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
  - -.....

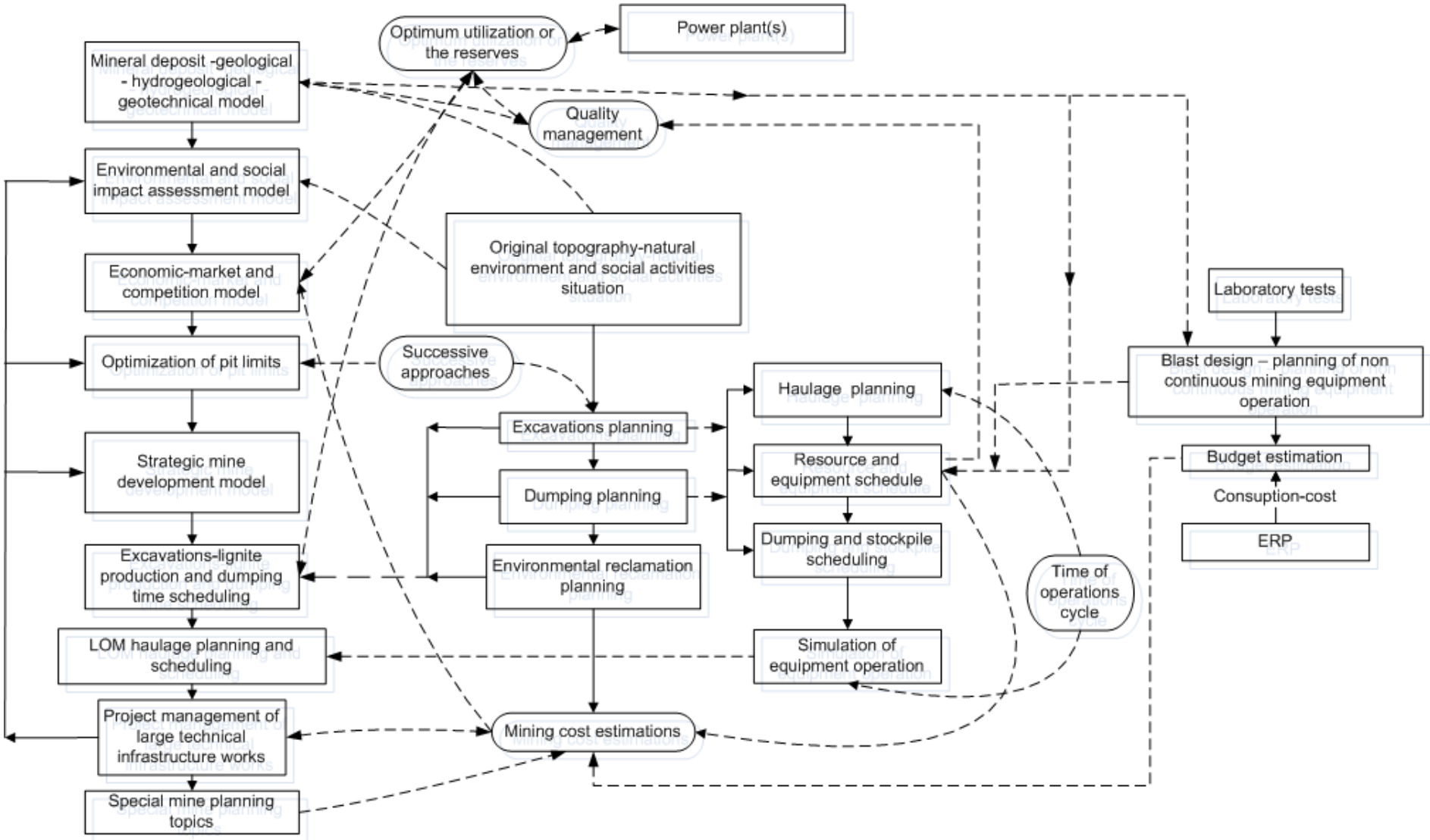
Strategic mine planning and design stage is critical for the sustainability and viability of the projects

New conditions

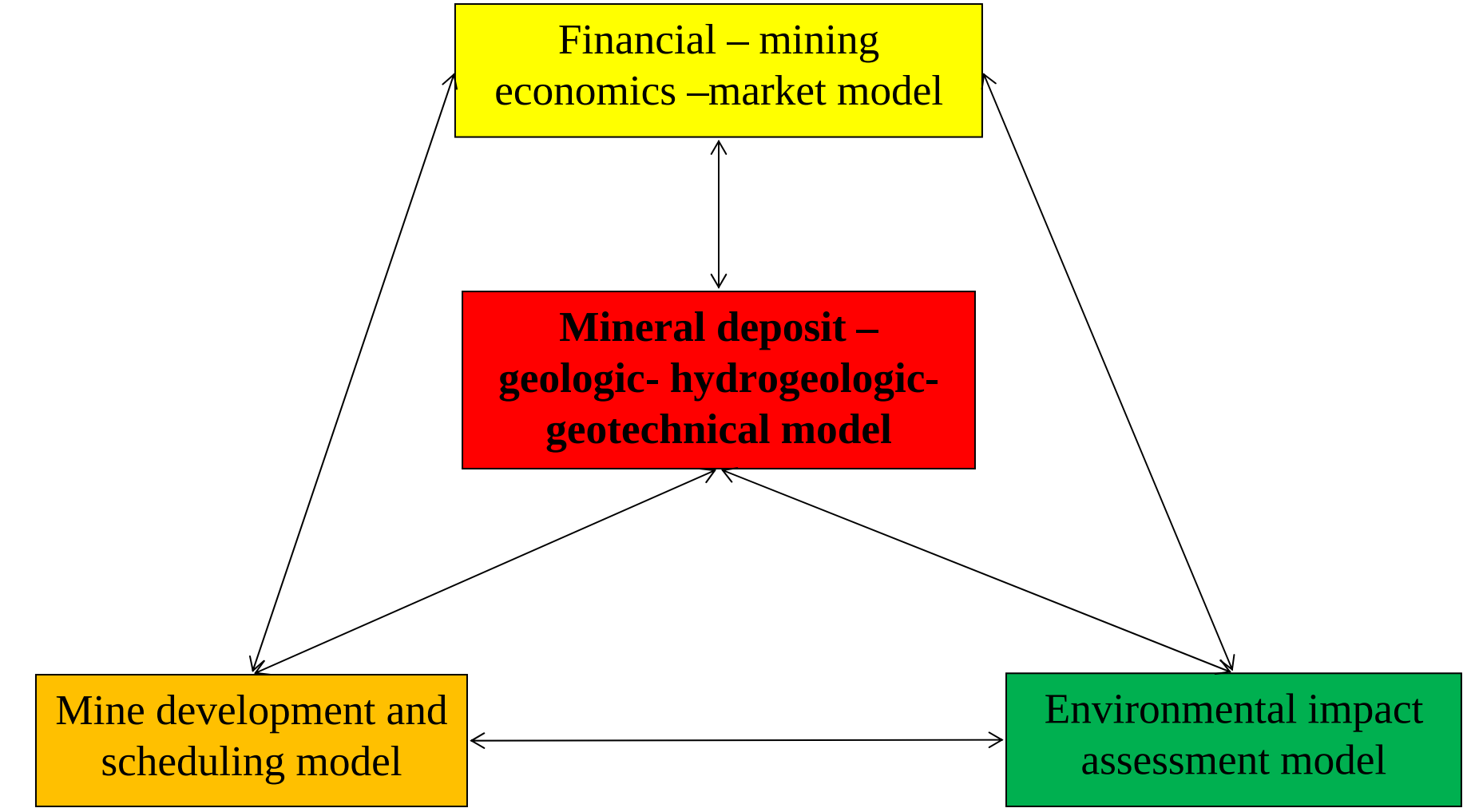
- Environmental concerns
- Social acceptance-pressure
- Increasing requirements for sustainability
- Land acquisition problems
- More difficult and often changing mining conditions (increase of the depth of mines, geotechnical problems,….)
- Archaeological investigations
- Economic crisis

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

General mine planning diagram



Mine planning interrelated sub-models



Mineral deposit – geologic-hydrogeologic-geotechnical model

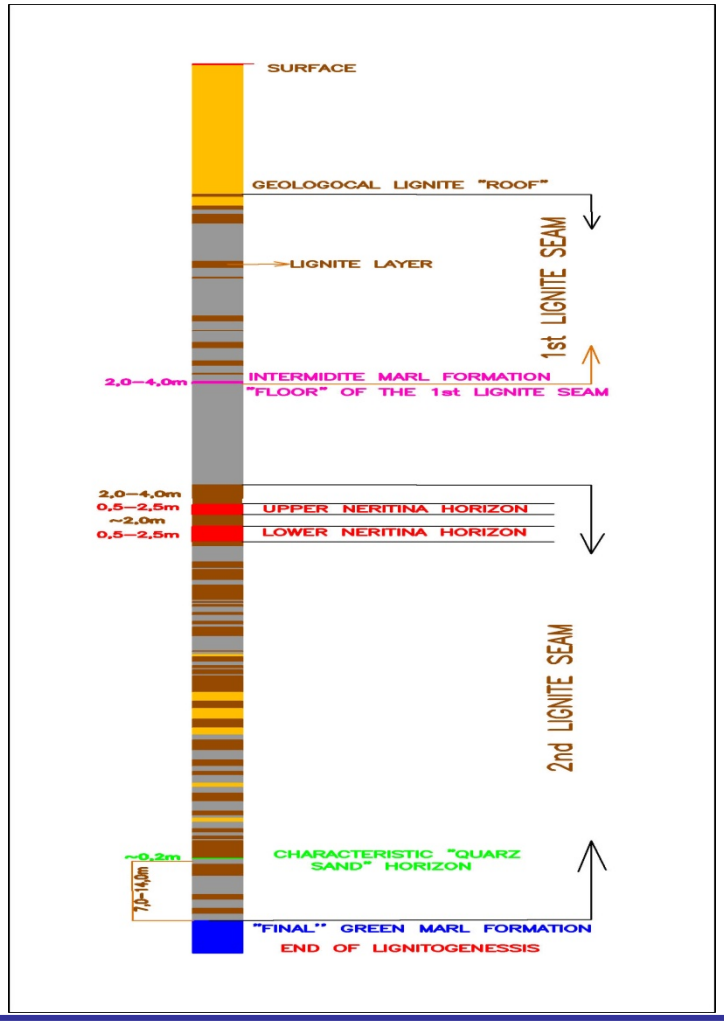
- **Mineable ore reserves estimation: It is a core component of any surface mining project**

- **Efficient use of mineral resources**

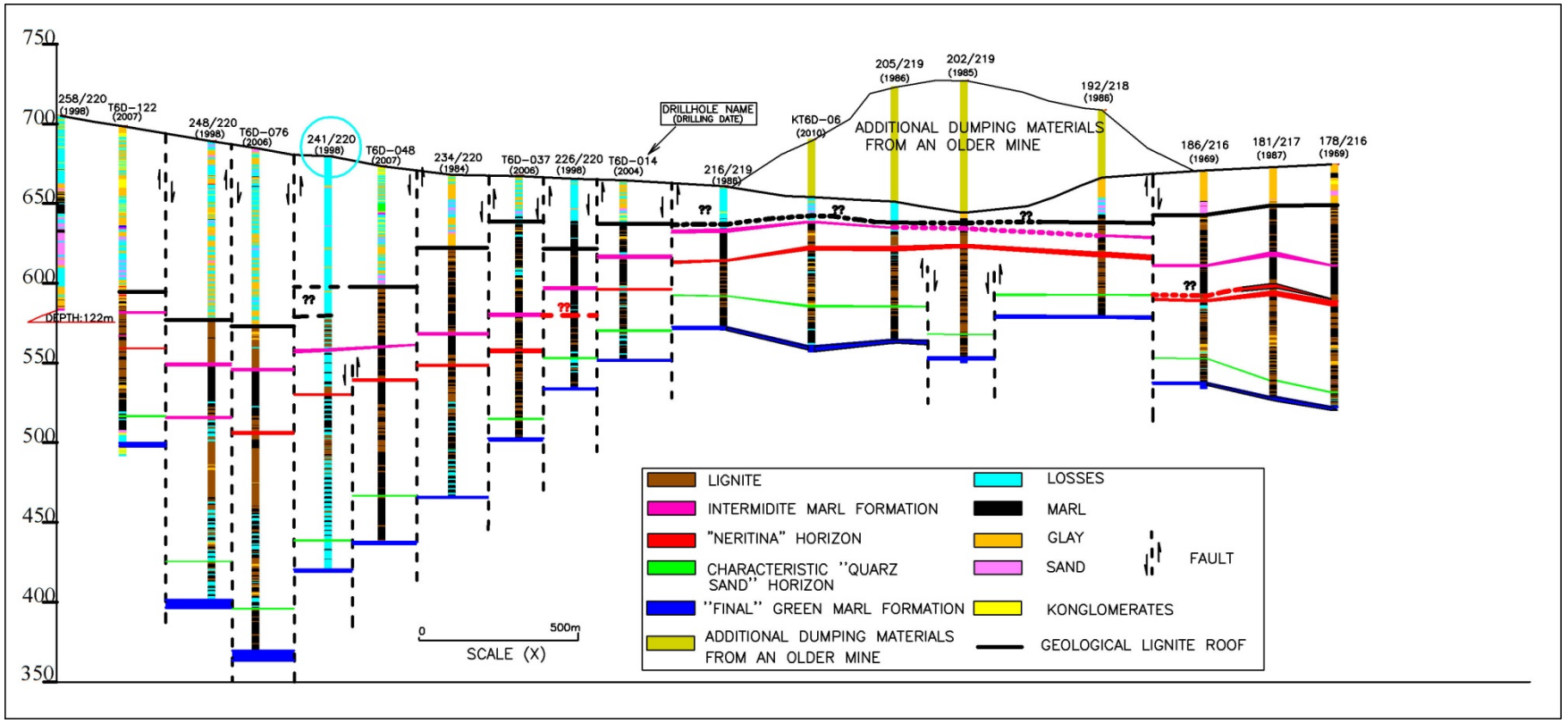
- **Geotechnical analysis: contributes to sustainable mine planning design**

- **Hydrogeological analysis: critical in the sustainability of mine development parameters and in the viability of the project.**

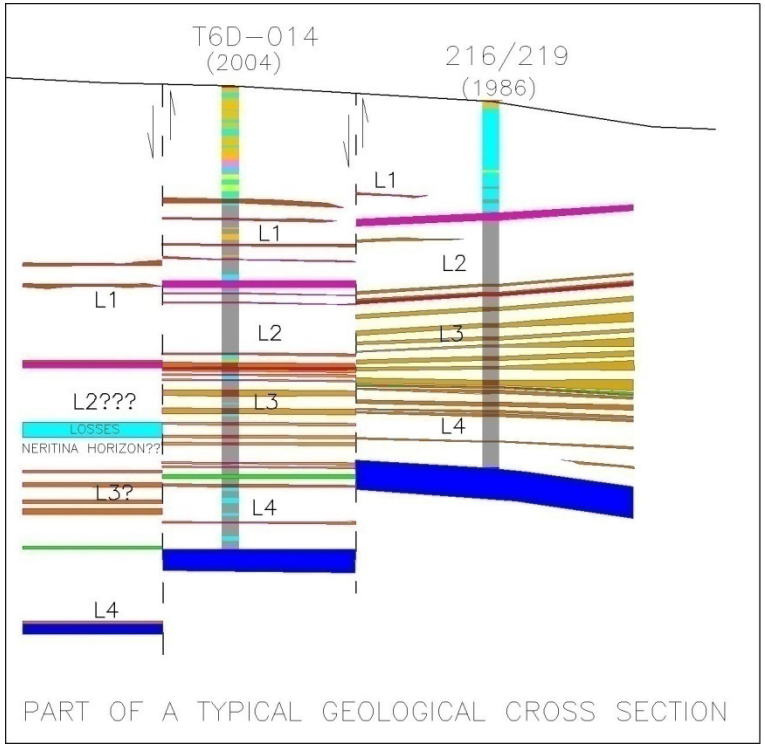
Typical drill-hole and mining face in a multilayered lignite deposit



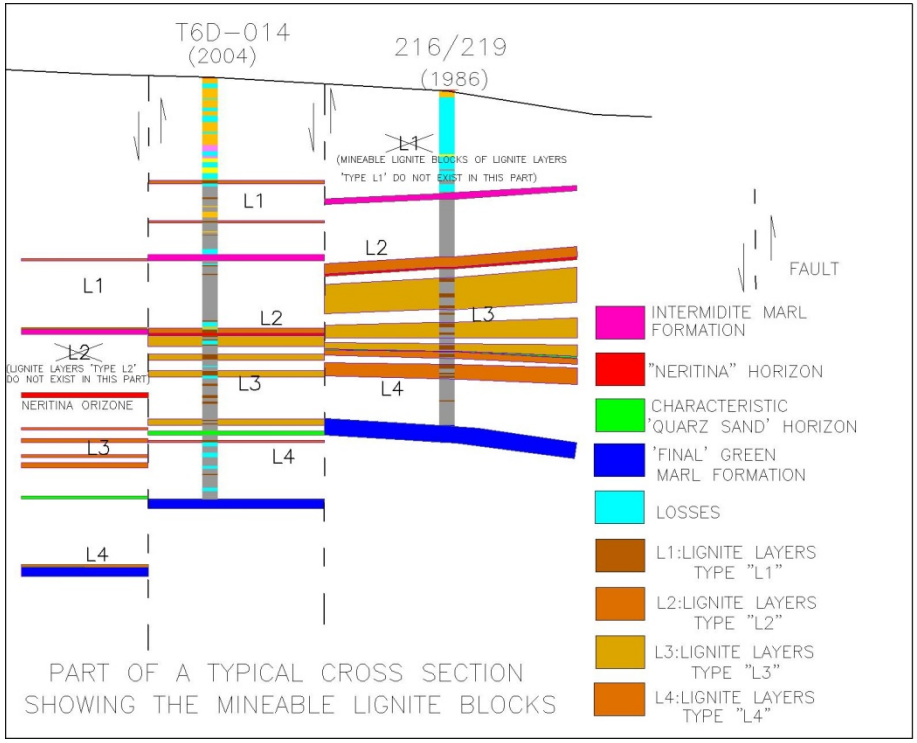
Typical cross section of a multilayered lignite deposit



Defining minable blocks

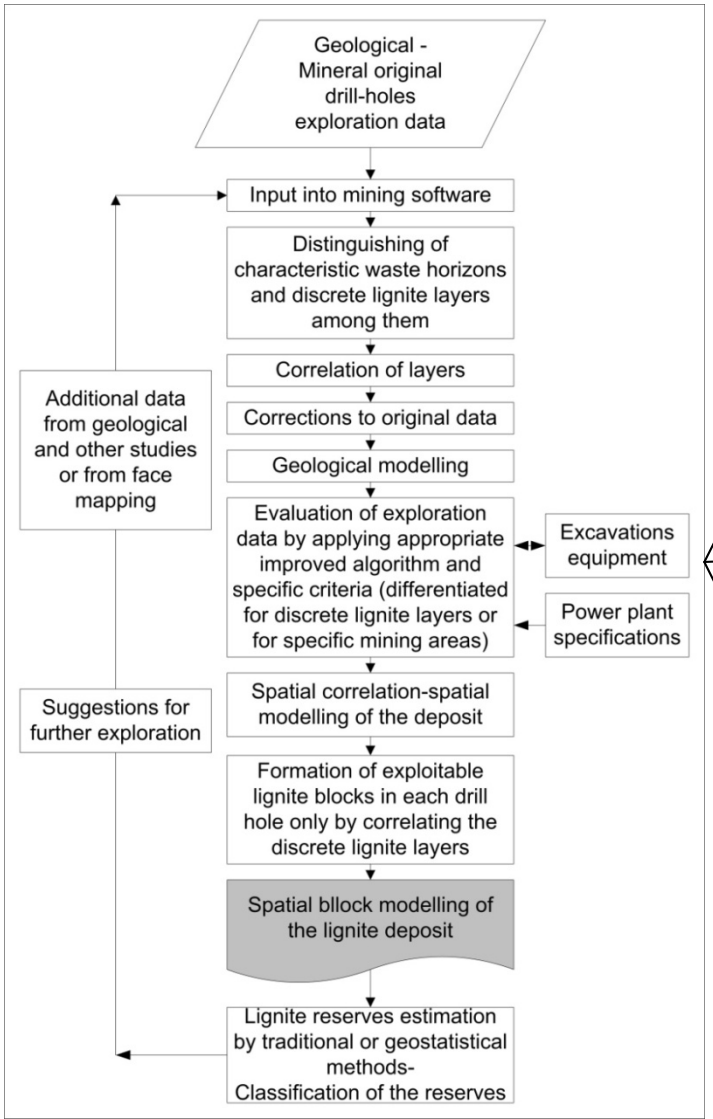


PART OF A TYPICAL GEOLOGICAL CROSS SECTION



PART OF A TYPICAL CROSS SECTION SHOWING THE MINEABLE LIGNITE BLOCKS

Deposit evaluation procedure



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.

Mine development and scheduling model (2)

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

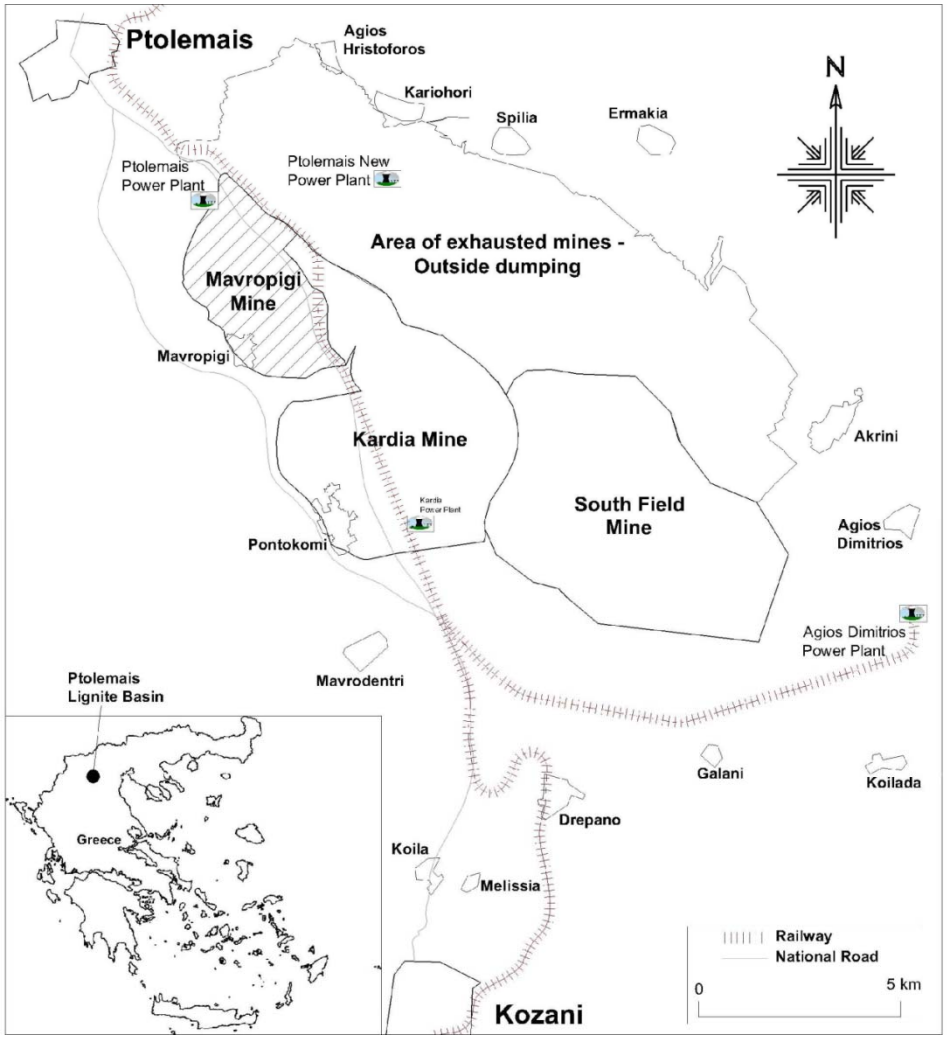
Main parameters:

- **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

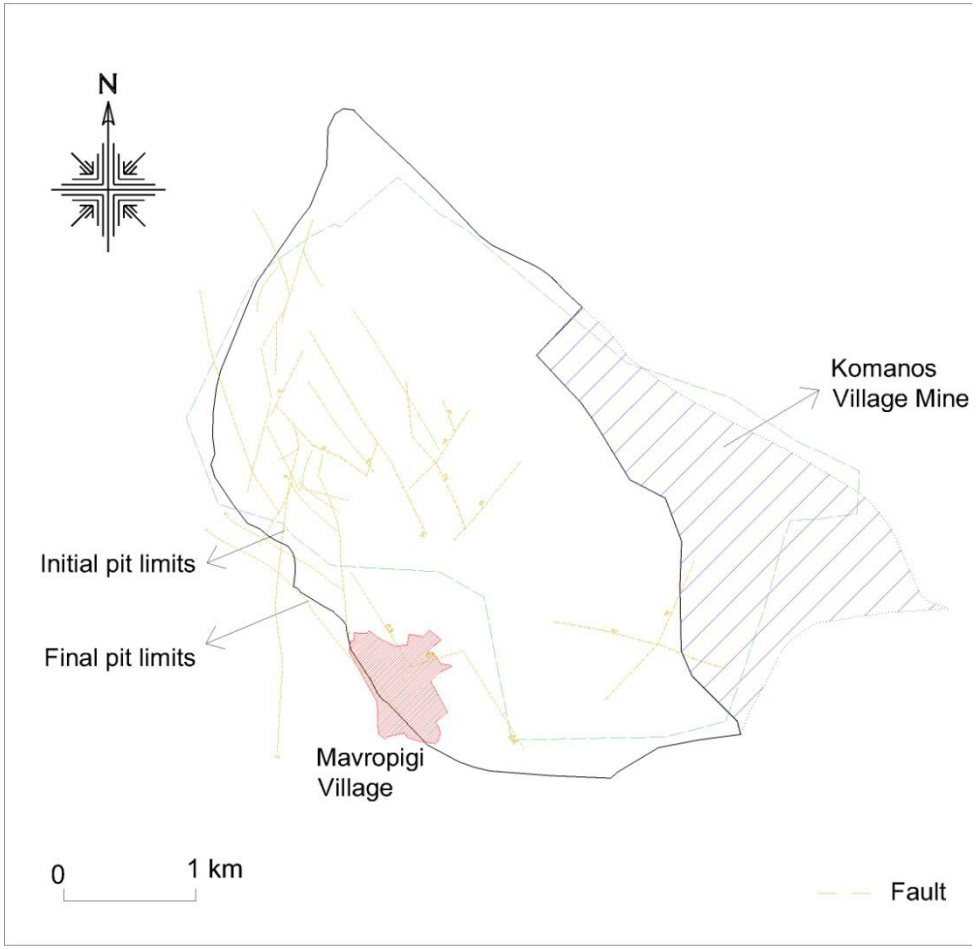
- **Main parameters: objective function, criteria and economic analysis for investment decision – making, constraints of the model.**
- **Escalation of capital and operating mining cost through all phases of mining project, commodity prices, interest rates, financial engineering and risk analysis model.**
- **Application of real options or the game theory analysis**

CASE STUDY: MAVROPIGI MINE

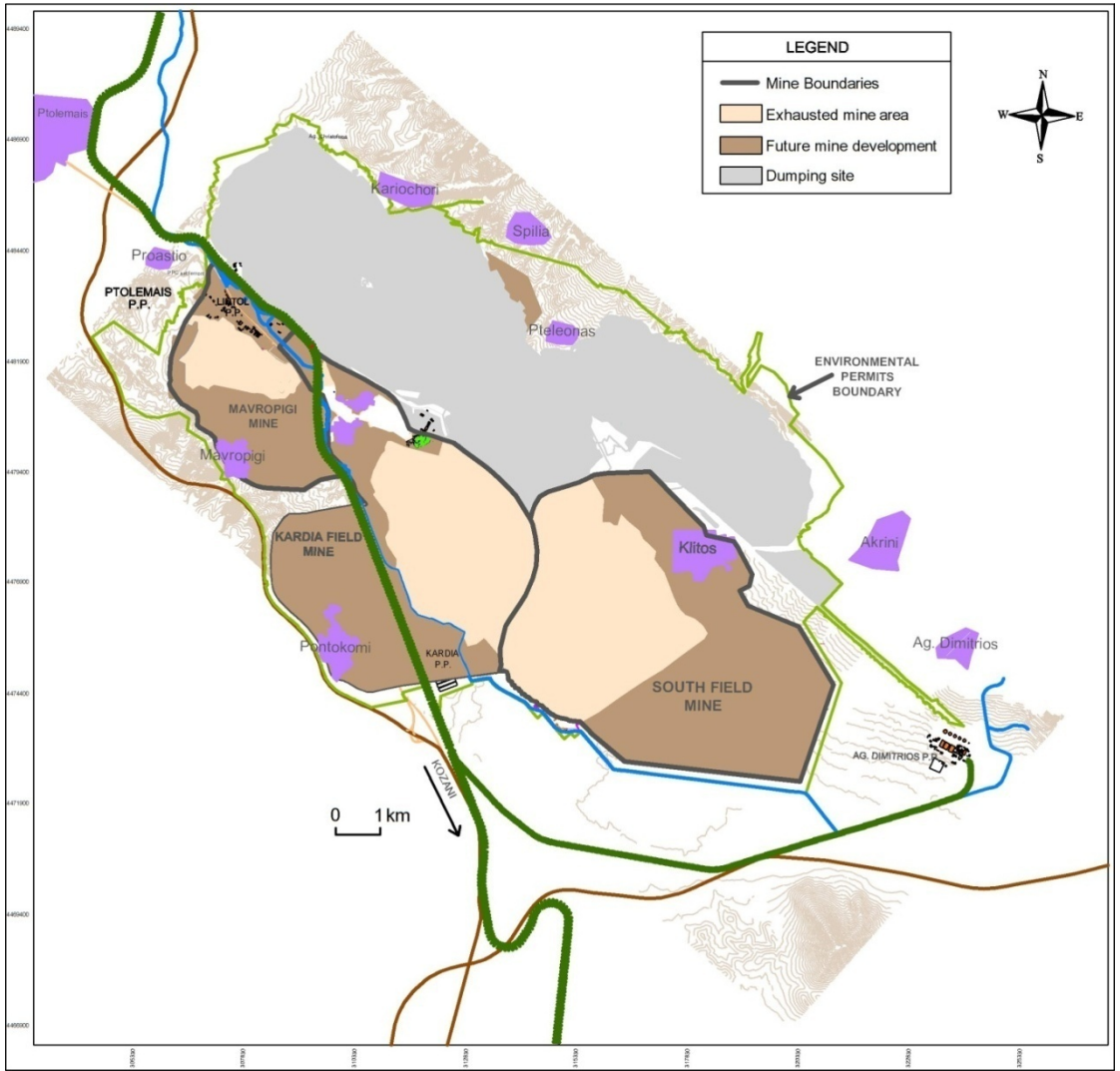


- **Mining area: ~ 11 km².**
- **Beginning of the mining operations: end of 2002**
- **Until the end of 2012, 51.8Mt of lignite was produced.**
- **Remaining reserves ~146.4 Mt**
- **Main mine equipment: 8 bucket wheel excavators and 3 spreaders**

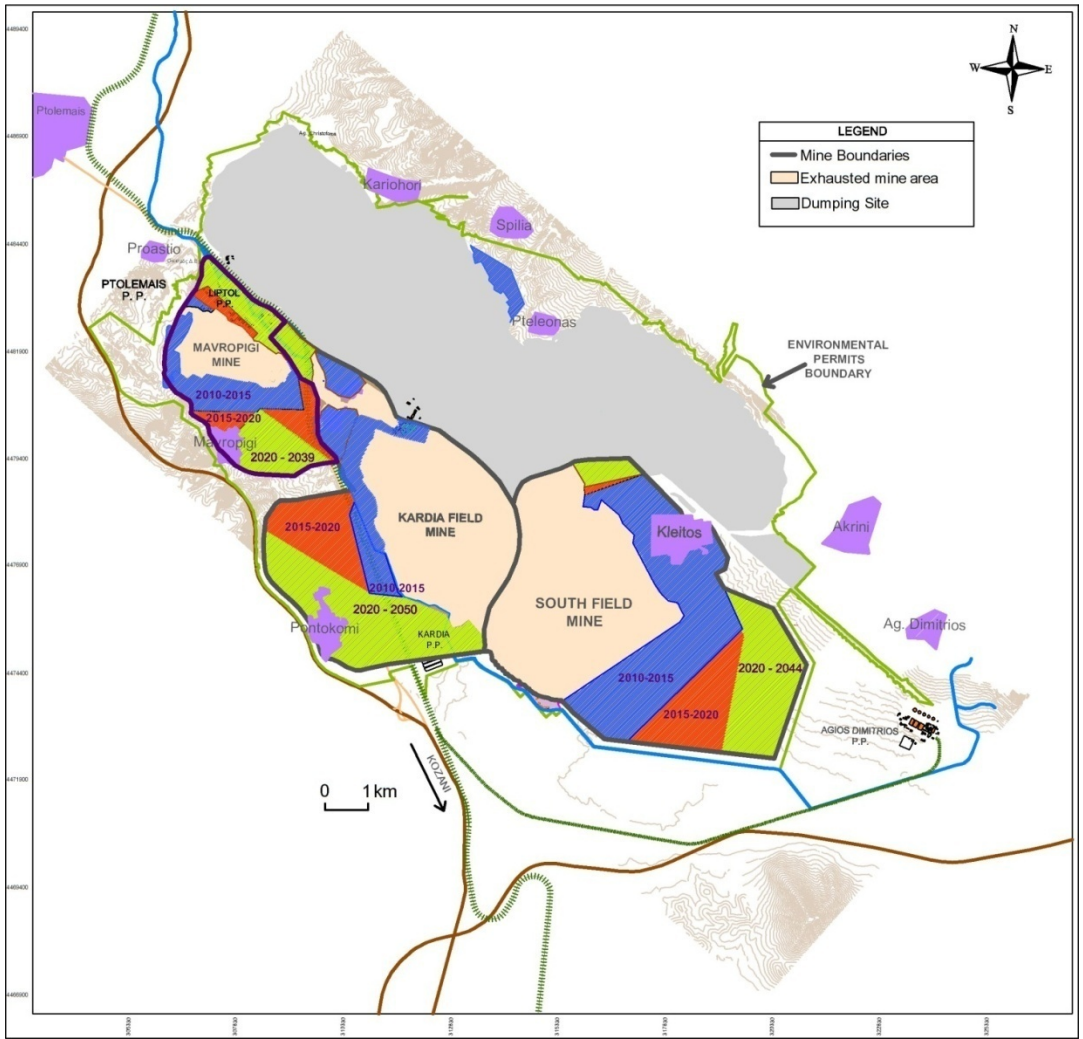
Fault system – initial and final pit limits of Mavropigi mine



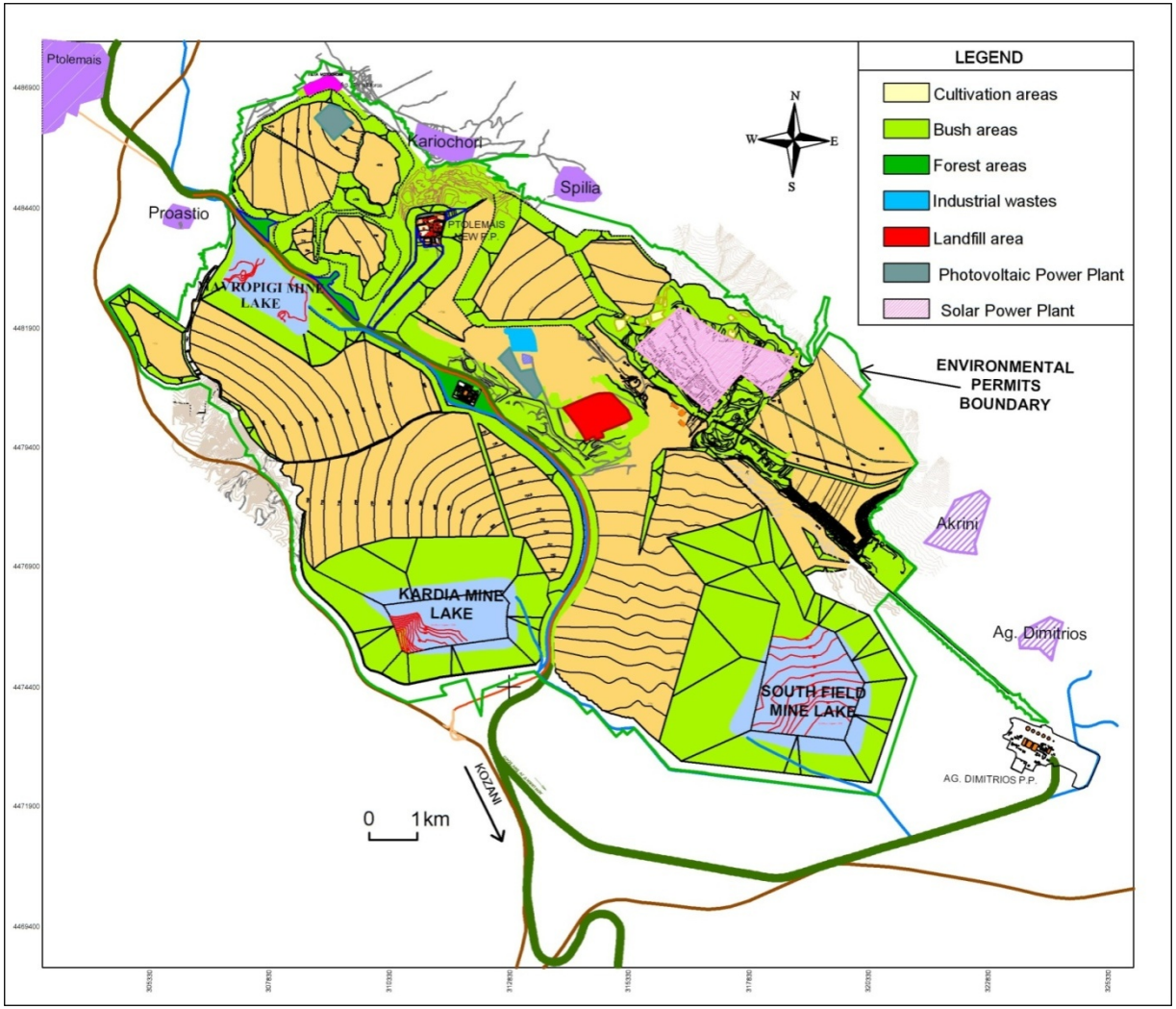
Position of Ptolemais Mines 2010



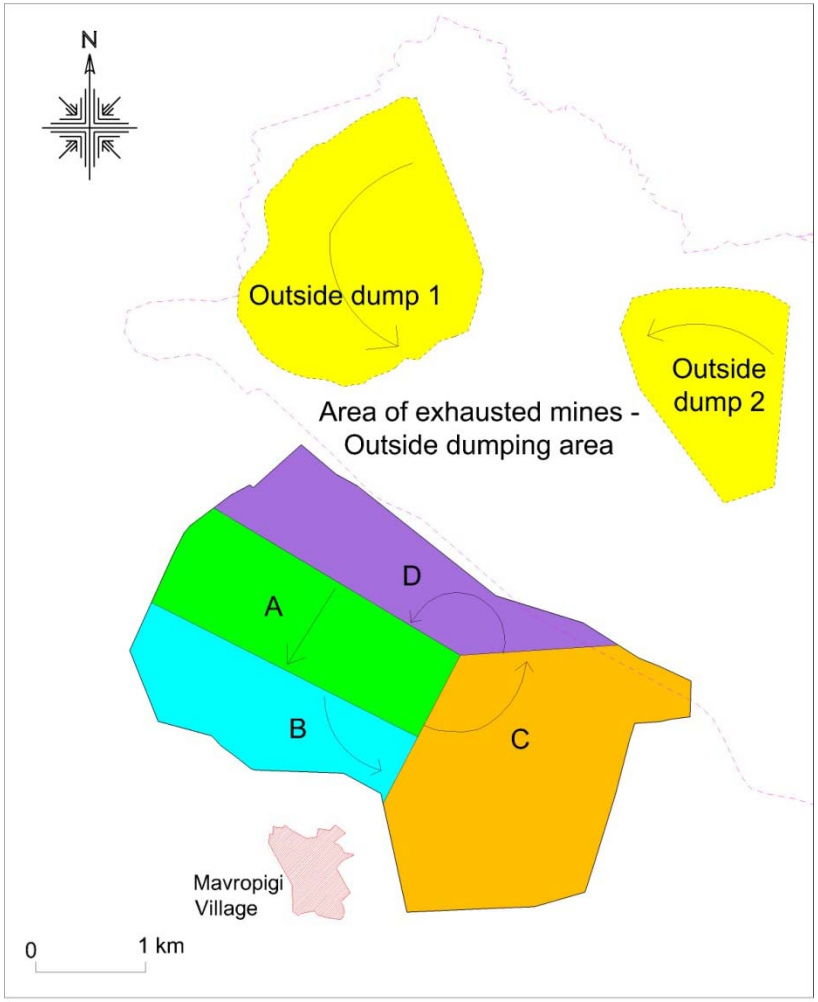
Time scheduling of Ptolemais mines development



Final Environmental Reclamation of Ptolemais Mines

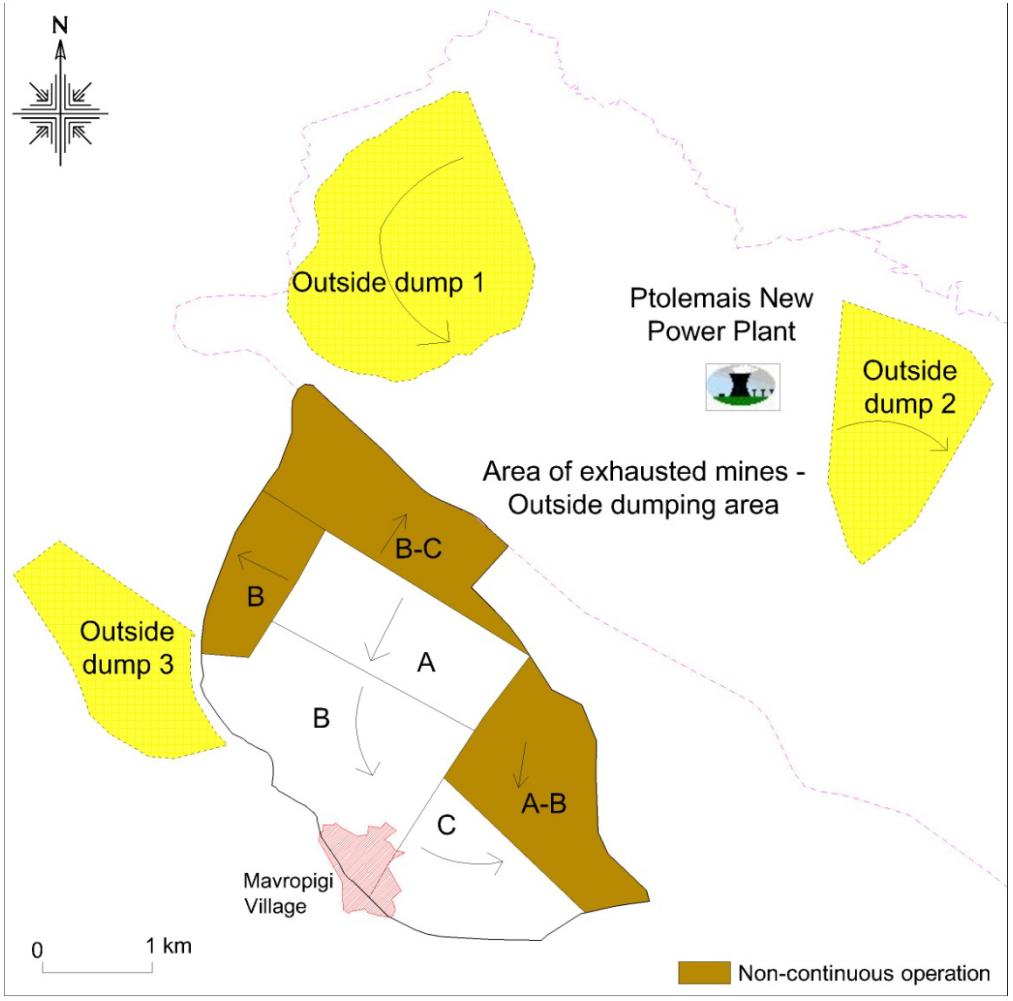


Mine development sequence in the initial strategic planning of Mavropigi mine.

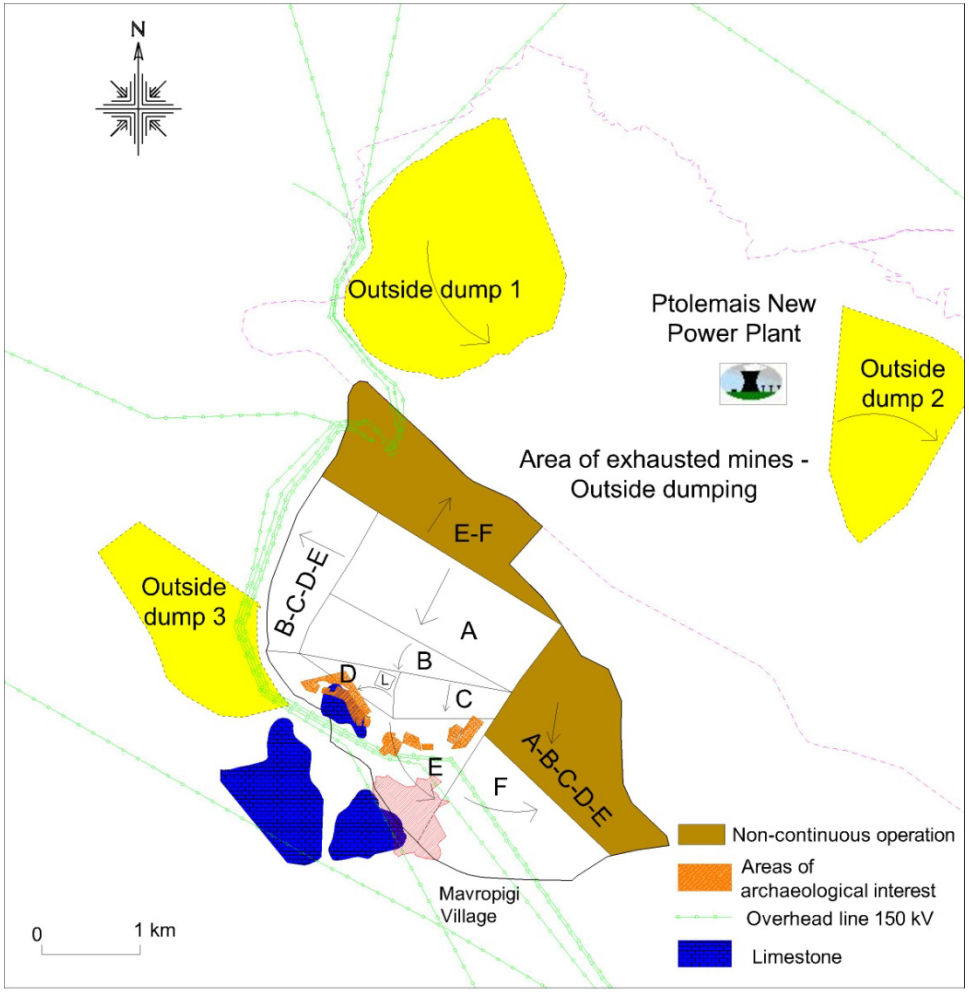


Mainly by continuous mining equipment

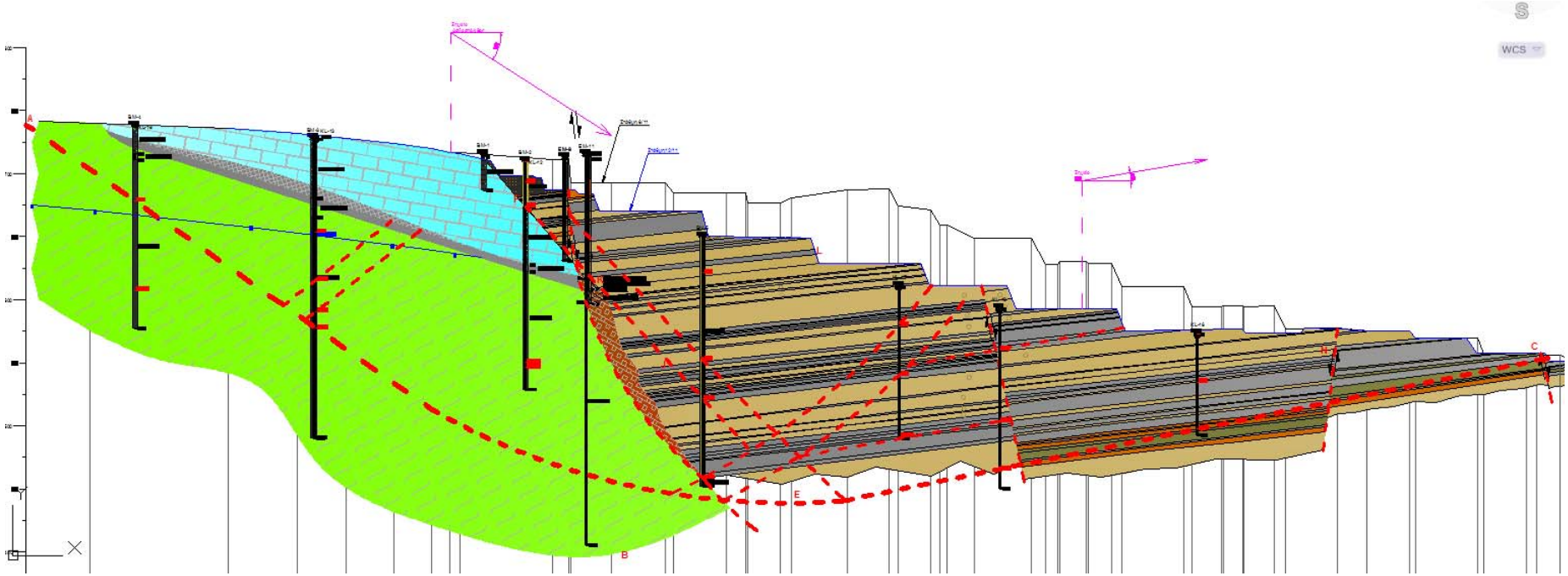
Mine development sequence after the modifications of pit limits and production targets



New changes in mine development sequence after land acquisition problems and geotechnical investigation of south-west final perimeter slope.



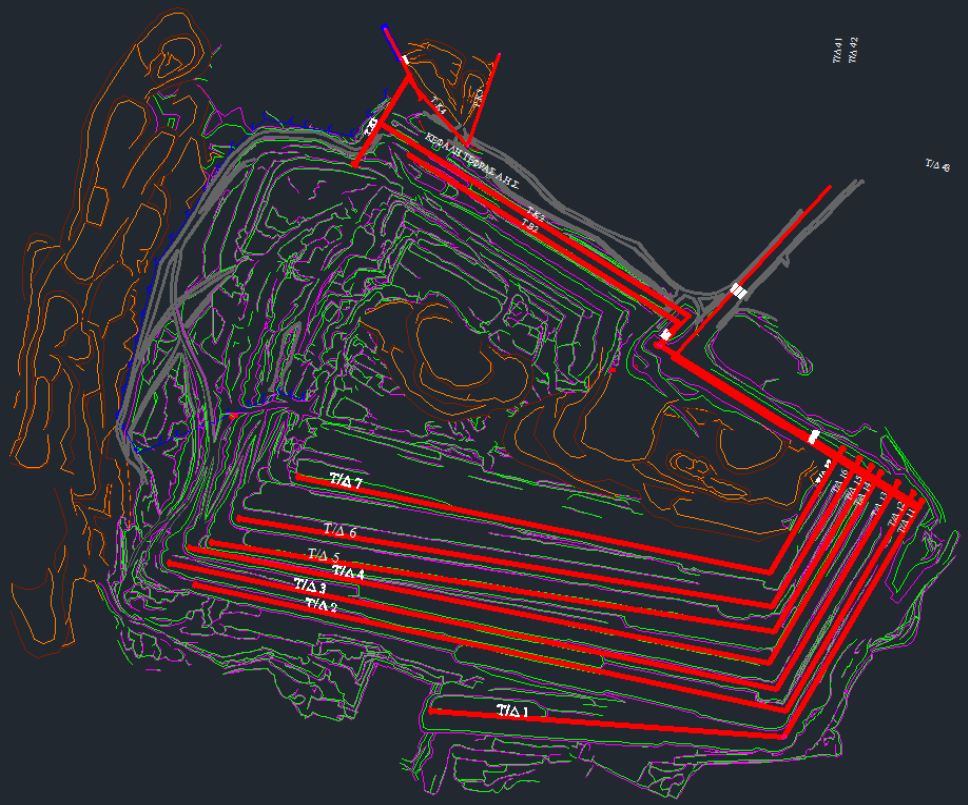
Mavropigi mine: limestone extension- geotechnical investigation



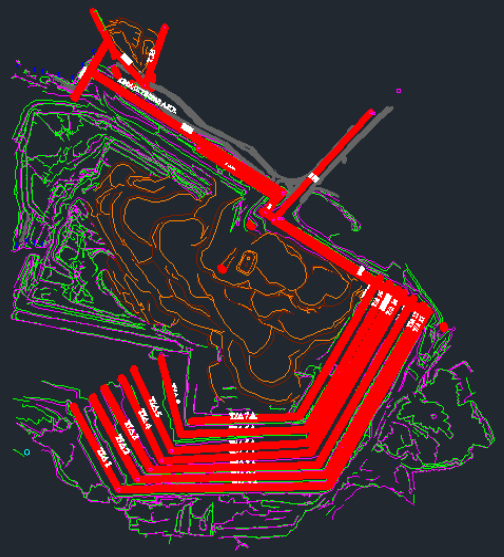
Mavropigi mine: Position February 2010

General View of Mavropigi Mine (2010)

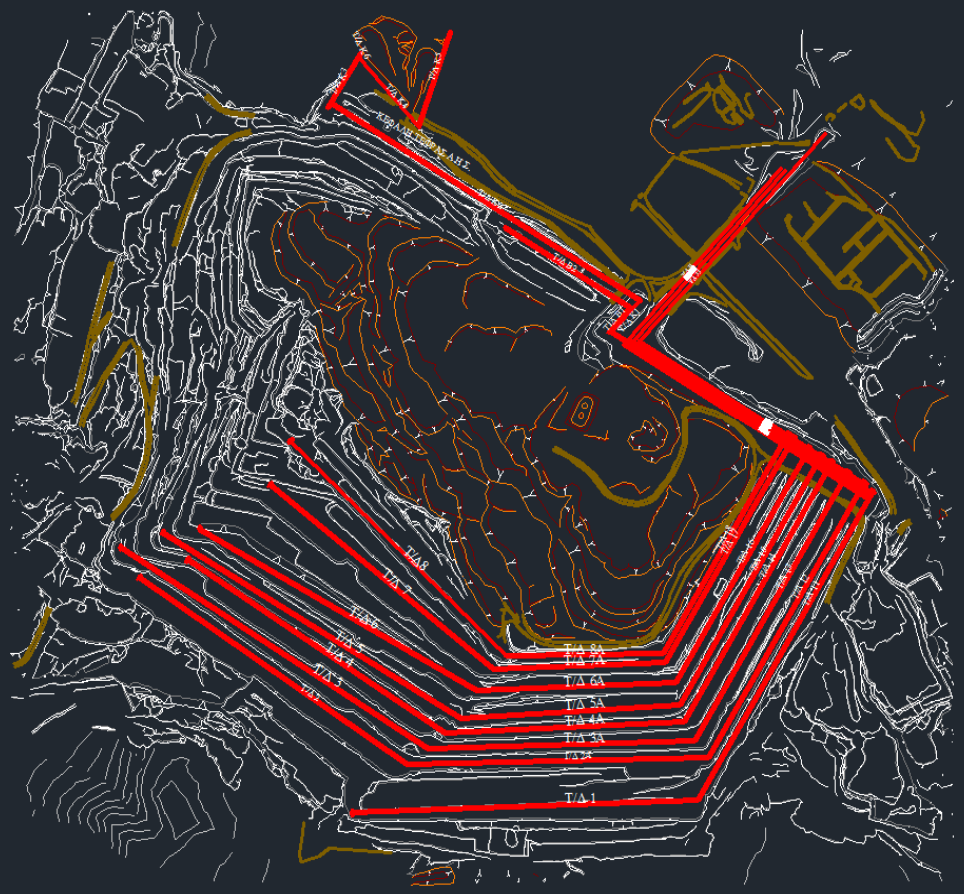
Mavropigi mine: Position July 2010



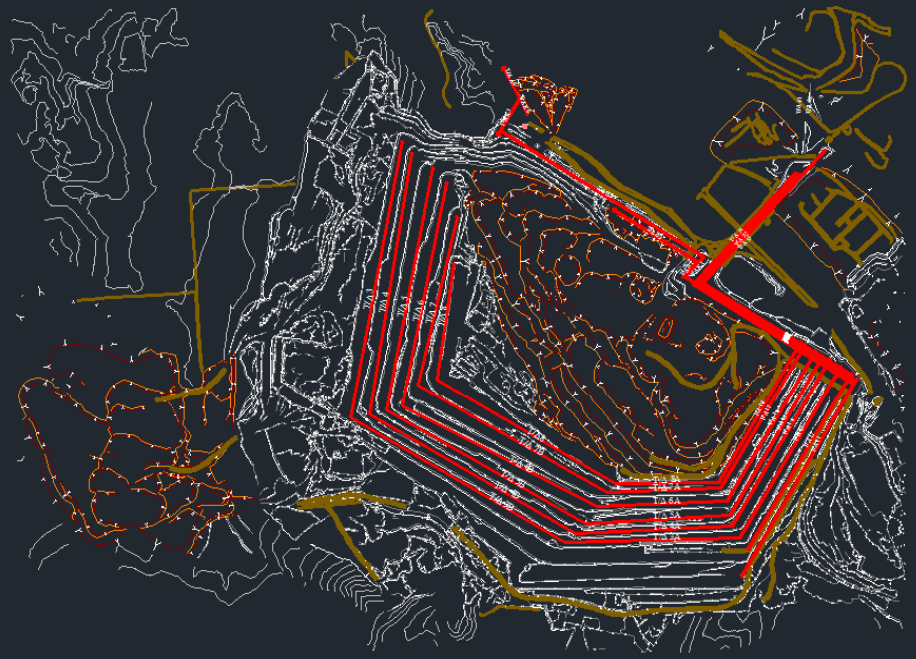
Mavropigi mine: Position August 2011



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**