Syferfontein Dolomite Mine (Pty) Ltd is a dolomite mining company based in Mopane area, located about 40km south of Musina.
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CHAPTER ONE: INTRODUCTION

1.1. Background of study area

Syferfontein Dolomite Mine (Pty) Ltd is a dolomite mining company based in Mopane area. The traditional method of drill and blast is applied in order to fragment the rocks. The terrain contains different rocks and structures of different characteristics. The mine has been in operation since 1999. Mining is by traditional drill and blast methods in an open-pit Quarry where all products are sorted and carried out and placed in concrete storage bins for transport to the Syferfontein Carbonates (Pty) Ltd Modimolle Central Processing Plant. Once final pit depth has been achieved, backfilling of waste material will commence. Prior to mining, topsoil and surface rubble is removed and stored on a "topsoil" dump, which will be used to spread over the disturbed area once mining is complete. The mining method is in accordance with the Environmental Management Programme as approved by the Department of Minerals and Energy (DME), Rehabilitation guarantees are regularly reviewed by the DME and adjusted on a two yearly basis.

1.2. Description of the Study Area

1.2.1. Location

Syferfontein Dolomite mine (Pty) Ltd is found in Limpopo Province of Republic of South Africa. It is approximately 8 km from N1 road and it is located at Mopane about 8 km from the N1/R525 intersection and about 40 km south of Musina. It is located between latitude 22˚37'20" South and longitude 29˚51'30, 63" East. Figure 1 is a map showing the geographic location of Mopane area with reference to the nearest town.
1.2.2. Vegetation

The Mopane shrubs is the dominating plant cover, with dense-medium grass over relatively flat terrenes and the evenly distributed Baobab tree within the reddish soil-coverage.Repeatedly, this appears mainly on the gentle and flat terrains, while thorn shrubs appear only on the flat clay soils and sandy soil along the stream channels on the non-perennials.

1.2.3. Topography

The area is situated in a relatively flat to gentle slope terrain of the Soutpansberg mountain ranges, geographically stretching in the general north-east direction from Tropic of Capricorn to the Beit-Bridge border post, with evenly distributed rocky hills (Brandl, 1981). The altitude or elevation ranges from 500 – 670 m above mean-sea-level, with a slight dipping towards the south-eastern direction.

1.2.4. Climatic condition

The climatic conditions of the area is quite distinctive in seasonal changes, with mild winter temperatures, low rainfall rates and hot summer days with highest rates of both temperatures and rainfall readings (Chinoda et al., 2009). The study area receives about 246mm of rain per year, with frequent rainfall during mid-summer period. It receives the lowest of rainfall even up to 0mm in June and the highest of 55mm in January.
CHAPTER TWO: ITEMS OF EQUIPMENT

2.1. Jackhammer driller

A jackhammer is a tool in which they use to drill the boulders, trying to create some cracks so that when they break them using sledge hammer it will be easier. The driller is operated by the circulating air driven by pipes into the driller, where in from this point the driller will vibrate pressed to the rock to a point of breaking it.
2.2. Sledge hammer

A sledge hammer is used as a substitute of a jack hammer when for instance the rock already contains cracks, so instead of using a jackhammer, they basically use a sledge hammer to break the rocks. The sledge hammers are usually used by man since they are huge and heavy that it requires man power.

2.3. Front end loader

A front end loader basically, they use it to move the rocks from the ground that the workers have stockpiled. These rocks are loaded into the front end loader then it dumps the rocks into the dump truck.
2.4. Bins

The bins are usually used by woman to collect the tiny rocks since they are not allowed to break the rocks using hammers. So they usually pick up those small rocks which usually looses off when the males are breaking by the hammers and they collect it into the bins, of which each woman is required to fill eight of this bins per day.

2.5. Pneumatic rock drills

These are hand held rock penetration tools driven by compressed air and consist of hollow drill steel that provides for the circulation of the flashing fluid. The compressed
air used is provided from the existing compressed air installations. In Syferfontein, rotary pneumatic rock drills are used due to the inconsistency of the rock resistance to penetration.

2.6. Excavator

Excavators are heavy construction equipment consisting of a boom, stick, bucket and cab on a rotating platform (known as the “house”). The house sits atop an undercarriage with tracks. It is used to excavate the blasted materials and other unconsolidated. It is also used to load the ore to the articulated dump truck in the mine.

2.7. Articulated dump truck or dumper
An articulated dump truck or dumper is an all-wheel drive, off-road dump truck. It has a hinge between the cab and the dump box, but is distinct from a semi-trailer truck in that the power unit is a permanent fixture, not a separable vehicle. It is used to transport the ore and waste material from the pit to the waste dumps and to the sorting site, even from sorting site to the plant for crushing and milling.
CHAPTER THREE: MINE PROCESSES

SCHEMATIC REPRESENTATION OF PRODUCTION CYCLE IN SYFERFONTEIN MINE

3.1. Production Cycle

The production cycle at Syferfontein Dolomite Mine consist of rock breakage and material handling where different items of equipment which includes hand held rock drills, excavator, load-haul dump truck, explosives and its ancillary items are used.

3.1.1. Drilling and Blasting

Drilling and blasting together with excavation works interchangeably depending on the nature of materials that are encountered during the mine advancement i.e. consolidated (mostly consist of hard rocks that cannot break easily, and therefore requires drilling and blasting to break such rocks into smaller blocks that can be excavated) or unconsolidated (mostly consist of soil or soft rocks that can be
easily excavated, and therefore requires no drilling and blasting). In Syferfontein Dolomite Mine, mostly the hard rocks are encountered and, drilling and blasting is usually considered as the main method of rock breakage.

Due to the unavailability of a geologist to actually direct the advancement in drilling, the mine supervisor and the drilling team leader are actually responsible for the direction in drilling. Since there are no professionals, what they basically do is to follow the rock which is mostly rich in grade A and that's where they will start to formulate their drilling pattern based on their observation. There should be a maximum spacing of one meter between drillholes at any direction and with a diameter range of 34mm to 42mm. The drillholes are drilled to a depth of 3m to 4m and are closed by dry grass to avoid the falling in of soils and rock particles. The number of drillholes usually depends on the area to be drilled and the availability of the explosives together with the demand of the ore supply for sorting, crushing and milling.

Pneumatic drills (hand held rock drills) are used for drilling with the application of rotary drilling method in which the air is supplied from the compressed air installations existing in the mine. After the process of drilling explosives are charged for blasting, and ammonium nitrate explosives called Anfex® are used for blasting. The process of charging includes various practices i.e. the practice of filling the explosives into the drillholes, connecting the power cord and stemming. In a 4m drillhole the following sequence is followed respectively: 660ml of Anfex; 660ml of sand; 660ml of Anfex; 330ml of sand; 660ml of Anfex and the remaining volume is filled with sand as part of stemming.

The sand filled between the explosives before the actual stemming is for consolidating the explosives and also is thought to be a better strategy to save explosives (it is rendered cost effective use). During the charging, the power cord is inserted in the hole to a full depth for effective detonation and after charging the main power cord is connected to the one inserted in the drillholes and is connected according to rows in which a Relay (the cord is fold at a maximum length of 3cm when joining at each side of the Relay) is inserted at each turning point to enable simultaneous detonation. The power cord is then connected to the
detonating fuse that is connected to an electric cable to enable the triggering by the detonating battery.

After all this is connected, the area is ready to be blasted and at ignition, it takes only 1.5 seconds for the explosion to take place. During blasting workers are actually evacuated from the mine to avoid injuries from flying rocks.

Figure 10: A (Drilling); B (Anfex (ammonium nitrate) explosives); C (Charging (inserting the power cord into the drillhole)); D (Charging (stemming)); E (A relay connected to the power cord); F (Detonating fuse); G (Detonating battery) and H (Power cord).

### 3.1.2. Excavation

Drilling and blasting with excavation can be well expressed as a continuous process than as separate operation. As for Syferfontein mine, excavation is considered when extending the pit i.e. removing the top soil and other unconsolidated materials since the mine have no benches, so the pit is extended only when following the ore direction; and also when preparing broken rock for loading i.e. piling the broken rock into a defined area to enable easy loading. And the excavation process can operate together with drilling but is paused during blasting and resumed at least 20 minutes after blasting (within this 20 minutes, the first 5 minutes is reserved for checking blasting misfiring to ensure proper safety practice).
3.1.3. Loading

Since all these processes are interconnected and continuous, loading is actually conducted simultaneously with excavation i.e. the broken rock is excavated and loaded at the same time by the excavator.

3.1.4. Haulage

Haulage is the transfer of the loaded materials from the pit to the sorting area, it can be considered the last stage of the production cycle and a transition between production cycle and processing (the load haul dump truck is used for the transportation of the ore which is the loaded), even between sorting and, crushing and milling, load and haulage is required.

3.2. SORTING

3.2.1. Sorting Site

Sorting site is basically the area where the load dump truck dumps all the rocks which are hauled from the mine or pit. These rocks are dumped into this area where in they are usually broken into small manageable size so that they can be taken to the crushing mill. The number of workers in Syferfontein mine sorting site is 27 in total (23 are males and 4 are females) the reason for this is because the work which is done there is really tough and hard that it requires man power. Every worker is required to fill up two buckets of a front end loader, which is basically 2 tonnes per worker. This number of tones from each worker enables them to reach the required ton per day.

The process involved in this area is that after the load dump truck dumps the rocks, since they are basically in big sizes, what happens is that they break them into small sizes through the use of jack hammers and sledge hammers, usually done by man, since it requires man power, then it will then be loaded into a front end loader which is then dumped into the load haul truck which transport it to the crushing mill.

3.2.2. Sorting Process

The sorting process is basically done based on the grades of the rocks that they are mining. The dolomite that they have is basically in two if not three types of grades.
They have another type which they classify it as A, then they got B then lastly they got C, but because they can’t really note out the difference between grade A and B, and also because they want to ease the job for the workers, they actually decided to class both grade A and B as the same category, and grouped both into grade B, so basically now they have two grades that the workers have to sort.

Grade A/B this is the type which is not spotted, not weathered or contaminated but most likely clear and almost white in colour. This is the type which they usually prefer than grade C basically because it is more demanded in the market.

Grade C is basically the type which is spotted, contaminated but at least not weathered. It usually contains the colour white but with some black spots which could be as a results of metamorphism which could have been taking place. This type of grade is basically not their main interest, but they still process them since they are also in the market, especially in the coal mining company of which the use of it will be explained in the uses of Dolomite.

Workers usually sort these rocks according to the grades mentioned above. Grade A/B is sorted and stockpiled at a side separated from C so as grade C, then from this point it will be loaded by a front end loader into the dump truck.

3.3. PROCESSING PLANT

Within the processing plant section of the syferfontein mine, the dolomite which is to be processed is first crushed through crushing plant, a jaw crusher to make +/- 90mm dolomite that can pass through a mill which manufactures lesser size of dolomite, even powder.

3.3.1. Jaw crusher
The large materials are fed in the jaw crushe evenly and gradually by vibrating feeder by way of a hopper for the primary crushing. After the first crushing, the material will be conveyed to the impact crusher by belt conveyor for a secondary crushing. The impact crusher is vital crushing equipment in aggregate plant to produce good quality aggregate. The major feature of the impact crusher is the final produce of impact crusher is within cubical shape, which can be suitable to use as top quality aggregate.

3.3.2. Aggregate Mill

In a course aggregate milling plan, gemstones crushed by the jaw crusher and impact crusher tend to be suited to coarse aggregates. Shaking screen is used as combination screening machine in aggregate screening process. According to the requirements of size, choose the best display cloth to screen out your eligible aggregate. Aggregate automatic washer and belt conveyor are also crucial mining machines in stone aggregate production line.
CHAPTER FOUR: PRODUCTS

4.1. Product Distinction

Dolomite products within the syferfontein mine have different quality ranges. The type of Dolomite within the mine area which is of high interest is classified within A-type, B-type and C-type. The Dolomite types are differentiated by the reflectance which is measured by the reflectometer.

A-type dolomite is a pure dolomite with a reflectance of 85%-90%. This type of dolomite pure white and has no impurities with clear crystals. B-type dolomite is white to grey with minor impurities and has the reflectance of about 80%-85%. C-type rock has lots of impurities with the reflectance of about 75%-80%. A-type dolomite is rare within the Syferfontein mine so they mine B-type and C-type dolomite. The B-type dolomite costs more than C-type dolomite because it is of greater quality.

Figure 13: A-type Dolomite
Syferfontein mine sells their products to different companies for different reasons according to their sizes. For instance:

- 13mm dolomite chip in funeral services
- 2,2mm chips in paint industries
- 815µm sized dolomite in Tshikondeni mine
- 45µm powdered dolomite in tiles industries
4.2. Uses of Dolomite

Dolomite is a type of limestone rich in magnesium and calcium carbonate, and has smaller amounts of several other minerals. This mineral can be a good source of calcium carbonate and magnesium. Dolomite can also be used in the following:

- In marine (saltwater) aquariums to help buffer changes in pH of water.
- Powdered dolomite can be used in paint industries to thicken the paint that is manufactured.
- Dolomite chips can be used in graveyards to decorate the tombstones.
- In coal industries as for its reflectance to increase light intensity in underground mines. And also used as stone dust
- In horticulture dolomite are added to soils and soilless potting mixes to lower their acidity and as the magnesium source.
- For construction where it is usually a substitute for limestone.
- In agriculture dolomite can be used for soil conditioner.
- For medical purposes in calcium supplement and magnesium supplement. Also helpful in for bone health to increase quantity of calcium.
CHAPTER FIVE: PRODUCTION RATE

5.1. Factors affecting production rate at Syferfontein

There are many problems affecting production at the mine. They are appraised depending on their impacts on production. These problems affect workers, management and the mine resulting in low production. The identified major problems include: workers related problems, financial problems, operational methods and the problems related to the machinery. Each of these these problem has its own contribution in slowing down production.

- Lack of money is considered the main problem because if the mine lacks money, it is difficult to implement new and more advanced methods that may give rise to production.
- Another problem is the operational methods that the mine applies. The methods of production used at the mine are slow, labour intensive and are less productive.
- Another problem is shortage of workers. If a miner from the sorting site does not avail himself for a day, 3 tonnes of product will be lost.
- Machinery related problems include shortage of machinery and poor performance of the machinery.
- The last problem is employing unskilled labour. Workers lack knowledge of using equipment properly and in a productive way.

5.2. Ways to improve production rate within the mine

- Soliciting financial support- Financing small scale mining operation and making credit available for production improvement is most often identified by miners as a major problem. As most rotating funds have not work well because many financing institutions consider the small scale mining sector to be too risky for them to be part of. Another thing is that financial institutions that are willing to deal with them tend to charge high interest rates. Because of the low level of knowledge of mining business, financial operators are apprehensive of the credit applications made by small-scale miners.
• Increasing number of Workers-Shortage of workers is one of the major problems affecting production as few workers are expected to carry out a heavy workload.

• Application of Modern Methods and Advanced Technology-Traditional methods that are practiced at the mine are less expensive but they are time consuming and not that much productive.

• Development of Training Programmes- Both the management and workers requires training aimed towards improving production at the mine. Education, training, demonstration and surveillance are the key elements of any programme to improve productivity and occupational health and safety in small scale mines.

• Increasing number of equipment - The main cause of shortage of equipment is due to lack of funds, which means the management must address the financial problems first so that it will be easier to obtain the required equipment that will result in increased production efficiency. Increase in number of equipment will help in improving production because there will be machine that are reserved for substitution when others are damaged, preventing the situation where production completely stops while waiting for machinery to be fixed.
CHAPTER SIX: ENVIRONMENTAL ISSUES

6.1. Environmental Impacts of Dolomite Mining at Syferfontein

Even though dolomite is well known to be non-toxic when considered by its mineral composition (CaMg(CO$_3$)$_2$), the plethora of processes and activities that are involved in its extraction are usually the generators of negative impacts to the environment and these includes the mining method itself, and other activities such as land use pattern. These activities impact negatively to the environmental components such as air, water, land and biodiversity. The environmental impacts of Syferfontein dolomite mine are portrayed in many areas including: micro-meteorology; air quality; buffer zone (the area surrounding the mine); water quality; noise environment; land use pattern; soil quality and flora-fauna (biodiversity).

**Micro-meteorology:** this actually refers to the confined climate within a defined area around the mine and this area can be differentiated from the rest of the region by relative humidity which then influences the actual feel of the daily temperatures; and as for Syferfontein mine, daily temperatures usually has the feel to be higher in the operational area compared to the local normal temperatures expected.

**Air quality:** the challenge in air quality in Syferfontein is air pollution as in most mines and the potential sources of air pollution in the mine arises from drilling, blasting, overburden waste dumps, haul roads, and exhaust fumes of internal combustion machines and transportation of ore in the vicinity.

**Buffer zone:** this is considered as the total response of the surrounding area in a manner to reverse the alienated effect of the mining operation on the environment. It can be expressed through the stability of natural processes occurring around the mine as opposed to pollution and other forms of disturbances caused by the mine. In Syferfontein mine, natural processes such as evapo-transpiration are disturbed due to dust coating on the leaves of trees surrounding the mine.

**Water quality:** water quality in Syferfontein mine is not a major challenge because the area is characterised by very low rainfall but during wet seasons, the water is allowed to flow out of the mine i.e. runoff is not controlled and therefore result in raising pH in the waters of local streams which may have negative impacts on the aquatic life.
Noise environment: as most surface mining operation, Syferfontein mine is characterised by high levels of noise due to heavy machinery operation and most of the continual high noise is produced from the processing plant. The figure below displays the cautionary sign board that is posted within the mine premises.

Land use pattern: this is addressed in terms of how the mine landforms are arranged; for example in Syferfontein mine, the dumping area is not properly defined which leads to very large piece of land wasted as a dumping area, and this can be easily expressed by the concept of land degradation.

Soil quality: the pH of the soil is generally altered by the dolomite dust and making it fail to support some of the native plant species of the region, and moreover the soil at haul roads is highly loosened and made high susceptible to soil erosion. The alteration of soil can be through the elimination of some plant species through cut-down to clear the area for space of construction.

Flora-fauna: the biodiversity is affected negatively even at the early stages of the mine and are continued to be disturbed through the lifespan of the operation and beyond. The cutting down of the trees to provide space for the infrastructure have destroyed habitats of the fauna around the Syferfontein mine which has led to migration of some of the animals native to the area. The dust generated in various parts of the operation has coated the leaves of the surrounding area and this result into low productivity of such plants.

6.2. Mitigation Measures

Mitigation measures are addressed in terms of relative problems in Syferfontein mine where the approaches are classified under different categories:

a) The production of blast fumes containing noxious gases are controlled by proper and proportionate mixing of fuel oil with ammonia nitrate to ensure complete detonation; use of adequate relays, detonating fuse and power cord; and proper stemming of the blast hole.

b) The points of dust generation are:
   i) Drilling and blasting;
   ii) Loading of ore and waste;
   iii) Haulage of ore, waste rock and soil;
iv) Crushing and screening; and
v) Dispatch of ore in trucks.

Dust suppression of these points could be controlled through different methods including: wet drilling of blast holes (not practiced in Syferfontein mine); frequent sprinkling of the haul roads by water at regular intervals (the method is in practice in Syferfontein mine).

**Noise pollution control:** noise can be best abated at source by choosing machinery and equipment suitably, by proper mounting of equipment.

**Green Belt development:** conducting new plantations is of paramount necessity to the area. In addition to augmenting present vegetation, this will also help control soil erosion, making the ecosystem more diverse and functionally more stable; and the climate more conducive and improve water balance. It can be practiced along haul roads, the processing plant, dumping area and other parts of the mine; and this may help to prevent further deterioration of land. Based on nature of soil various plant can be suggested.

**Socio-economic measures:** the main area of challenge in the mine is the quality of life of the people. The important indicators which decide the quality of life and require to be improved for better living conditions are literacy levels, improved occupational structure, industrial development, infrastructural facilities, transportation, communication linkages; and other factors may be implemented to help effectively manage the environment and help comply with the national regulation standards and legislations.
CHAPTER SEVEN: HEALTH AND SAFETY

Works in the mine are very hazardous and dangerous; it actually threatens the health and safety of workers. This is why it is very crucial for workers to use protective personnel equipments to ensure safety upon themselves and good health. Then for the management is essential for them to provide PPE for the workers so that they can comply with the legislation health and safety act, accidents are costly; this is the money that will be used to cure all the injured or ill workers, so it’s really crucial that all this will be prevented.

**Following parameters are taken to ensure that health and safety is under control all the time.**

Syferfontein dolomite mine actual have PPE such as helmets, gloves, dust mask, ear plugs, safety harnies and boots. The mine is an operation which deals with drilling quarrying.

**A SET OF PERSONNEL PROTECTIVE EQUIPMENT**

- There is a First Aid clinic at the reception where in all the injuries are reported for possible treatments.
- Workers should wear boots at all times to prevent injuries especially cuts from rocks and also harm from jack hammers.
• They are also given safety goggles to wear to prevent eye injuries from flying rocks, dust and also to reduce the light illumination from the eyes since dolomite is very bright to an extent that the reflection can cause harm into the eyes.

• The process involves handling of rocks and they are hazardous that’s why they should wear gloves before handling rocks.

• Safety harness belts are used when drilling in steeper areas to prevent the driller from falling down the slope ear gloves before handling rocks.

• Dusk mask are used to cover the nose to prevent dust.

• Hard hat should be worn in order to protect the head from flying rocks from the ground during the process of drilling i.e. it is a must to wear the hard hat when enter into the mine.

• They also wear earplugs to prevent ear drum problems from the noise of the drilling machines.
CONCLUSION

Syferfontein is basically a mine where they undertake all the process in the mining area, both drilling and blasting, the sorting processes and then lastly the processing plant, where in the rocks are crushed into different sizes of products according to the market’s demands. Though it’s a small scale mining they have most number of mechanized items of equipment that they use which makes their mining process often easier and simpler.

In terms of health and safety there is no much effect related to the working environment and even if you are exposed to it for a long period, there is no known consequences, as long as you are complying with the health and safety regulation, such as wearing the dust mask to prevent from dust and also wearing the goggles to prevent eye injuries from flying rocks and lights effect, safety boots, ear plugs and helmets always when at the working area.

Within the milling section of the mine, final products are produced, with sizes of aggregates varying. The choice of sizes depend on the company buying, depending on their uses, for example 13mm dolomite chip in funeral services, 2,2mm chips in paint industries, 815µm sized dolomite in Tshikondeni mine, 45µm powdered dolomite in tiles industries.
RECOMMENDATION

The mine owner needs to provide efficient and adequate PPE to the workers, this will enable them to prevent various number of injuries occurring. It’s also crucial that they hire some skilled labour.

Despise the skilled labour; the mine may implement an educational programme that will elevate the level of literacy of the existing labour in which the whole mining process will be explained at ease to help the labour to comprehend the danger of not complying with safety measures provided by the mine.

The management should come up with some sort of production exploration so that they can know where their ore is spreading. This will save them from blasting in wrong areas thus saving costs and also improve their productivity efficiency.

They should be a mine design plan, where a plan of a mine is outlined with benches, to increase the life span of the mine.

Machinery used are not efficient thus they breakdown from time to time, to avoid such, the mine should invest in buying new equipment for the mine.
REFERENCE
