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**MAD345 - Mining II**

**INTRODUCTION**

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Hacettepe University

9 October 2019
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EXCAVATION SYSTEMS TO EXPLOIT MINERAL DEPOSITS

UNDERGROUND MINING
- Metalliferous
  - Open cast
  - Quarrying
  - Steam beds & terraces
  - Oil wells (petroleum, NG)

SURFACE MINING
- Coal
  - Open pit
  - Quarrying
  - Harvesting lake deposits
  - Beach dunes

ALLUVIAL MINING
- UG gasification

NON ENTRY MINING
- Frasch process/Borehole mining (Sulphur)
  - Solution mining (Trona)
    - Extraterrestrial mining

NOVEL TECHNIQUES

Source: “Surface and Underground Excavations”, Tatiya R.R.
Galvin, J.M., 2016, "Ground engineering: principles and practices for underground coal mining", Springer


Introduction

Prospecting

Mining

Dilution

Resource and Reserve Estimation

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Prospecting/Exploration

• Finding and Defining it: searching, sampling, and analysis to identify ore reserve and generate feasibility report

Development

• Planning and Building it: permitting and logistics for mining operations + building the mine

Extraction

• Mining it: extracting the ore

Closure/Reclamation

• Cleaning it up: remediation and/or redevelopment of the land to a more natural state

Source: https://www.superfund.arizona.edu/learning-modules/tribal-modules/copper/mine-life-cycle
Mining is an economic activity.

The decision to mine (or not to mine) a particular ore deposit depends upon an analysis of costs, benefits and tangible (i.e. monetary profit) or intangible (i.e. hopes of stimulating the economy, fears of environmental damage) risks.
Steps in obtaining mineral commodities

- Prospecting
- Mine exploration and development
- Mining (extracting ore)
- Mineral processing (separating ore minerals from gangue)
Applying knowledge of association of ores with specific geological settings. remote sensing techniques, seismic reflection profiles, magnetic field intensity, gravitational techniques to detect geological structures.

Developing detailed maps of rock types and geological structures (faults, folds, intrusions) obtaining samples of ore for chemical analysis 3D solid model of geological structures and orebody.
Geologic Settings

**Prospecting**
- 6m @ 3.4 g/t Au
- 2m @ 3.2 g/t Au
- 3m @ 2.7 g/t Au
- 1m @ 3.6 g/t Au

**Mining**
- 2m @ 1.3 g/t Au
- 10m @ 7.1 g/t Au
- 2m @ 2.1 g/t Au
- 2m @ 9.3 g/t Au
- 11m @ 3.6 g/t Au
- 4m @ 1.2 g/t Au

**Dilution**

**Resource and Reserve Estimation**

**Legends**
- Drill hole number
- Drill hole trace
- Significant gold intercept
- Depth of hole
- 50ppb contour

**Scale**
- 0 to 25m

**Surfaces**
- Quaternary Transported Cover
- Oxidised Dolerite
- Base of Oxidation

**Units**
- 384200 mE
- 384250 mE
- 375m RL
- 200m RL
- 325m RL

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Common Requirements

- Safe working conditions
- Access for equipment, personnel, services (electricity, water, compressed air, ventilation)
- Arteries for the transport of ore & waste out of the mine and possibly backfill into the mine
- Drainage
Open Pit Mine—Bench Mining, Strip Mine or Quarry

Overburden, ore and waste need to be mined

Underground Mine—Bulk or Selective

Significantly less waste needs to be excavated
More expensive/challenging
Numerous mining methods
Hard Rock – Requires drilling and blasting
Soft Rock – Use of continuous mining machines or free dig
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<th>Underground</th>
<th>Open Pit</th>
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<td>Deposit</td>
<td>Relatively small, high grade or Deep with sub-vertical ore zone</td>
<td>Relatively large, low grade or Shallow, with sub-horizontal ore zone</td>
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<tr>
<td>Geology</td>
<td>Structurally controlled veins and breccias</td>
<td>Lithology controlled stockworks, disseminated zones</td>
</tr>
<tr>
<td>Resource/Reserve</td>
<td>Generally difficult or not cost effective to prove up large resources / reserves</td>
<td>Generally cost effective to establish 10 to 15 year resource / reserve life</td>
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<tr>
<td>Productivity</td>
<td>500 to 8,000 tonnes per day</td>
<td>5,000 to 100,000 tonnes per day</td>
</tr>
<tr>
<td>Environmental</td>
<td>Generally easier to permit, limited footprint, relatively cheap to reclaim</td>
<td>Large footprint from pit, waste dumps and tailings, relatively expensive to reclaim</td>
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<tr>
<td>Mine Life</td>
<td>up to 100 years</td>
<td>10 to 25 years, rarely longer</td>
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Key Aspects

- Focus on employee safety, hazards or safety risks
- Housekeeping specifically at shaft stations and work faces
- General structural geology faults, joints, slips, orientation and frequency of structures
- Ground conditions Areas screened, bolted and reinforced as well as quantity of loose rock behind mesh
- State of ramp, haulage drifts
- Water ingress
- Air quality
- Rock fragmentation
- General state of the equipment and age, tire wear and cuts
- Mood and engagement of the workforce
Health problems experienced by miners

- Collapse of mine
- Fire (methane, coal dust, etc.)
- Asphyxiation (methane, carbon monoxide, etc.)
- Pneumoconiosis (from inhaling coal dust)
- Asbestosis (from inhaling asbestos fibers)
- Silicosis (from inhaling silicate dust)
- Heavy metal poisoning (e.g. mercury)
- Radiation exposure (e.g. uranium mining)
Costs that scale with grade of ore. The lower the grade, the more ore must be mined, shipped to the mill, milled, and the more tailings must be disposed of.

**Fixed costs are**

- building a transportation infrastructure.
- refining ore minerals, once it has been milled.
The price of mineral commodities passes through three stages that depend on changes in costs:

▶ Technical improvements in mining and/or metallurgy
▶ These improvements become balanced by effects of decreasing ore grades
▶ Cost rises because improvements in technology can not keep up with increasing scarcity.
Selecting Mining Method

- Orebody recovery and **dilution**
- Amount of development needed
- Capital requirement and operating costs
- Type of equipments required
- Cycle time and sequence of operations
- Production (tonnes per year)
- Risk
**Dilution:** Material that is mined in the process of ore extraction. Typically a contamination of ore with below cut off grade material or with barren waste wall rock.

**Recovery:** The percent of valuable material or ore that is extracted relative to the total amount of ore.
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Definition
Ore in Reserve Block Model
Planned Dilution
Actual Drift
Narrow or varying orebody widths
Structures in the hanging wall
Poor mining practices (blasting, bore hole)
Poorly understood orebody. Not enough drill information ("nugget" orebody)

**Primary dilution:** Planned Dilution, minimum mining width required to extract. 2 m ore width and 4 m wide drifts.

**Secondary dilution:** Unplanned Dilution, Overbreak (too much extracted) or Underbreak (less extraction). Failure in the Hanging Wall due to poor ground conditions (rock bursting, fault zones)
More data collected by diamond drilling, chip sampling, mapping, sampling of blast holes

Use different mining equipment or appropriate mining methods

Right size equipment for proper widths

Different blasting techniques

Surveying of pre and post stope blasting

Grade control procedures – sort waste and ore *(difficult)*

Mine the waste and lower the grade leaving the mine
**Ore:** A mineralised deposit whose characteristics have been examined and found to be commercially viable. The extents of the ore body are determined by the cut-off grade.

A **mineral resource** is a concentration or occurrence of diamonds, natural solid inorganic material, or natural solid fossilized organic material including base and precious metals, coal, and industrial minerals in or on the Earth’s crust in such form and quantity and of such a grade or quality that **has reasonable prospects for economic extraction.** The location, quantity, grade, geological characteristics and continuity of a mineral resource are known, estimated or interpreted from specific geological evidence and knowledge.
A **mineral reserve** is the economically mineable part of a Measured or Indicated Mineral Resource demonstrated by at least a Preliminary Feasibility Study. This Study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate, at time of reporting, that economic extraction can be justified. A **Mineral Reserve** includes diluting materials and allowances for losses that may occur when the material is mined.
A **Qualified Person** means an individual who is an engineer or geoscientist with at least five years of experience in mineral exploration, mine development or operation or mineral project assessment, or any combination of these; has experience relevant to the subject matter of the mineral project and the technical report; and is a member or licensee in good standing of a professional association.
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Definition
Definition