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CASE STUDY ON URANIUM AND ITS MINING

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Abstract:

Uranium occurring naturally contains three isotopes, namely 238U, 235U, and 234U. Uranium mining deals with the extraction of uranium from the ground in many different mining ways. Mining of uranium is proceeded by: When uranium is near the surface, miners dig the rock out of open pits. Open pit mining strips away the topsoil and rock that lie above the uranium ore. When uranium is found deep underground, miners must dig underground mines to reach it. The mineral is then removed through underground mining " stoping" , board and pillar..." according to the occurrent and divers parameters. The various mining method are defined and according to our case study one underground mining method, its working principle, the machinery, how ventilation and transportation accesses used in it will be considered and studied.

Key words: *Mining, stope, pillar, support, ventilation, machinery, transportation*

1. Introduction

Uranium like other elements, occurs in several slightly differing forms called 'isotopes'. These isotopes differ from each other in the number of uncharged particles (neutrons) in the nucleus. Uranium is naturally found in the Earth's crust as a mixture largely of two isotopes: uranium-238 (U-238), accounting for 99.3% and uranium-235 (U-235) about 0.7%.

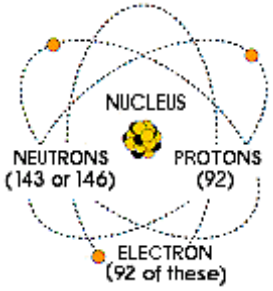

Fig: 1 Uranium, electronic cloud

One of the isotopes is important because under certain conditions it can readily be split, yielding a lot of energy. Then isotope is said to be 'fissile' and we use the expression 'nuclear fission'. It is the isotope U-235.

Uranium mining is defined as the process of extraction of uranium ore from the ground. The worldwide production of uranium in 2020 amounted to 43,582 tonnes. Canada, Kazakhstan, and Australia were the top three uranium producers, respectively, and together account for 68% of world production. Namibia, Niger, Russia, Uzbekistan, the United States, China are other countries producing more than 1,000 tonnes per year. Almost all of the world's mined uranium is used in nuclear power plants.

Uranium is mined by conventional underground or open-pit mining of ores (43% of production (or) by in-situ leaching (57% of world production). In in-situ mining, a leaching solution is pumped down drill holes into the uranium ore deposit where the ore minerals ii dissolves. The uranium-rich fluid is then pumped back to the surface and processed to extract the uranium compounds from solution. In conventional mining, ores are processed by grinding the ore materials to a uniform particle size and then treating the ore to extract the uranium by chemical leaching. The milling process commonly yields dry powder-form material consisting of natural uranium, "yellowcake," which is sold on the uranium market as U_3O_8.

2. Objectives of Uranium mining

The main objective of uranium mining is to extract the valuable mineral which is uranium in the most efficient and safe manner for our daily life use such as:

- To explain the different method of uranium mining.
- Conduct the case study of an underground uranium mine

3. Differentes methods used in uranium mining

As for the extraction of any other hard rock various methods can be used to extract uranium:

3.1. Open pit

Fig: 2 Rössing open pit uranium mine, Namibia

In open pit mining, overburden is removed by drilling and blasting to expose the ore body, which is then mined by blasting and excavation using loaders and dump trucks. Workers spend much time in enclosed cabins in order to limit their exposure to radiation. Airborne dust levels is suppressed by an extensive used of water.

3.2. Underground

when the uranium is located too deep below the surface for open pit mining, an underground mine might be used with tunnels and shafts to access and remove uranium ore.

The underground mining of uranium is in principle no different from any other hard rock mining and other ores are often mined in association (e.g., copper, gold, silver). when the uranium ore body has been identified a shaft is sunk in the vicinity of the ore veins, and crosscuts are driven horizontally to the veins at various levels, usually every 100 to 150 meters.

The various subdivisions of underground mining methods are:

- Room and pillar
- Stoping
- Caving

3.3. Heap leaching

in heap leaching extraction process chemicals (usually sulfuric acid…) are used to extract the economic element from ore which has been mined and placed in piles on the surface. Heap leaching is generally economically feasible only for oxide ore deposits. The geological process during what the oxidation of sulfide deposits occurs is called weathering. Oxide ore deposits are found typically close to the surface. When no other economic elements are not within the ore a mine might choose to extract the uranium using a leaching agent, usually a low molar sulfuric acid.

3.4. *In-situ* leaching

Fig: 3 Trial well field for in-situ recovery at Honeymoon, South Australia

Also known as solution mining, In-situ leaching (ISL), or in-situ recovery (ISR) , involves leaving the ore where it is in the ground, and recovering the minerals from it by dissolving them and pumping the formed solution to the surface where the minerals can be recovered. Consequently, there is little surface disturbance and no tailings or waste rock generated. However, the orebody needs to be permeable to the liquids used, and located so that they do not contaminate ground water away from the orebody.

3.5. Seawater recovery

The concentration of uranium in sea water is low, around 3.3 parts per billion or 3.3 micrograms in every liter of seawater. But this resource is gigantic in term of the quantity of and some scientists believe this resource to be almost limitless with respect to world-wide demand. Therefore, even if a portion of the uranium in seawater could be used the entire world's nuclear power generation fuel could be provided over a very long time period. Some anti-nuclear organizations describe this statistic to be exaggerated. Although since the 1960s, research and development for recovery of this low-concentration element by inorganic adsorbents such as titanium oxide compounds has occurred in the United Kingdom, Germany, and Japan, and was halted due to low recovery efficiency.

4. Case study

For this case study, a uranium man has been chosen and detail has been reviled as follow.

4.1.1. DETAILS OF THE MINE

Location : India

Ore reserves & capacities

Geological ore reserves	:	45.48 million tons
Minable ore reserves	:	26.79 million tons

Plant capacity	:	900,000 MT ore/ annum
Plant life	:	30 years
Land required		
Plant	:	35 Ha
Mine	:	787 Ha
Township	:	100 Ha
Tailing ponds	:	60 Ha
Water requirement		
Mine	:	1500 cu.m / day
Plant	:	3530 cu.m / day
Source of water	:	River
Distance from plant	:	50.5 KM]
Electrical power supply	:	Local
Voltage level	:	132 KV
Power requirement		
Mine	:	5 MVA
Plant	:	14 MVA
Distance between		
Plant & mine	:	620 m
Mine & township	:	6 KM
Manpower requirement		
Mines	:	550
Plant	:	333
Common services	:	51
Total	:	934

4.1.2. Geological Details of the mine:

Location	**India**
Host Rock	**Siliceous Dolomitic Phosphatic Lime Stone (Vempalle dolostone)**
Age	**Middle Peterozonic**

Major Minerals	**Dolomicrite, Dolospar and Microstylolite**
Major Uranium Minerals	**Pitchblende, Caffeinate, and U-Ti Complex**
Associated Minerals	**Chalcopyrite,Pyrite,Molybdene and Collophane**
Avg. Specific Gravity	**2.80**
Geological Ore Reserves	**45 million Tons**
Mineable Ore Reserves	**28.64 million Tons**
Avg. width of HW load	**3.2m**
Avg. width of FW load	**2.5m**
Cut off Grade	**0.02 %e u_3o_8**
Cut off Thickness	**0.5m**
Strike Direction	**NW-SE**
Strike Length of Ore body	**5.6 km**
Dip direction	**N22^{0}E**
Ore body along Dip	**1 km**
Avg. Dip	**15^0-17 ^{0}**

5. Mining Department:

This is very most important department in mining. This department helps to get the production continuously, by doing the blasting operations in mines.

Plans Used in the mine:

1. Surface Plan
2. Geological Plan
3. Water Danger Plan
4. Under Ground Plan
5. Ventilation Plan
6. Vertical Section Plan: More than 30 degrees gradient then the vertical section used.
7. Transverse section plan

Scales Used for Plans:

Surface Plan ---------- 1:2000

Geological Plan----------1:2000

Water Danger Plan------1:1000

Under Ground Plan------1:1000

Ventilation Plan----------1:1000 or 1:500

Transverse section plan---1:1000

The above Plans are drawn with the NATIONAL GRIDS type of plans for submitting to DGMS.

Yearly once the above plans are submitted to DGMS.

In this mine **TOTAL STATION** instrument is used for doing the survey.

6. METHOD OF MINING

6.1. MODE OF ENTRY

In this mine the ore body is reached by three Declines. The three declines with 5m X 3m of size are driven at 9^0 to 10^0 in apparent dip direction from S-W to N-E direction cutting the ore body in two parts up to full depth of the ore body (275 m). The ASD (advance strike drives) is driven in strike direction from the both service declines till the boundary of the ore body. The incline distance between two ASD will be 60 m

Pillars (5 m X 5 m) will be left against each ASD along the full strike length. The panels will be prepared at 120 m length in strike direction. The panels is worked using Brest stoping method with the help of low profile jumbo drill, low profile loader, and low-profile dump truck for bringing the muck to the surface initially, till the conveyer is installed. 10 m rib pillar will be left after 120 m of panel to isolate working areas. Ramps will be driven between ASDs at 9^0 for transporting ore to the conveyer.

The mining parameters are fixed as under:

S.NO	ITEM	DESCRIPTION
1.	Main declines	3 Nos at 9^0 parallel to each other at 15 m distance in apparent dip direction 5mX 3m size
2.	Ventilating shaft	4 nos. 3.5 m dia located at surface up to a depth of 35 m
3.	Mining sequence	Extraction of H/W lode followed by F/W lode & pillar extraction
4.	Major equipment combination	Drill jumbo, loader, dumper
5.	Service equipment	Passenger carriers, lube truck, crane truck, multi-purpose vehicle

6.2. METHOD OF WORKING

There are different methods of stoping used in metal mines. The method is selected on basis of following factors –

- Thickness of ore body

- Depth of ore body from surface
- Dip of ore body
- Character of ore body
- Character of Hanging wall & Foot wall
- Cost of ore body
- Nature of mineralization of ore bodies
- Continuity of ore body
- Cost of supports …. etc.

In this uranium mine ROOM AND PILLAR method is used for extraction of the ore. The ROOM and PILLAR method is explained below:

Also called board and pillar, the **Room and pillar** is a mining system in which the mined material is extracted across a horizontal plane while leaving optimally sized pillars of untouched material to support the roof overburden leaving open rooms underground. The relatively flat-lying deposits such as those that follow a particular stratum are preferable for the use of room and pillar. The key factor for a successful and efficient room and pillar mining resides in the selection of the optimum pillar size. When the size the pillars are too small the mine will collapse. when the pillars size are too large then significant quantities of valuable material will be left behind reducing the profitability of the mine. The percentage of mined material can vary depending on many factors, including roof conditions, the material mined, and height of the pillars; typical values are: stone and aggregates 75%, coal 60%, and potash 50%.

Ore body is approached through the declines and crosscuts. The cross cuts are located at regular intervals of 60 m. when the cross cuts are touch the ore body the ore body is developed by levels such as Advanced Strike Drives (ASD). Here the size of cross cut is 5m X 3m. the ASD's are developed at their horizons, they are interconnected by RAMP's at regular intervals of 120 m. when such connections are made the ore body gets divided into first into slices and then into the ore blocks. These blocks are act as a support during development. the ramps connect can be used for transport of men and vehicles, laying pipe lines, cables in addition to its normal use of ventilation. Thus, the development is completed. When such development is completed the stoping operations are undertaken.

APPLICATIONS:

1. When the ore body is strong.
2. Hanging and footwalls are strong.
3. Thickness of ore body is not more than 4.5 m
4. Inclination of the ore body is 0^0 to 30^0
5. When the ore body having the moderate depth.

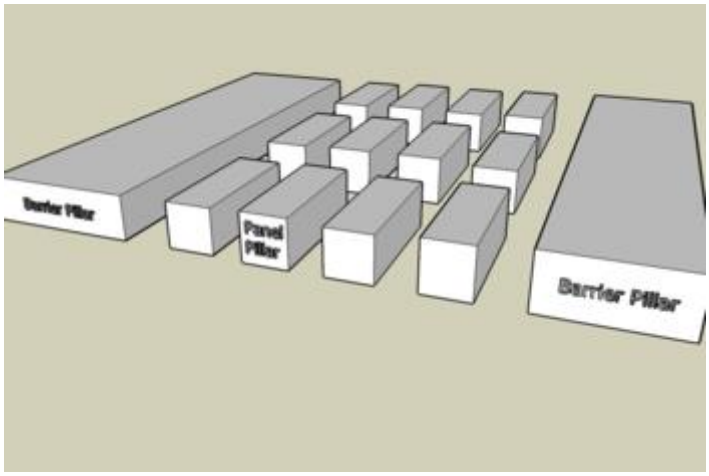

Fig: 4 ROOM and PILLAR method.

6.3. WORKING OF STOPE

In this method the rib pillars are left for protection of the panel. The size of the rib pillar is 10m length and 3m height. The horizontal drives of 4.5 m X 3 m and the small thickness of ore pillars are formed. The ramps are driving at regular intervals the ore body is divided into no. of pillars. These pillars are extracted by drilling the holes with the help of JUMBO DRILL machine. Burn cut pattern is done for extraction. Number of parallel holes are drilled and charge the holes with explosives and then blasted. After blasting the muck or broken material is convey to surface with the combination of LHD and LPDT.

7. TRANSPOTATION

In this Uranium mine the broken rock or ore transported from underground to surface by using the Load Haul Dumper (LHD), Low Profile Dump Truck (LPDT). The conveyer system is built and some more time is taken for running of the main conveyer. Up to that time the LPDT's are transport the broken material from u/g to surface.

SUPPORTING SYSTEM IN THE MINE

1. Arch supporting from entrance to up to 200m
2. Roof bolting supports
3. Girder supporting
4. Wire mesh …etc.

8. VENTILATION

It is proposed that mine will be ventilated through 4 Nos. mechanical ventilator fans at exhaust end. It is proposed to allow fresh air to enter through declines. The fresh air will reach to farthest part of the active mine workings and pass-through active man always to exhaust through ventilation drive.

S.NO	ITEMS	PARAMETER
1	Type of Fan	Axial flow fan
2	Rotor Diameter	3000 mm
3	Fan Speed	725 rpm
4	Fan blades & materials	8 no.s. aerofoil section-cast alluminium alloy LM9 – heat treated & X-ray tested
5	Fan Blade Angle Setting	12.5 to 30 degrees at an interval of 2.5 degree
6	Rotor Material	cast alluminium alloy LM6, insert – mild steel
7	Rotor Shaft- size & material	180 mm dia Forged steel – EN24-grain refined and ultra-sonicalkly tested
8	Bearing for Fan shaft	SKF 22326 CC WC3 spherical roller baering
9	Bearing block for rotor shaft	cast iron grade 20
10	Jack shaft – size & material	140 mm dia rolled-EN8-ultra sonically tested
11	Bearing block–for jack shaft	Cast iron – grade 20
12	Bearing for jack shaft	SKF22228CCK - spherical roller baering
13	Base frame – material	Mild steel fabricated
14	Slide rail & tensioning arrangement	Slide rail- cast iron grade 20 tension screw – EN8
15	Raiser block - material	cast iron grade 20
16	Fan casing – material	M.S fabricated – 8 mm
17	Inlet cone	M.S fabricated – 6 mm
18	Drive assembly	Multi-groove fan & jack shaft pulley with poly V-belt
19	Painting	Sand Blasting – Spray Galvanized-1 coat primer and 2 synthetic Enamel paint over primer

FAN MECHANICALS

POWER SUPPLY AND DISTRIBUTION

SURFACE SUBSTATION

PURPOSE	To store the Power and Send required Power to the Mine. Metering and protection
Rated Volts	6.6 kv
Rated Amperes	800 A
Insulation level	7.2/20/60 kvp
CT type	East Resin
STC(CT) Duration	31.5 kv 35 sec
STC Panel Main circuit Duration E/circuit Duration	 31.5 kA 3 sec 31.5 kA 1 sec
Total no. of panels	26
Year of manufacturing	2009

MACHINARY

In the uranium mines the machines are divided in to two types. They are

1. Productive equipments

2. Service equipments

Productive equipments:

The Machines have the Rated Air pressure in the Front and Rear tyres of the following Machines used in the Uranium Mines

Machine Name	Rated Pressure	
	Front	Rear
LH 410	85-90	65-70
EJC 30 SX	100	100
DD210L	130	130
DS210LV	130	130
TH205L	130	130

Service equipments:

The following machines are considered as service equipments because of these machines are done the service in mines. They are namely –

1. Multipurpose vehicle
2. Scissor lift
3. Lube truck
4. Explosive truck
5. Fire engine

Machines Used in UCIL:

- Jumbo Drill Machine - 5
- Roof Bolting Machine - 5
- Low Profile Dumping Truck or LPDT - 7
- Load Haul Dumper or LHD - 6
- Multi-Purpose Vehicle or MPV - 1

9. Conclusion

- This done study highlights the importance of Uranium
- Due to this study, we were able to identify the differences in uranium and the different type of uranium.
- In the process of occurring of uranium, it has been identifying that uranium occurs in 2 differents ways which are:

1. Naturally occurring isotopes
   - Uranium 238
   - Uranium 235
   - Uranium 234
2. Artificial isotopes

- Uranium 236
- Uranium 233
- Uranium 232

- Uranium has been studying throughout this paper and the mining methods used to extract it has been described.
- By this study we came to understand the need of pillars and their size on order to optimize the efficiency of a mine using board and pillar mining method.
- Bord and pillar mining allows extraction of mineral without the use of mechanical supports because the mine roof is supported by the pillars.
- Mechanical ventilation with powerful fans are necessary to provide the needed amount of fresh air in an underground mine.
- This study highlights the different steps needed for a uranium mining process.

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