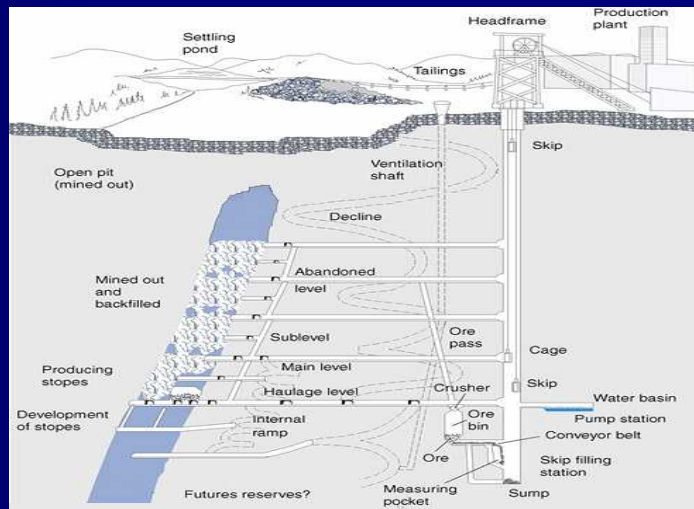


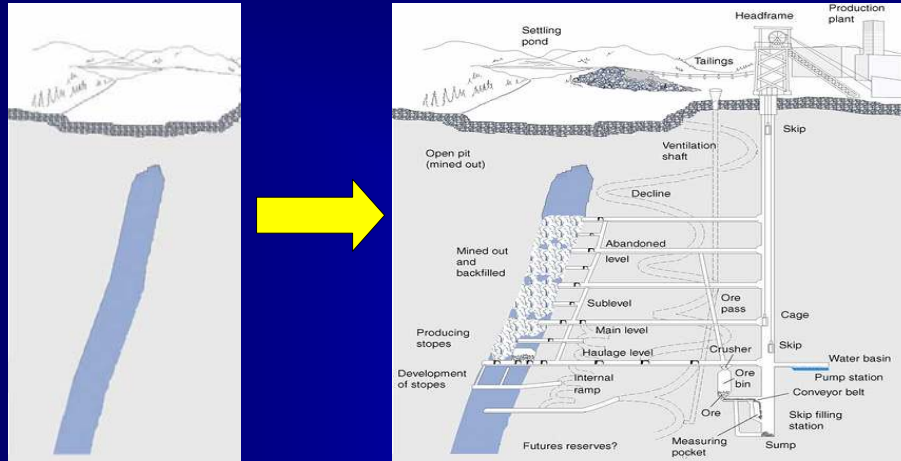
Development



Content

1. Introduction
2. Development Aspects
3. Underground Openings

Definition 1



Development is the work of opening a mineral deposit for exploitation

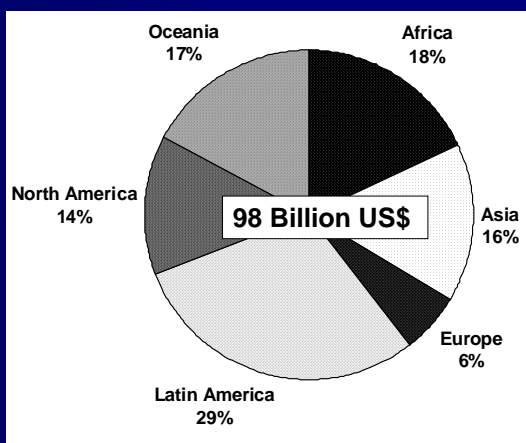
Definition 2

- All steps necessary to bring a mine into full, first scheduled production (Planning, Design, construction, other phases)
- Physical standpoint: Development provides access to the deposit (miners, equipment, supplies, power, water, ventilation air, waste, mined mineral, etc.)
- Other purposes: preparatory work, facilities, personnel, services, mineral processing function, etc.

Mine Development Aspects



World planned Mine Investment 2001

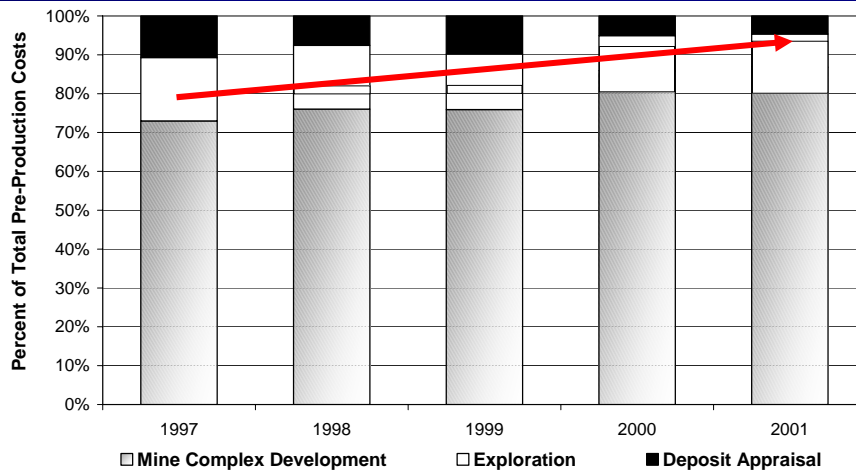


- 37 Minerals (Base Metals, Iron Ore, Precious Metals, Industrial Minerals)
- 605 Projects
- 3 Years Investment Period => 32 Billion US\$ per year
- Open Pit: 230 Mill. US\$
- Underground: 100 Mill. US\$

Source: Project Survey 2002. Engineering and Mining Journal. January 2002.

Increasing Development costs

Canadian Pre-Production Costs



Introduction 1

- ➡ No sharp demarcation between development and exploitation
- ➡ development gets underway first and is one step ahead of exploitation
- ➡ development will proceed until the mine is closed; reasons:
 - ➡ expence to develop an entire mine at once is too great
 - ➡ a mine evolves

Introduction 2

- ▶ As much development as affordable should be completed prior to the first production
- ▶ General target: maximum quantity of ore with a minimum of development (development openings are expensive)

Locational Factors in Development

- ▶ Transport of minerals to market and supplies to the mine
- ▶ Availability of labor and support services (housing, educational and recreational facilities, healthcare, etc.)
- ▶ Operational (and psychological) impacts of climate and weather

Natural/Geologic Factors in Development

- Topography and terrain
- Spatial relations (size, shape, attitude, etc.) of ore body, including depth
- Geologic considerations (mineralogy, petrography, structure, genesis, rock temperature, water, etc.)
- Rock mechanics properties (strength, modulus of elasticity, hardness, abrasiveness, etc.)
- Chemical and metallurgical properties (effect on storage, processing, smelting, etc.)

Social-Economic-Political-Environmental Factors in Development

- Demographic and occupational skills of local populace (workforce)
- Means of financing and marketing (determines scale of operation, continuity of operation, etc.)
- Political stability of host country
- Pollution legislation (air, water, wastes, etc.)
- Other governmental aids and restrictions applicable to the mining industry

Sequence of Development 1

1. Adoption of feasibility report as a planing document (subject to modification as development progresses)
2. Confirmation of mining method and general mining plan
3. Arrangement of financing, based on confirmed cost estimates from the feasibility report
4. Acquisition of land, including mineral rights and surface, as needed
5. Filing of environmental impact statement, obtaining of mining permit, and posting of bonds subject to both federal and state statutes, as applicable

Sequence of Development 2

6. Provision of surface access, transportation communication, power supply, etc.
7. Planning, construction of surface plant, including support and service facilities, offices, etc.
8. Erection of processing plant, ore-handling, shipment, stockpiling and waste disposal facilities
10. Selection (acquisition) of mining equipment
9. Construction of main access openings and secondary openings as required (shafts, etc.)
11. Recruitment/training of labour force, support services (housing, transportation, consumer stores, etc.)

Financing of Mining Ventures 1

- Mining is a high-risk industry for investment purposes
- Risk diminish in inverse ratio to extent/quality of analysis
- Factors to consider:
 - Land acquisition (buy, lease, etc.)
 - Marketing (long-term contracts almost a necessity)
 - Time to repay loans (\pm lifetime of the mine)
 - Risk factor (set by lending agencies)
 - Political climate of host country
 - Joint venture?

Financing of Mining Ventures 2

- Forms of Financing:
 - Own Money
 - Loans from banks, private investment sources, other (foreign) companies, trust funds, insurance companies
 - Issues of securities, stocks and bonds, through investment houses or banks
 - Leasing of equipment
 - Government loans (Subsidies, World Bank, International Monetary Funds for projects in Third World countries)

Mine Development Plan 1

- Getting the mine into production at the earliest possible moment
- Complexity of mine development
 - Activities take place simultaneously
 - Interaction between the different activities
 - Scheduling and coordination of activities



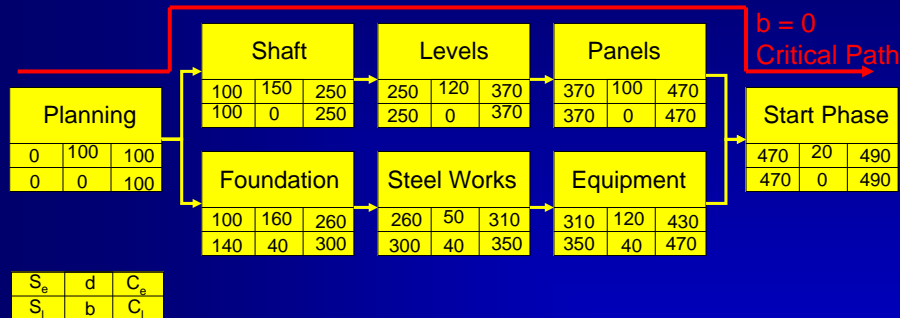
Operations research techniques (Network techniques) for project Management

Mine Development Plan 2

List of activities/tasks

| No. | task | duration [days] | preceding task | following task |
|-----|-----------------------------|--------------------|-------------------|-------------------|
| 1 | Planning | 100 | | 2;6 |
| 2 | Shaft Sinking | 150 | 1 | 3 |
| 3 | Development Levels | 120 | 2 | 4 |
| 4 | Development Panel Openings | 100 | 3 | 5 |
| 5 | Production Start up Phase | 20 | 4;8 | |
| 6 | Foundation Processing Plant | 160 | 1 | 7 |
| 7 | Steel works | 50 | 6 | 8 |
| 8 | Equipment Installation | 120 | 7 | 5 |

Mine Development Plan 3 Network Diagramm



d = duration

 S_e = Earliest Starting Date C_e = Earliest Completion Date S_l = Latest Starting Date C_l = Latest Completion Date

b = Buffer time

Steps:

1. "calculate forwards" $C_e = S_e + d$
2. "calculate backwards" $S_l = C_l - d$
3. Calculate Buffer time $b = C_l - C_e = S_l - S_e$

Land Acquisition

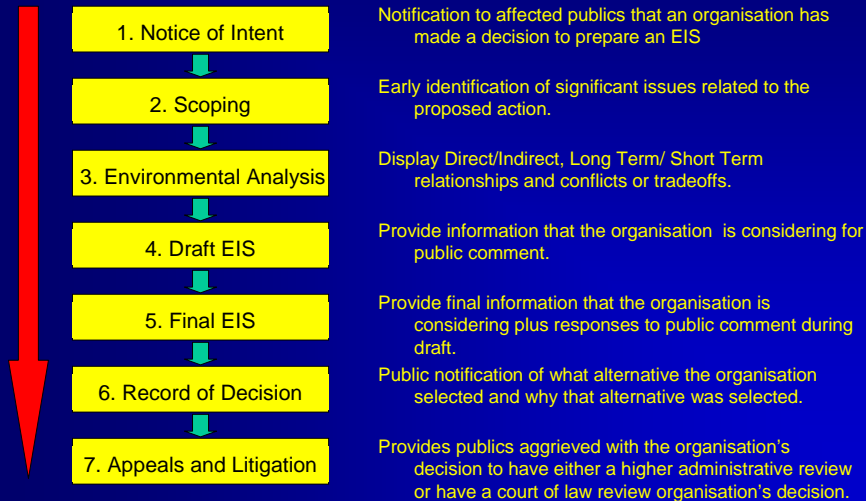
The way to acquire legal right to minerals differ from country to country => carefully investigate the relevant national laws (Germany: Ownership of land doesn't necessarily include Ownership of minerals)

Four ways to acquire legal right to minerals (USA):

- 👉 "patenting a claim" to locatable public land
- 👉 Leasing public land from government
- 👉 Ownership of private land
- 👉 Leasing of private land (payment of royalties)

Environmental Impact Statement (EIS) Steps

8 - 48 month



Environmental Impact Statement (EIS) Content 1

(a) Cover Sheet (1 page)

- responsible organisation
- title of the proposed action
- location
- name, address, telephone number

(b) Summary (1-15 pages)

- accurate summary
- conclusions
- areas of controversy
- issues to be resolved
- alternatives

(c) Table of Contents (1-5 pages)

- list of chapters, appendices and corresponding page numbers

(d) Purpose and need (1-5 pages)

- underlying purpose and need that the organisation is responding to; including alternatives

Environmental Impact Statement (EIS) Content 2

(e) Alternatives including the proposed action (5-25 pages)

- results of the information and analysis
- environmental impacts of the proposal
- alternatives in a comparative form (to sharply define the issues and providing a clear basis for a choice among options)

(f) Affected environment (5-25 pages)

- description of the affected environment
- effects of the alternatives
- proposed alternative

(g) Environmental Consequences (5-25 pages)

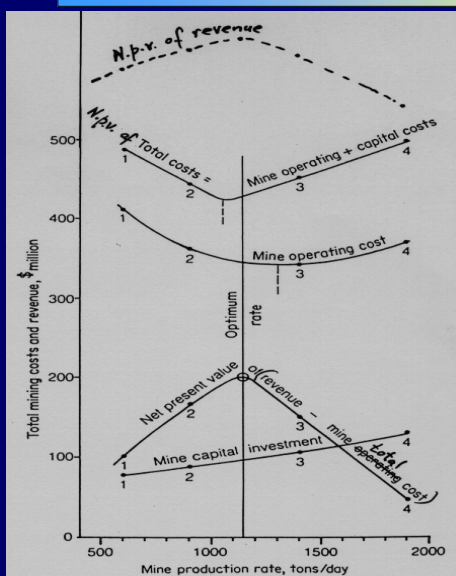
- scientific and analytic basis for the comparisons of the alternatives
- environmental effects which cannot be avoided
- relationship between short-term uses and long term environmental productivity, irreversible commitments of resources, direct or indirect effects and their significance, conflicts, energy requirements, etc.
- means to mitigate adverse environmental effects

(h) List of Preparers (1-2 pages)

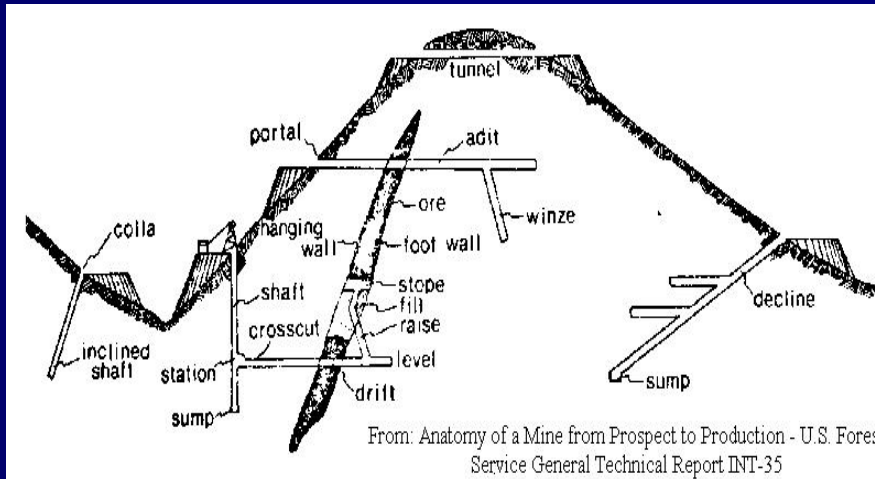
(i) List of agencies, organisations and persons who received the EIS

(j) Index (k) Appendix

Production Rate



Underground Openings



Types of Underground Openings

1. Primary: Main Openings

- ☞ Shaft
- ☞ Slope
- ☞ Adit

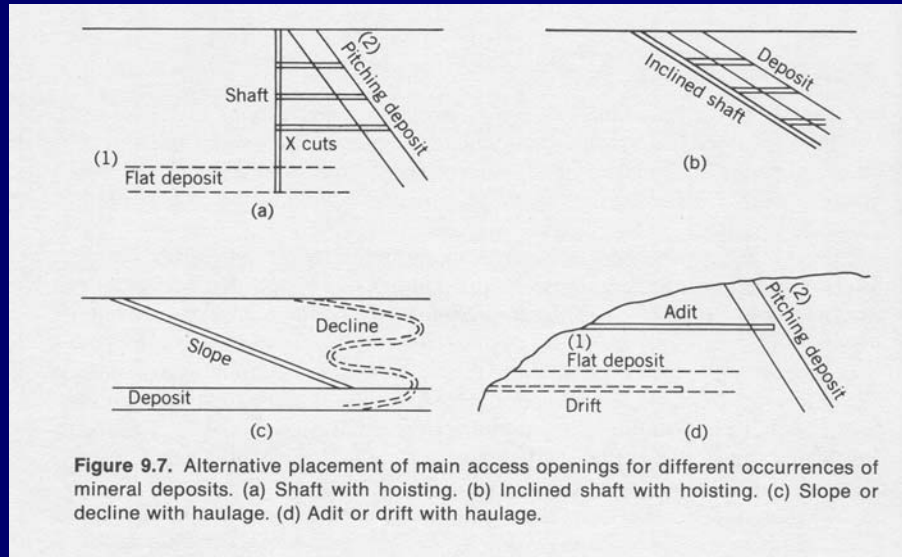
2. Secondary: Level or Zone Openings

- ☞ Drift
- ☞ Entry
- ☞ etc.

3. Tertiary: Lateral or Panel Openings

- ☞ Crosscut
- ☞ Ramp
- ☞ etc.

Main Access Openings



Adit

- ➡ One connection to surface
- ➡ Horizontal (Inclination $\pm 0,2^{\circ}$ for water transport)
- ➡ Where deposit outcrops, in hilly areas
- ➡ Starting point as deep as possible => access to a bigger part of the deposit above the adit
- ➡ Starting point high enough to prevent high water inflow and for the deposit of development waste
- +
- +
- +

Slope

- Main area: shallow, flat deposits, especially coal
- Inclination $\pm 15^\circ$
- Belt conveyor or truck haulage
- Cost per meter in between cost of a shaft and cost of an adit
- 3 - 5 times longer than a shaft to attain same depth
- Moderate ground conditions
- +
- +
- +
- +
-

Shaft

- Main area: large, deep, or flat deposits
- mostly vertical
- Skip hoisting
- +
- +
- +
- +
-
-

Development Rates

| | Cross Section | Development Rate | Trend |
|-------------------------------|---------------------|-------------------|-------|
| Vertical Development | | | |
| Conventional Shaft Sinking | All Diameters | 1.5 – 6 m/day | → |
| V-mole Boring Machines | Ø 5 – 8.2 m | 6 – 14 m/day | → |
| Raise Boring | Ø <2.5 m | ~ 20 m/day | ↗ |
| | Ø 2.5 – 6 m | ~ 10 m/day | ↗ |
| Horizontal Development | | | |
| Tunnel Boring Machines | Ø up to 12 m | 200 – 800 m/month | → |
| Drilling and Blasting | Larger Openings | 100 – 400 m/month | → |
| Roadheaders | | 15 – 80 m/week | → |
| Continuous Miners | ~ 16 m ² | up to 100 m/day | ↗ |

Location of Main Access Openings

👉 Conditions at the surface

- 👉 flat area for surface plant; high water; buildings; cost of land; available space; transportation; Energy, water; topography; stability of slopes; space for development waste; environmental aspects; public acceptance

👉 Conditions of overlying waste

- 👉 depth of overburden (=> depth of deposit); type of overburden (freezing, cement injection)(salt)

👉 Conditions of the deposit

- 👉 depth, shape, size of deposit; costs for haulage, transport, ventilation => main access in the middle of the deposit; safety pillars, stability => main access in the footwall of the deposit

👉 Mining Method

- 👉 Target points for the development

Number, Size of Main Access Openings

Number

- legal requirements (safety, ventilation)
- at least two
- total costs

Size

- production rate
- ventilation
- material transport
- equipment size
- total cost

Interval between Levels

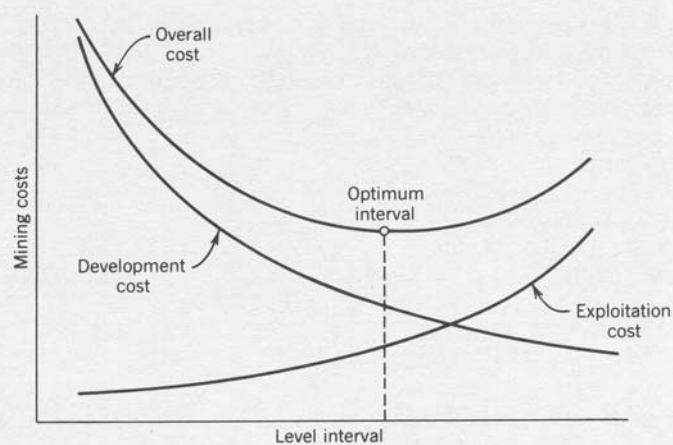


Figure 9.5. Determination of the optimum interval between levels for a hypothetical multi-level mine.