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INTRODUCTION TO UNDERGROUND MINING

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ABSTRACT

As known mankind is always looking for new technologies and materials to increase the living standing by: building skyscrapers, improving the means of transport, producing much more electricity to face to the growing of the need of energy.

To be able to take all these challenges we are utilising the resources providing to us by the nature and a large amount of these natural resources come from mines such Metals like Gold, iron, aluminium, copper, used for building, transport and fashion purpose: Coal and Uranium for energy production purpose

So that our life is strongly linked to mining, that is why everyone must have at least a basic knowledge about the different kinds mining end their importance.

Because of the fact that the majority of people restrict mining to the surface mining, in this paper we are going to talk mainly about UNDERGROUNG MINING so that we can help people to know its different kinds , their needs and how one of them takes place.

Key words: mining; underground; pillar; impacts; equipment

INTRODUCTION TO MINING

Mining literally means **extraction** .Our Mother Earth has lots of resources deep within her and mining is the method of extracting all these valuable resources from the earth through different means. There are different methods to extract these resources which are found in different forms beneath the earth's surface. It goes without saying that it is the most important achievements of mankind, the first being agriculture.

The modern civilization is indebted to the mining industry for extracting the valuable resources from the depths of the earth's surface and it can be mentioned that all the important gadgets used by the modern civilization is supplied by elements extracted through mining. Its contribution to mankind is enormous. The natural mineral substances like solid, liquid and gas were extracted from the earth and used by mankind for various purposes. When we go back to history, it is seen that this process of extraction is closely associated with all ages like Stone Age, Iron Age, steel age, etc. Many important achievements in human history were achieved with the minerals extracted thereby providing a major incentive. By the extraction of these minerals, countries started to accumulate wealth and they were considered as the greatest civilization of the world and those countries that did not extract these minerals were considered to be a country suffering from a lower standard of living. The advanced countries carried forward the extraction of nature's wealth and expanded their economic activities beyond their borders. The excavation of minerals led to the expansion of industrial growth and discovery of different islands in search of minerals.

Underground Mining

Underground mining is carried out when the rocks, **minerals**, or **precious stones** are located at a distance far beneath the ground to be extracted with surface mining. To facilitate the minerals to be taken out of the mine, the miners construct underground rooms to work in. The mining company selects the best feasible way to get the minerals extracted out.

Most mining is carried out using; Continuous mining that employs a continuous mining mechanism to cut the **coal** deposits from the walls. This means there is less of blasting and drilling and utilizes fewer miners down in the mines. It is safer than the yester year **techniques of mining**.

This kind of mining is done when the rock or mineral is on the side of a mountain. This makes it an easy, cheaper way to mine. Minerals that are mined with draft mining are gold, coal etc.

Two prominent ways through which underground mining is done are:

Underground mining (hard rock) & **Underground mining (soft rock)**

Underground hard rock mining refers to various underground mining techniques used to excavate *hard* minerals usually those containing metals such, copper, zinc, nickel, tin and lead, but also involves using the same techniques for excavating ores of gems such as diamonds.

Underground mining (soft rock)

The method of extracting coal, oil shale, potash and other minerals from soft or sedimentary rocks are called underground soft rock mining. In contrast to this is the underground hard rock mining where techniques are used to extract minerals that are hard. This method, called the soft rock mining is used only in places where the deposits in sedimentary rocks are layered and soft. This method is implemented after a careful study and the amount of deposits available in the area. The economic liability of the project is also taken into consideration before going ahead as the investment into the scheme will be large and returns should commensurate with the amount of spend on the project.

Process of underground mining

In an underground mine, ore and minerals are extracted in stopes or rooms. Sometimes material, known as a pillar, is left behind to support the mine ceiling and then later recovered when mining is completed. Providing support to the roof is key in the prevention of falling rock; one the potential dangers of any underground mining operation. In the past, roof support consisted of bracing the roof of the mine with timber and eventually concrete. Ore was also mined mostly by hand with picks and shovels and then hauled back up to the surface by cart using a rudimentary hoisting system or small horses known as pit ponies.

Today, underground mining exists as a highly mechanized operation. Supporting the mine roof is accomplished using both temporary and permanent steel supports or , most commonly, by bolting the roof of the mine using roof bolting equipment. Ore is mined using a wide selection of specialized cutting and drilling equipment such as continuous miner and rock drills. Once extracted, the ore is hauled from the slope or room back up to the surface by rubber-tired vehicles known as shuttle car or load haul dump trucks (LHD), or by a conveyor belt system.

TYPES:

- **Room and pillar mining** is the most common method of underground mining. The roof of the mine is supported by areas or columns of coal (pillars) spaced out at regular intervals in rooms from which the coal is mined. The two types of room and pillar mining are conventional and continuous mining.
- **Longwall mining** is a more modern method of underground to extract coal from a coal bed. The technique was developed to replace room and pillar mining and includes the mechanized removal of long panels of coal from a rock face using longwall mining equipment—coal shearers mounted on series of self-advancing hydraulic supports. As the longwall miner advances along the panel, the roof behind the miner's path collapses.
- **Cut-and-fill stooping** is a method of underground mining used in vertical stopes and in mining high-grade irregular ore bodies. The rock mass surrounding the ore deposit is also usually weak—unable to support loads over an extended stooping height. As the name of the method implies, successive cutting of the ore into horizontal slices is carried out starting from the bottom of the stope and progressing upward, towards the surface. This horizontal slicing leaves a void that is backfilled with material to provide support until all the ore is extracted from the mine.
- **Sublevel stooping** is an underground mining method that involves vertical mining in a large, open stope that has been created inside an ore vein. Usually the stope operates as the centre for production. In sublevel stooping, this is not the case. The stope is not meant to be occupied. Drilling, blasting, and mining are carried out at different elevations in the ore block.
- **Block caving** is an underground mining method that permits the bulk mining of large, relatively low-grade bodies of ore. As a sublevel mining process, block caving involves the controlled collapse of ore from under its own weight into chutes or draw points using gravity. In order for a block caving operations to be successful, the rock mass must be able to fracture naturally once an undercut has been applied.
- **Borehole mining** is a remote-controlled method of underground mining used to mine a broad range of natural resources and industrial materials. A borehole tool comprised of two pipes—one that delivers a stream of high pressure water, and another that delivers slurry back up to the surface—is used.
- **Shaft mining** is a form of underground mining using shafts driven vertically from the top down into the earth to access ore or minerals. Shaft mining, also termed shaft sinking, is particularly ideal for concentrated mineral deposits, such as iron or coal, that are deeply imbedded underground.
- **Auger mining** is a surface mining technique used to recover additional coal from a seam located behind a high wall produced either by stripping or open-pit mining. Auger mining is especially employed when contour strip mining has been exhausted and the removal of overburden to access additional coal no

longer becomes economically feasible. Auger mining can also be utilized in underground mining when faulty or poor roof conditions are present or other problems preclude the use of other underground mining techniques.

- **Vertical crater retreat**, also referred to as **vertical retreat mining**, involves drilling large-diameter holes into the orebody vertically from the top of the mine, as opposed to the conventional blast hole stope method of drilling them in fans from bottom to top.
- **Slope mining** is a type of underground mining where the coal bed is located very deep and parallel to the ground and the shafts are slanted. This type of mining is normally carried out when drilling shafts vertically downward becomes problem

As said above there exist many methods to extract minerals from the ground related to underground mining and one of these methods is Room and pillar mining.

So let us give a brief statement about room and pillar mining and explain how it goes on:

HISTORY

Room and pillar mining is one of the oldest mining methods. Early room and pillar mines were developed more or less at random, with pillar sizes determined empirically and headings driven in whichever direction was convenient.

Random mine layout makes ventilation planning difficult, and if the pillars are too small, there is the risk of pillar failure. In coal mines, pillar failures are known as squeezes because the roof squeezes down, crushing the pillars. Once one pillar fails, the weight on the adjacent pillars increases, and the result is a chain reaction of pillar failures. Once started, such chain reactions can be extremely difficult to stop, even if they spread slowly.

Room and Pillar mining, otherwise known as the continuous mining. This is one of the safest methods. It is efficient and eco-friendly too. As the name indicates it is a method by which the large pillars of coal are left standing to support the room of the mine. A major portion of the coal is used to stand intact as pillars to maintain the quality of the surface land. By this method the minerals mined are extracted across a horizontal plane and as a result, they create a horizontal display of rooms and pillars. This type of mining is used in mining iron and coal. The selection of the size of the pillars matters a lot in successful room and pillar mining. The size of the room and the pillar are almost equal and if the pillar is larger than the room there is a possibility of valuable materials to be left behind in the process of mining, which will affect the profit of the mining project. If the pillar is small there are chances for the mine to collapse. This is one of the oldest methods of mining. It is necessary to take care to fix the pillar firmly otherwise if one pillar fails this will affect the surrounding pillars and as a result it will lead to the collapse of the mine. To prevent this damage, barrier pillars are created which will prevent the collapse of the mine. The final stage of this process is known as retreat mining. It helps the pillar to be removed or pulled back. The wall of the mine is then allowed to collapse behind the mining area. The removal of the pillar should be done systematically and this will reduce the risk factors involved in mining.

The proportion of material mined differs relying on a lot of factors, comprising the material mined, height of the pillar, and roof circumstances; characteristic values are: stone and aggregates 75%, coal 60%, and potash 50%.

TYPES:

There are two different types of room and pillar mining. The first involves the conventional method of drilling holes into the coal, blasting the rock and loading it into carts to be transported out of the mine; the second, known as continuous mining, involves a continuous miner machine cutting coal from the mine's face in a continuous flow, eliminating drilling and blasting equipment.

PROCESS:

Mine layout:

Room and pillar mines are developed on a grid basis except where geological features such as faults require the regular pattern to be modified. The size of the pillars is determined by calculation. The load-bearing capacity of the material above and below the material being mined and the capacity of the mined material itself will determine the pillar size.

If one pillar fails and surrounding pillars are unable to support the area previously supported by the failed pillar they may in turn fail. This could lead to the collapse of the whole mine. To prevent this the mine is divided up into areas or panels. Pillars known as barrier pillars separate the panels. The barrier pillars are significantly larger than the "panel" pillars and are sized to allow them to support a significant part of the panel and prevent progressive collapse of the mine in the event of failure of the panel pillars.

Room and pillar mining is usually used while extracting coal, iron, and copper ores; it is best suited for deposits that are relatively flat. Rooms generally are 2,067 feet (630 m) wide and pillars are up to 328 feet (100 m) wide; pillars, and subsequent grid-like patterns, are formed as mining advances.

This type of mining requires care and precision to ensure the pillars left behind are of the correct size to enable miners to extract enough ore with the support of the pillars but not so much that they leave behind a substantial amount of valuable ore.When mining with this method, miners must consider the height of the pillar, the conditions of the roof and the likelihood that it could cave, as well as the type of mineral that is being extracted. It is important that all of the pillars are supportive, as one falling pillar will result in Subsequent collapsing of the cave, a disaster that is known to occur in this method of mining.Sometimes the pillars are filled with backfill or waste material to provide additional support. Other times, timber and steel supports are elevated alongside the pillar. Self-supporting pillars can stand without additional support.Ore located in the pillars is usually abandoned and not recovered, for doing so could result in the collapse of the mine.

RETREAT MINING

Retreat mining is often the final stage of room and pillar mining. Once a deposit has been exhausted using this method, the pillars that were left behind initially are removed, or "pulled", retreating back towards the mine's entrance. After the pillars are removed, the roof (or back) is allowed to collapse behind the mining area. Pillar removal must occur in a very precise order to reduce the risks to workers, owing to the high stresses placed on the remaining pillars by the abutment stresses of the caving ground.

Retreat mining is a particularly dangerous form of mining: according to the Mine Safety and Health Administration (MSHA), pillar recovery mining has been historically responsible for 25% of American coal mining deaths caused by failures of the roof or walls, even though it represents only 10% of the coal mining industry.

ROOM & PILLAR EQUIPMENT

HIGH-PERFORMING EQUIPMENT FOR EVERY ASPECT OF THE ROOM AND PILLAR MINING PROCESS

We feature state-of-the-art Cat® equipment for cutting, loading, hauling and every other room and pillar mining procedure, including:

- **Continuous haulage machines:** Cat produces diesel- and battery-powered mineral haulers that provide the ultimate combination of power, manoeuvrability and capacity. They're available in a wide range of operating heights and conveyor widths to meet the requirements of virtually any underground mining operation.

- **Scoops:** Today's Cat low-profile scoops for mining are the product of more than 40 years of design and engineering expertise. Key features include planetary wheel drives, proprietary IGBT electric controls and a multi-purpose contoured bottom bucket.

- **Face haulers:** If you're looking for rugged, dependable face haulage equipment that also provides the valuable element of flexibility, Cat face haulers will meet your needs. Choose from a wide range of battery- and diesel-powered machines in various sizes and configurations.

- **Feeder breakers:** These revolutionary Cat machines offer fast and efficient breaking and feeding of crushed rock or ore. Capabilities include processing rates of up to 1,800 tons per hour, standard pick force ranges of up to 100,000 lbs. and maximum breaking strengths of up to 30,000 psi.

- **Roof bolters:** Cat roof bolters are designed to enhance productivity and safety in room and pillar mining operations. Important product features include user-friendly operator zones, quick free-steering towing conversion and individual planetary wheel drives.

- **Continuous miners:** Cat continuous miners can handle hard and soft cutting application with equal ease and efficiency, regardless of seam thickness.

Evolution of underground mining equipment

Equipment developed for open-pit mining adapted to large room and pillar underground work and new innovations in high speed drilling and blast hole loading is increasing production which in turn, under proper management and labour climate, will reduce mining costs.

Abstract Numerical modelling has been used to investigate a variety of problems in underground mining and tunnelling: subsidence induced by longwall coal mining; stresses generated when an open stope is filled

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cemented backfill and the stability of exposures created during subsequent mining of adjacent stopes; the interaction of two tunnels; and the effects of under-mining a pre-existing tunnel and shaft. In each case, results from nonlinear stress analyses can be used to guide the design of excavations and rock support …

Technology gives new life to old mine

Sibanye Gold is driving new mining technology hard to unlock more than a million ounces of sterilised gold it could not otherwise mine, extend the lives of its mines and roll out into the platinum mines it is buying.

The mechanisation of mines is a critical development for SA, particularly in its gold mines, which are decades old and face declining grades as they go ever deeper.

SA has the world's deepest mine at more than 4km deep and smarter, less dangerous methods are needed to work at these kinds of levels. There are an estimated 1-billion ounces of unmined gold in SA and this technology could be the key to extracting a big portion of that. An estimated 1.7-billion ounces have been mined in SA.

In the platinum sector, where the dollar price has remained stagnant for years and prices have risen, technology will be a boon to lift output, an issue most mines in SA are struggling to improve.

Mining companies are spending about R1bn a year on modernisation and research and development on this problem. Success would extend the lives of mines by a decade or more, save jobs and could, theoretically, see some old mines reopen.

The crux of the work is to make mining safer by pulling people out of dangerous work, improving productivity and finding a way to operate mines without a break.

Sibanye, which was formed two years ago by Gold Fields unbundling three gold mines into a separately listed company, appointed one of its most experienced operational managers, Peter Turner, to lead the technology division.

There are two key technologies Sibanye will begin testing at its Kloof mine, west of Johannesburg, and its newly bought but yet to be mined Burns tone mine in Mpumalanga, says Mr Turner.

The work at Kloof is being conducted in conjunction with JSE-listed Master Drilling and involves sinking a 30cm diameter blind hole in a declining reef, reaching down about 30m and using water to wash the gold and broken rock to a receptacle. The tests will be on high-grade remnant and strike pillars left behind to keep underground working areas stable and will focus on reefs with grades of 50g or more per tonne.

ADVANTAGES

- Flexible – Can utilize multiple faces, and therefore be selective of production and grade. Especially advantageous with base metals that have cyclical price cycles.
- Highly Mechanized – Not very strenuous on the workforce. Allows for high efficiency and productivity.
- Easy Maintenance – Usually utilizes mobile, trackless equipment which is easy to transport in and out of maintenance areas. Equipment Can also be transferred easily between levels.
- Low Operating Costs – Largely due the mechanization and productivity, operating costs are usually considerably lower than most underground mining methods.

- Low Development Costs – Most of the development work takes place within the orebody, which means ore production and development work are carried out simultaneously.
- Good Working Conditions – Work takes place in large open stopes with good footing. Room and pillar does not force workers to have to go into confined stopes and stand on top of broken muck.

DISADVANTAGES

- Roof Maintenance – A large portion of the roof is exposed making monitoring and maintenance very time-consuming and costly. The roof can often require high lift equipment for appropriate inspection.
- High Capital Costs – Initial infrastructure and equipment fleet can be expensive, although total costs are typically cheaper in the long run with lower operating costs.
- Low Recovery – Room and Pillar can have one of the lowest recovery rates of any underground mining method. There must be significant reserves left behind to support the mine. Pillars may contain high grade ore which cannot be recovered.
- Lack of flexibility in structural planning – It is difficult to make structural changes part way through production because most of the previously mined out rooms must be supported for the duration of the production life. The stress on a pillar is dependent on the location of other pillars and stress distributions can change drastically with changes in pillar location.
- Traffic Safety Concerns – Due to the large mechanised fleet of equipment required for room and pillar, many piece of equipment must work in close proximity. Traffic accidents and safety of the workers can be an issue.

Impacts of underground mining

1 Underground mining causes huge amounts of waste earth and rock to be brought to the surface – waste that often becomes toxic when it comes into contact with air and water.

It causes subsidence as mines collapse and the land above it starts to sink. This causes serious damage to buildings.

It lowers the water table changing the flow of groundwater and streams. In Germany for example, over 500 million cubic meters of water are pumped out of the ground every year. Only a small percentage of this is used by industry or local towns – the rest is wasted. What's worse is that removing so much water creates a kind of funnel that drains water from an area much larger than the immediate coal-mining environment.

Coal mining produces also greenhouse gas emissions.

2. Methane generation in coal mines and its global environment concern

Coal mine methane, less prevalent in the atmosphere than CO_2 but 20 times as powerful as a greenhouse gas, forms during the geological formation of coal is released during the coal mining process. Most coal mine methane come from underground mines. While this methane is often captured and used as town fuel, industrial fuel, chemical feedstock and vehicle fuel, it's very rare that it all gets used. Methane is also used in power generation projects. However, despite big investment in research only about 50 such projects exist worldwide. China which mines more than 95 percent of its coal underground about 300 of the state-owned mines are classified as methane-outburst prone. Worldwide emissions are expected to increase by 20 percent in the next 12 years.

3. Smouldering of coal

stack yards and waste piles Coal fires - burning or smouldering coal seams, coal storage piles or coal waste piles – are a significant environmental problem in many countries, including China, Russia, the US, Indonesia, Australia and South Africa. Underground coal fires can burn for centuries, filling the atmosphere with smoke laden with carbon-monoxide (CO), carbon-dioxide (CO_2), methane (CH_4), sulphur dioxide (SO_2), nitrous

oxides (NOx) and other greenhouse or toxic gases - as well as fly ash from vents and fissures. Other effects of coal fires include rising surface temperatures and contamination of groundwater, soil and air environment especially. Although coal fires can be caused by thunderstorm lightning, and forest or peat fires, they are often caused by mining accidents and improper mining techniques. In Indonesia, the same fires that are used to clear large tracts of rainforest have ignited over 300 coal fires since the 1980s. China has the world's most coal fires while India accounts for the world's greatest concentration. In China, between 15 and 20 million tons of coal burn uncontrollably each year accounting between 0.1 percent and 1 percent of the world's human-induced CO_2 emissions.

4. Acid mine drainage

Acid mine drainage is created when water mixes with coal and other rocks unearthed during mining taking on toxic levels of minerals and heavy metals. This toxic water leaks out of abandoned mines to contaminate groundwater, streams, soil, plants, animals and humans. As a result an orange colour can blanket the river, estuary or sea bed killing plants and making surface water unusable as drinking water. Sources of acid mine drainage can remain active for decades or centuries after a mine closes.

5. Waste disposal

The total amount of coal combustion wastes produced is staggering: In the United States alone about 130 million tons of coal combustion waste products are produced every year. Most coal power waste winds up in landfills, surface impoundments or in mines whereas smaller amounts are used for e.g. cement or thermal power production. Typically, solid waste is stored in landfills while liquid waste is stored in impoundments. Ideally these disposal sites should be designed to prevent the toxic wastes from entering the environment. But a recent US industry survey of disposal units revealed that this is not the case. About 40 percent of the coal waste landfills and 80 percent of the coal waste surface impoundments in the US lack liners.

6. Effects on human health

Toxic levels of arsenic, cadmium, chromium and lead can be found in coal-fuelled power plant waste. If these contaminants enter the environment - through dust, leaching into groundwater or from discharges into surface waters - they can contaminate drinking water supplies and accumulate in livestock and crops. Arsenic has been associated with cancer and cardiovascular and neurological damage. Cadmium has been linked to kidney damage plus risks of prostate and respiratory cancer. Lead is extremely dangerous for children and has been linked to developmental delay, hypertension, impaired hearing acuity, impaired haemoglobin synthesis and male reproductive impairment. The USEPA Environment Protection Agency found that the average health risks to the public due to metals from power plant waste disposal units could be up to 10,000 times higher than their allowable risk levels for cancer and other illnesses. Coal causes climate change: Coal burning is responsible for one-third of all our carbon dioxide pollution (CO_2). It is the most polluting way to generate electricity accounting for over 70 percent of the CO_2 emissions from the power sector. CO_2 is the most prevalent of the greenhouse gasses (GHGs) fuelling the greatest environmental, humanitarian and economic threat, the world has ever faced. According to the mining experts study the potential cost of dealing with the climate change caused by this CO_2 will be up to 20 percent of the world’s GDP by 2100. Avoiding climate changes worst impacts means halting the growth in CO_2 emissions by 2015 and then reducing the emissions radically thereafter.

7. Common health and environmental threats posed by coal mining

Pneumoconiosis, aka black lung disease or CWP (Coal Washing Points) is caused when miners breathe in coal dust and carbon which harden the lungs. Estimates show that 1,200 people in the US still die from black lung disease annually. The situation in developing countries is even worse.

Cardiopulmonary disease, chronic obstructive pulmonary disease, hypertension, lung disease, and kidney disease have been found in higher-than-normal rates among residents who live near coal mines, according to a 2001 study.

Toxic levels of arsenic, fluorine, mercury and selenium are emitted by coal fires entering the air and the food chain of those living nearby.

Mine collapses and accidents kill thousands of workers around the world every year. Chinese coal mine accidents killed 4,700 people in 2006.

Coal is the single biggest source of climate changing CO_2 pollution.

Coal mining destroys ecosystems releases toxic levels of minerals and gasses into our water and air (including the potent greenhouse gas methane) expose miners and those who live nearby to coal dust and other toxins. Thousands of people die in mine collapses around the world every year.

Beside CO_2 coal combustion releases millions of tons of sulphur dioxide and nitrogen oxides into the air which create acid rain and smog

Coal burning also yields particulate matter pollution which creates air pollution and respiratory ailments, among other health problems.

Another by-product of burning coal is mercury which infiltrates the food chain and attacks the human nervous system. Young children and babies whose nervous systems are still developing are especially vulnerable.

Burning coal creates millions of tonnes of waste products that contain toxic levels of heavy metals and minerals. These mostly end up in landfill sites or impoundments and pose a threat to our health and environment

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