Strategic mine planning of surface mining projects incorporating sustainability concepts

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Characteristics of surface mining projects

- Dynamic complex systems
- With a long-term horizon
- Many uncertainty and risk factors:
  - geological-mineral deposit characteristics,
  - technical
  - environmental, social
  - economic
  - .......

Strategic mine planning and design stage is critical for the sustainability and viability of the projects
New conditions

- Environmental concerns
- Social acceptance-pressure
- Increasing requirements for sustainability
- Land acquisition problems
- More difficult and often changing mining conditions (increase of the depth of mines, geotechnical problems,....)
- Archaeological investigations
- Economic crisis

Main question: How sustainability issues could be incorporated into strategic mine planning and scheduling model
General mine planning diagram

- Mineral deposit - geological - hydrogeological - geotechnical model
- Economic-market and competition model
- Optimization of pit limits
- Strategic mine development model
- Excavations-lignite production and dumping time scheduling
- LOM haulage planning and scheduling
- Project management of large technical infrastructure works
- Special mine planning topics
- Optimum utilization of the reserves
- Power plant(s)
- Quality management
- Original topography-natural environment and social activities situation
- Successive approaches
- Excavations planning
- Dumping planning
- Environmental reclamation planning
- Haulage planning
- Resource and equipment schedule
- Dumping and stockpile scheduling
- Simulation of equipment operation
- Mining cost estimations
- Laboratory tests
- Blast design – planning of non continuous mining equipment operation
- Budget estimation
- Consumption-cost
- ERP
- Time of operations cycle
Mine planning interrelated sub-models

- Financial – mining economics – market model
- Mineral deposit – geologic- hydrogeologic- geotechnical model
- Mine development and scheduling model
- Environmental impact assessment model
Mineral deposit - geologic-hydrogeologic-geotechnical model

- Mineable ore reserves estimation: It is a core component of any surface mining project

- Efficient use of mineral resources

- Geotechnical analysis: contributes to sustainable mine planning design

- Hydrogeological analysis: critical in the sustainability of mine development parameters and in the viability of the project.
Typical drill-hole and mining face in a multilayered lignite deposit
Typical cross section of a multilayered lignite deposit
Defining minable blocks

Part of a typical geological cross section showing the mineable lignite blocks.
Deposit evaluation procedure

Deposit evaluation procedure:

1. Geological - Mineral original drill-holes exploration data
   - Input into mining software
   - Distinguishing of characteristic waste horizons and discrete lignite layers among them
   - Correlation of layers
   - Corrections to original data
   - Geological modelling
   - Evaluation of exploration data by applying appropriate improved algorithm and specific criteria (differentiated for discrete lignite layers or for specific mining areas)

2. Additional data from geological and other studies or from face mapping
   - Spatial correlation - spatial modelling of the deposit
   - Formation of exploitable lignite blocks in each drill hole only by correlating the discrete lignite layers
   - Spatial block modelling of the lignite deposit
   - Lignite reserves estimation by traditional or geostatistical methods - Classification of the reserves

3. Suggestions for further exploration
   - Excavations equipment
   - Power plant specifications
Mine development and scheduling model (1)

- It is a complex, multi-objective optimization problem incorporating technical, environmental, economic, social or other constraints.

- Mine development flexibility is a very important issue. Strategic long term planning requires a reassessment of exploitation options, in the context of anticipated changes.
Optimization objectives:

• The recovery and efficient utilization of the mineral resource.

• The optimal environmental and ecological planning of the mining operation

• The economic performance of the mining project.

• The social acceptance of the project and the contribution to long-term viability of the local and regional economies.

• The minimization of risk in all stages of mining operation.
Environmental impact assessment model

Main parameters:

• Land acquisition requirements-processes
• Relocation of infrastructures affected by the project.
• Environmental protection and land reclamation planning of the mined out and waste dumping areas.
• Archaeological investigations in the mining area.
Financial - mining economics - market model

- Main parameters: objective function, criteria and economic analysis for investment decision-making, constraints of the model.

- Escalation of capital and operating mining cost through all phases of mining project, commodity prices, interest rates, financial engineering and risk analysis model.

- Application of real options or the game theory analysis
CASE STUDY: MAVROPIGI MINE

- Mining area: ~ 11 km².
- Beginning of the mining operations: end of 2002.
- Until the end of 2012, 51.8 Mt of lignite was produced.
- Remaining reserves ~146.4 Mt.
- Main mine equipment: 8 bucket wheel excavators and 3 spreaders.
Fault system - initial and final pit limits of Mavropigi mine
Position of Ptolemais Mines
2010
Time scheduling of Ptolemais mines development
Final Environmental Reclamation of Ptolemais Mines
Mine development sequence in the initial strategic planning of Mavropigi mine.

Mainly by continuous mining equipment
Mine development sequence after the modifications of pit limits and production targets
New changes in mine development sequence after land acquisition problems and geotechnical investigation of south-west final perimeter slope.
Mavropigi mine: limestone extension-geotechnical investigation
Mavropigi mine: Position February 2010
General View of Mavropigi Mine (2010)
Mavropigi mine: Position July 2010
Mavropigi mine: Position May 2012
Mavropigi mine: Position January 2013
General view (1) of Mavropigi Mine (2013)
General view (2) of Mavropigi Mine (2013)
CONCLUSIONS

• Technical, environmental, economic, social or other sustainability parameters should be incorporated into strategic mine planning surface mining projects concerning all stages of the mining project.

• The critical role of such parameters can be derived by dividing the mine planning model into interrelated sub-models.

• Critical parameters: Mineable reserves, geotechnical and hydrogeological data, land availability and acquisition, flexibility, relocation of infrastructures, archaeological investigations