³;
Rrm = 375. 0,7: Rrm = 262,5 t / panel

✓ Number of panels to be exploited per year:
To reach the desired production is 130 000 t/year it is necessary to determine the number of panels intended for exploitation in a year, represents the ratio between the desired annual production and the reserves of the mineralized rock in a panel.
Np = Pa / Rrm
Np: number of panels to be used in one year, (pan / year), Pa: annual production, Pa = 130 000 t /year.Np = 495 panel / year.
5.2 The proposed extraction machine

The choice of machine depends mainly on the desired annual production of the mine, which must have adequate capacity for a better yield and be economically acceptable. For this purpose, the machine that will be needed to increase the productivity of the Sig mine from 3000 t/year to 130,000 t/year is Ebz120 shearer machine as illustrated in (Figure 6). Which is used in particular in the coal mines and that suits the condition of our case of kieselguhr ore in view of the same almost hardness. Ebz120 shearer machine has been designed for medium to large veins to meet the needs of the world's most demanding long-life installations. Ebz120 shearer machine model can work in veins measuring up to 3.89m and it suits our case where the thickness of the mineralized layer does not exceed 3m.

![Ebz120 Underground Coal Roadheader for Coal Mine](image)

The choice of machine in this study is largely justified, since all the analyses carried out in the mines show that most of the failures are caused by the extraction method, the cutting machine and the conveyors [17], in particular in conditions where the rocks do not have sufficient strength, and We have therefore proposed a machine (Ebz120) because of its performance, as shown in (Table 2), which allows increasing the productivity of the mine while ensuring the safety of miners on the place.

| Table 2. Selected technical parameters of the shearer machines Ebz120 [16] |
|---------------------------------------------------------------|
| Max cutting height     | 3.89m          |
| Production capacity   | 3m³/min        |
| Dimension (L.W.H)     | 9.1x2.1x1.6m   |
| Loading capacity      | 180m³/h        |
| Tractive force        | 170KN          |

5.3 Work regime

- Daily efficiency of the machine:
  First of all, we will calculate the performance of the machine by post. The production of the machine in theory is 3m³/m. so 180m³/h. with the density of kieselguhr is 0.7 t/m³. So we can say that the production of the machine will be 126 t/h in theory. And with the conditions mine 85%, so it will be 107 t/h.
  We have 6 hours of work per post
  \[ Y_p = 107.6 = 642 \text{ t/p} \]
  \[ Y_p: \text{ yield per post (t/p)} \]
The daily yield can be defined by following:

\[ Y_d = Y_p \cdot \frac{N_p}{d} = 642 \cdot 1 = 642 \text{ t/d} \]

Therefore we can calculate from the results obtained the annual production of the mine as follows: \( P_a = Y_d \cdot N_d \), \( P_a = 642 \cdot 250 = 160000 \text{t/year} \)

5.3.1 Loading machines

For the loading of the kieselguhr ore into the Sig mine between extraction and unloading at the mine, the use of Sgb320 shielded conveyors was chosen as indicated in (Figure 7). This choice aims to the acceleration of the loading work given its high capacity as shown in (Table 3), and this conveyor was adequate with the shearer machine.

![Figure 7. Sgb320 Scraper Conveyors Machine](image)

**Table 3. The Technical characteristics of Sgb320 Scraper Conveyors Machine [16]**

| Technical characteristics                  | Value               |
|--------------------------------------------|---------------------|
| Model                                      | SGB620/40T          |
| Design length (m)                          | 100                 |
| Delivery volume (t/h)                      | 150                 |
| Chain speed (m/s)                          | 0.86                |
| Installed power (kw)                       | 40                  |
| Circular chain specification (mm)          | 18×64-B             |
| Middle groove specification (mm)           | 1500×620×180        |

5.3.2 Loading and transport to the treatment plant

After the changes we made to mining technology to increase the productivity of the mine. The transport system to the storage and treatment points must also be improved to ensure the planned movement of the mine.

a. Loading

✔ The Loading Efficiency by Post:

Ore and sterile will be loaded with a loader

\[ Y_w = 3600 \cdot L_c \cdot K_f \cdot K_u \cdot T_w / T_c \cdot K_e \]

Where \( L_c \): bucket capacity = 3 m³, \( K_f \): fill coefficient of the bucket = 0.75, \( K_u \): coefficient of use = 0.6, \( T_w \): duration of a workstation = 6 h, \( T_c \): The duration of a loading cycle (S) = 20 sec, \( K_e \): expansion coefficient = 1.5. \( Y_w \): workstation yield.

\( Y_w = 972 \text{ m}^3 \)

✔ The daily yield per ton is:
\[ Y_d = Y_w \cdot N_w \cdot \rho \]

Nw = number of workstation per day = 1, \( \rho \) = density of the rock = 0.7 t/m\(^3\)

\[ \text{Yd} = 972.1 \cdot 0.7 = 680 \text{ t / day} \]

\[ \text{Yd} = 680 \text{ t / d} \]

✓ Annual yield:

\[ Y_a = N_d \cdot Y_d \]

ND = number of working days per year = 250 days per year

\[ \text{Pa} = 170\,000 \text{ t / yr} \]

For production 130 000 T / year, and according to the results obtained, we can say that 1 loader is sufficient. But we take into account the duration of back and forth trucks and also take into account sudden stops charger or maintenance, we can offer 3 chargers to meet the need for production.

a. Transport

✓ Yield of a truck:

\[ Y_t = 3600 \cdot T_c \cdot T_p \cdot T_w \cdot K_f \cdot K_u / t_c \]

\[ T_c : \text{capacity of the truck} = 20t, T_w = 6 \text{ h}, K_f = 0.70, K_u =0.70, t_c: \text{the time of realization of a cycle} = 2700\text{sec} \]

\[ Y_t = 3600.20.7.0,70.0,70 / 2700 = 78,4 \text{ T/p} \]

✓ Yearly Performance of a Truck:

\[ P_{ta} = N_d \cdot N_w \cdot Y_t = 250.78,4.1 = 19\,600 \text{ T/an} \]

\[ \text{Ra} = 19\,600 \text{ T} \]

We can therefore say that, according to the results obtained, the trucks needed to ensure the production desired by the company are 6 trucks must be provided, with 2 trucks in reserve.

6. Discussion and conclusion

The proposed new extraction method has many advantages in that it: ensures the productivity of the mine with a very high production rate compared to the extraction technology used, and also ensure the good recovery of mineralized layer and pillar at the same time, and suitable for the poor roof (unstable overlying rocks) which has a very low resistance as our case, the workers are all the time under the support mechanic and that explains that the safety of workers are always assured. And according to the results obtained with this method, the production of the mine has increased up to 160 000 t/year, with working hours less.

To achieve the desired results of increasing production. And according to the obtained results of computation, it is necessary to increase also the conditions of a working regime where it has been concluded that the number of loaders necessary is 3, and the number of the truck is 6 of capacity of 20t. considering all possibilities relating to the sudden stop of the machine and the maintenance.

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