Modelling and Resource Estimation of a Thin-Layered Lignite Deposit

Ioannis K. Kapageridis
Mining Engineer, PhD CEng CSci MIMMM
Laboratory of Mining Information Technology and GIS Applications
Department of Geotechnology and Environmental Engineering
Technological Educational Institute of Western Macedonia, Greece

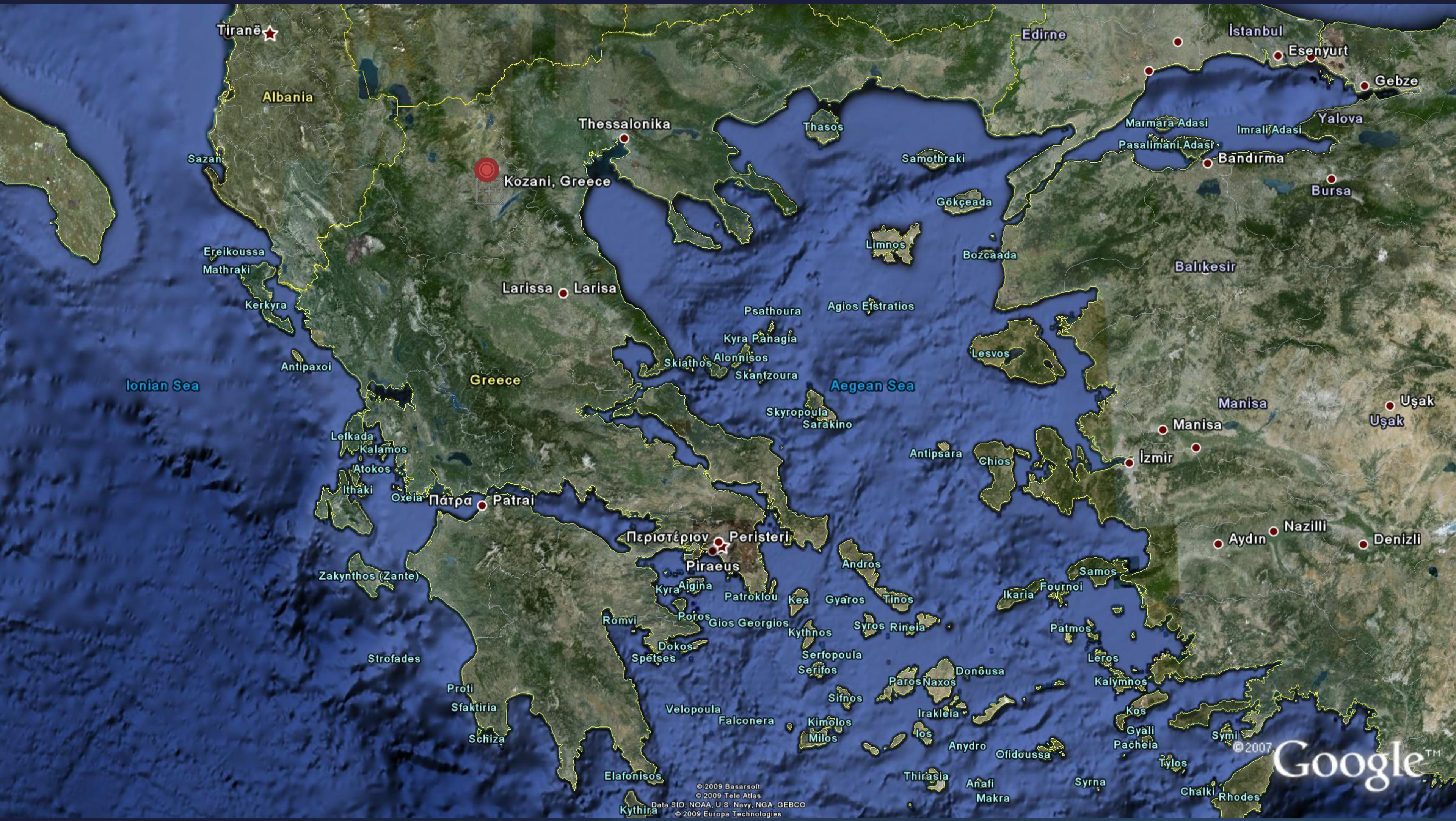
TECHNOLOGICAL EDUCATIONAL INSTITUTION OF WESTERN MACEDONIA

Christos J. Kolovos
Mining & Metallurgy Engineer, PhD
Mines Strategic Development Unit, Mines Division
Public Power Corporation of Greece SA

SW Field - Location

- This study concerns the South Western Lignite Field located between Ptolemais and Kozani in North-West Greece.
- The SW Field is one of the “zebra” type lignite deposits of the Amyntaio-Ptolemais basin .
- The Public Power Corporation of Greece operates a number of surface lignite mines and power stations in the region.
- PPC considers the development of the SW Field as an expansion to current operations.

SW Field – Location Map



SW Field – Location Map

SW Field - Thin-layered Structure

- The lignite deposits of the Ptolemais-Amyntaio basin present a difficult modelling problem.
- Each deposit consists of several thin lignite layers ranging from a few centimetres to a few tens of centimeters in thickness.
- These layers are practically impossible to model individually due to fast lateral transition of lignite layers to humus clay and vice versa and the lack of reliable and detailed stratigraphic correlation of these layers.
- This leads to compositing methods being applied prior to any interpolation and modelling.

Thin-layered Structure of the Ptolemais-Amyntaio Lignites

Geology

- The lignite bearing strata in the study area belong to the upper Pliocene.
- Over the lignite bearing strata lie a series of green-gray clay and marl layers - an alternation of mainly sandy clays, calcareous marls and silty clayish marls.
- A series of yellow-brown sandy layers follows, consisting of mainly calcareous sands with clay intercalations and occasionally sandy marls.
- Over the yellow-brown layers lies a series of red-brown clays and conglomerates - an alternation of reddish sandy clays and loose conglomerates with clay-silica binding matter.
- The Proastion conglomerates are the most recent system of stream deposits consisting of loose conglomerates, sands and sandstones.

Software Used in the Study

Two software packages were used in this study:

1. An in-house package called ***METAL***, programmed by PPC personnel, that allows mineable lignite intervals evaluation, resource and reserves estimation, hard rock reserves estimation, etc.

2. ***VULCAN 3D Software*** mine planning package built by Maptek Pty Ltd., integrating specific coal oriented database and modelling sub-systems called **ISIS** and **GridCalc** respectively.

Raw Data Management

- Raw data from more than 1500 drillholes covering the entire area of lignite deposits in Ptolemais were exported from METAL into an ISIS database.
- This included collar information and lignite quality analyses (Ash, Lower Heating Value, and Relative Humidity) on specific drillhole intervals.
- Average drillhole spacing was around 200m.
- A general description of the material in each interval is included together with a number of coded descriptive fields regarding parameters such as colour and texture.

Database Structure

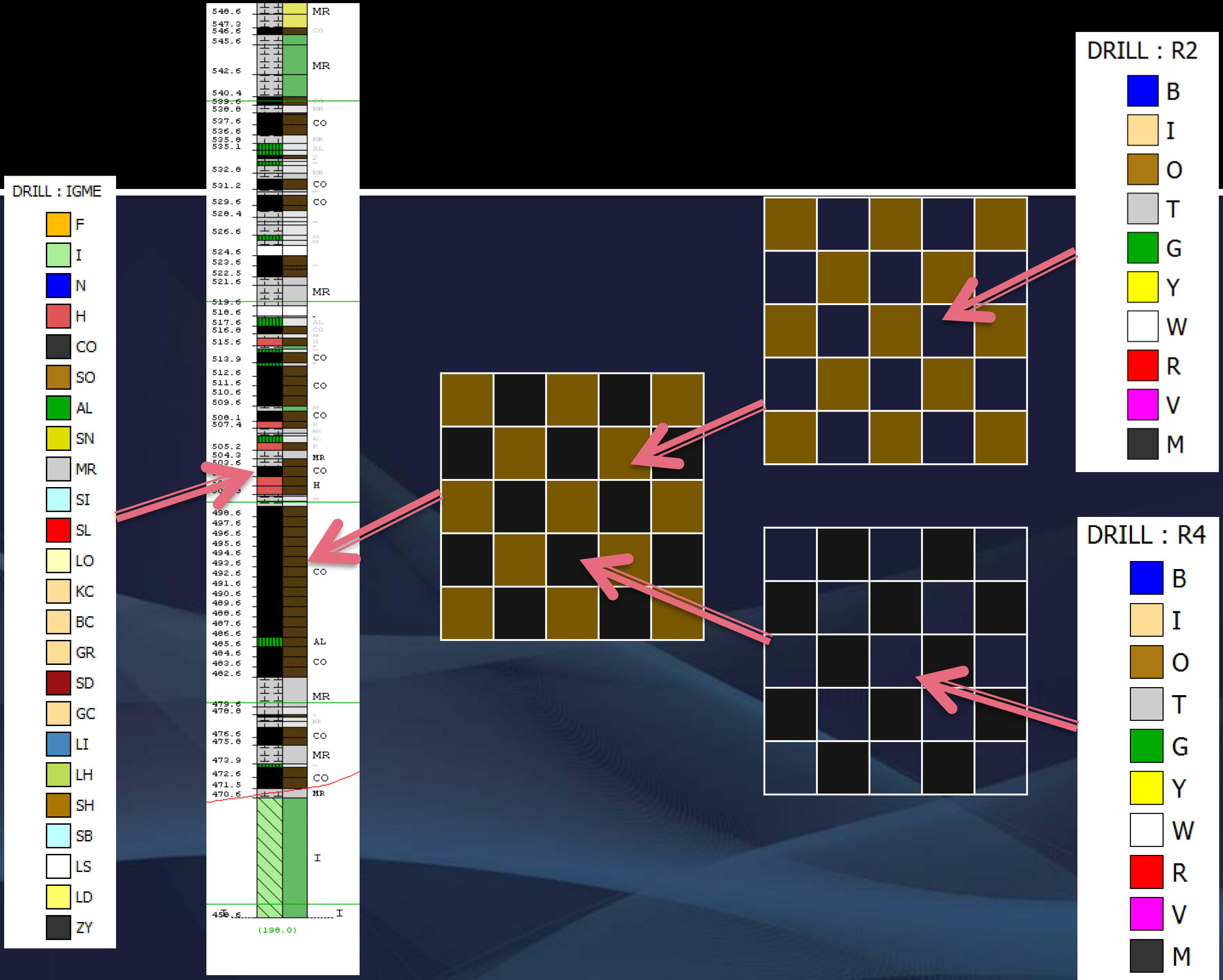
TABLE	FIELDS								
COLLAR	CODE	PCODE	X	Y	Z				
	hole code	hole name	collar coordinates						
RAW	FROM	TO	DESC	R1-R13	LENGTH	ASH	KCAL	RH	COLOUR
	top offset	bottom offset	material type	descr. fields	thickness	ash	lower heating value	humidity	material colour
COMPO	FROM	TO	DESC	LENGTH	ASH	KCAL	RH	SR	SG
	top offset	bottom offset	composite type	thickness	ash	lower heating value	humidity	stripping ratio	specific gravity
CORREL	DEPTH	CODE							
	bottom offset	horizon							
HARD	FROM	TO	THICK	ZONE					
	top offset	bottom offset	length	overburden zone					

Stratigraphic Correlation

- Stratigraphic correlation of the SW Field deposit was performed by the Institute of Geology and Mineral Exploration (IGME) of Greece in order to study the tectonics of the deposit.
- Correlation was based on a number of drillhole section plots prepared in Vulcan, and the original drillhole logs.
- Plotting was performed using Vulcan's Batch Plotting utility which allowed quick generation of very complex plots combining information from multiple databases and tables.
- Lignite seams were grouped in two main bands, the lower and upper band.

Compositing Material Colour

- Two of the descriptive fields in the RAW data table gave information about the actual colour of the material.
- This allowed proper colouring of the raw intervals.
- The drillhole traces were split in two halves with the left being coloured according to the material type field and the right being coloured using a composite colour based on the material colour fields.
- Colour compositing was achieved using two transparent fill patterns.

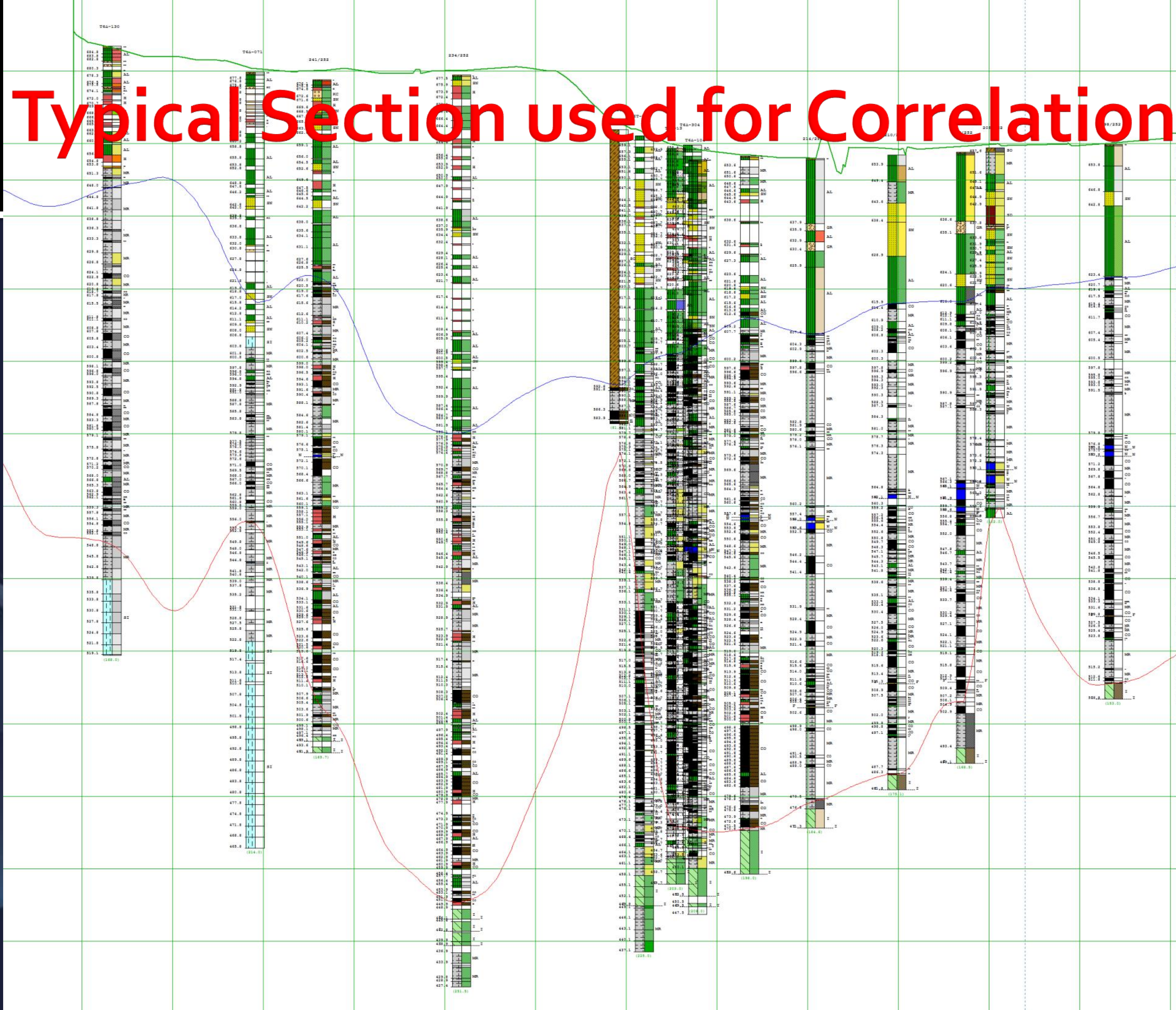


DRILL : IGME
F
I
N
H
CO
SO
AL
SN
MR
SI
SL
LO
KC
BC
GR
SD
GC
LI
LH
SH
SB
LS
LD
ZY
DRILL : R2
B
I
O
T
G
Y
W
R
V
M
DRILL : R4
B
I
O
T
G
Y
W
R
V
M

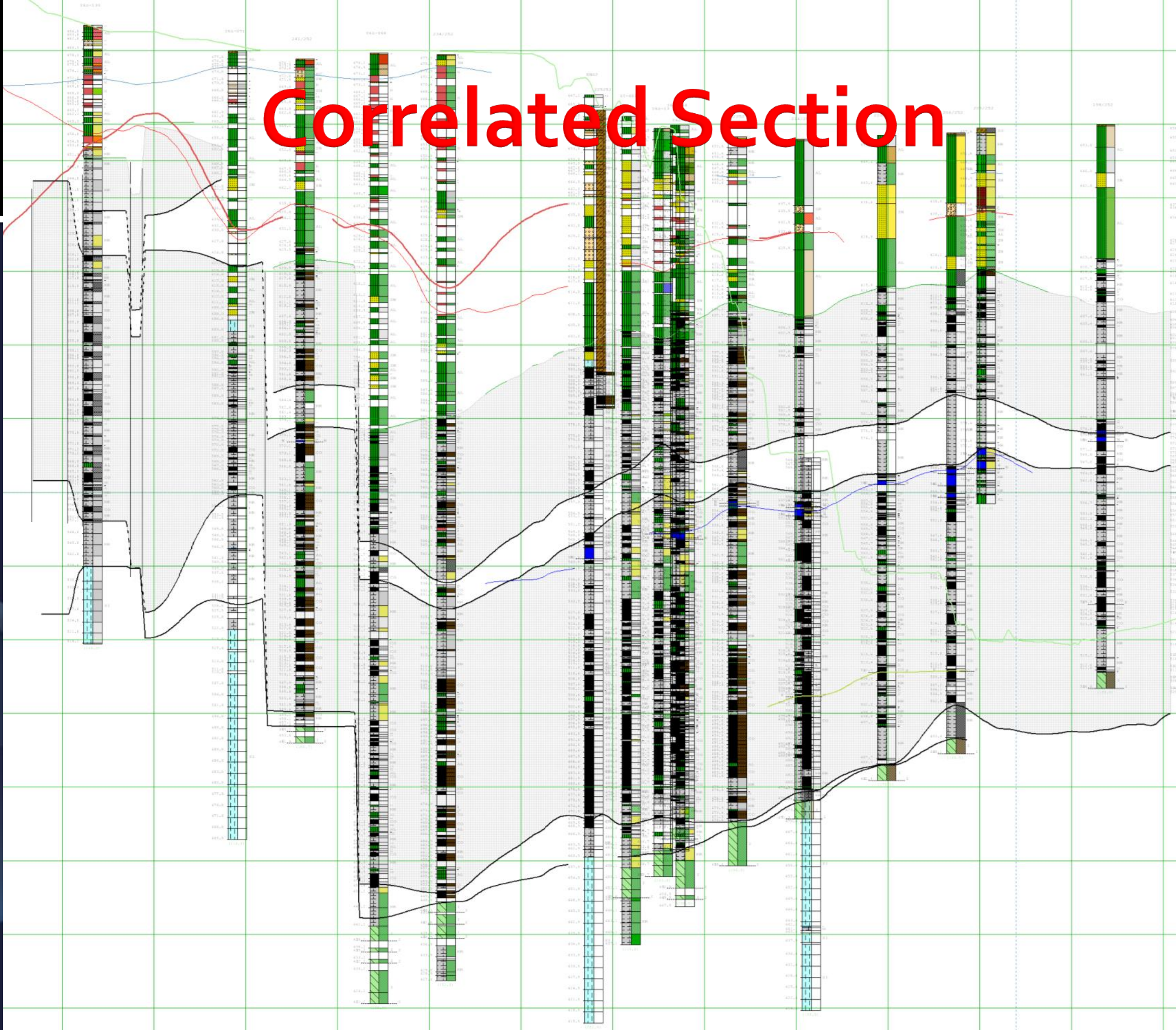
Correlated and Modelled Surfaces

Surface - Horizon	Code in Database	Colour in Plots
Old mine dump areas	MD	Cyan
Recent dump areas	DND	Gray
Würm sediments	DV	Light blue
Proastio formations	DP	Red
Red-brown series	DR	Brown
Yellow-brown series	DY	Yellow
Green series	DG	Green
First Geological Roof	GO1	Black
First Geological Floor	GD1	Black
Second Geological Roof	GO2	Black
Neritina horizon	N	Dark blue
Characteristic sand horizon	F	Light green
Second Geological Floor	GD2	Black
Final Marl Roof	OM	Black
Base roof	BG	Dark cyan

Typical Section used for Correlation



Correlated Section



Fault Modelling

Three characteristic horizons that could be correlated were used for determining faults.

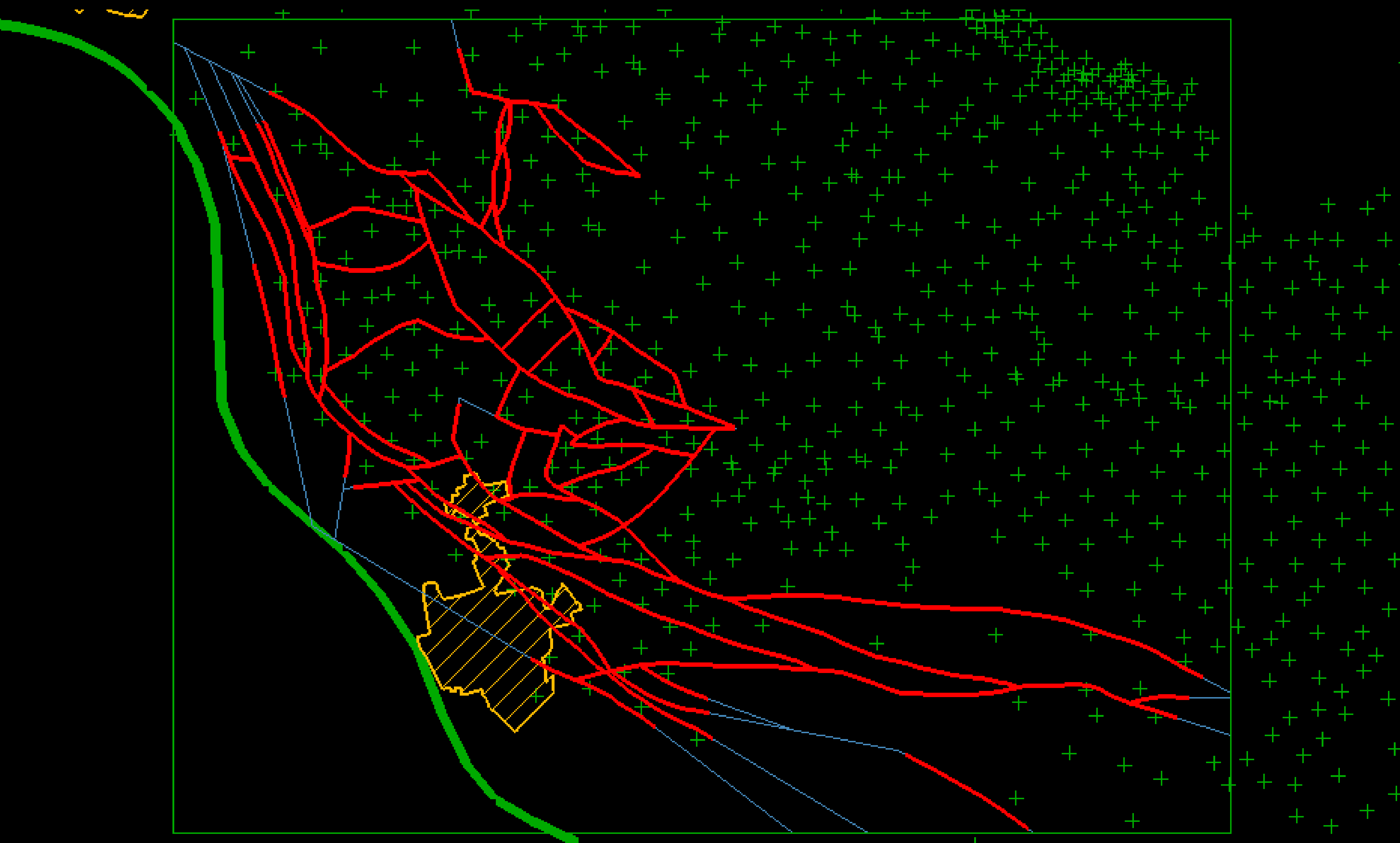
1. The **characteristic sand horizon** is a very specific horizon of the Kozani-Ptolemais basin - a light grey horizon covering the entire basin, consisting of feldspars (plagioclase), biotite, and quartz.
2. The **Neritina horizon** is another characteristic horizon of the basin that is found between the lower and upper lignite band, consisting of light coloured marls, which contain fossils of gastropod Theodoxus (Calvertia) Macedonicus, mostly known from its older name Neritina.
3. **Final marl** lies below the deepest lignite seam and is a white-yellowish calcareous mud with 92.1% $CaCO_3$ and 5.6% $MgCO_3$.

The combined identification of the characteristic sand and final marl in a drillhole is a safe indication of where the lignite bearing strata end, and drilling should stop.

Fault Modelling

- Faults in the area follow a main direction NW-SE.
- The fault lines were combined into polygonal zones to be used in structural modelling of the deposit.
- Some of the originally designed fault lines had to be extended for the zones to close.
- Grid Calc builds a grid by modelling each zone independently and connecting the adjoining edges.

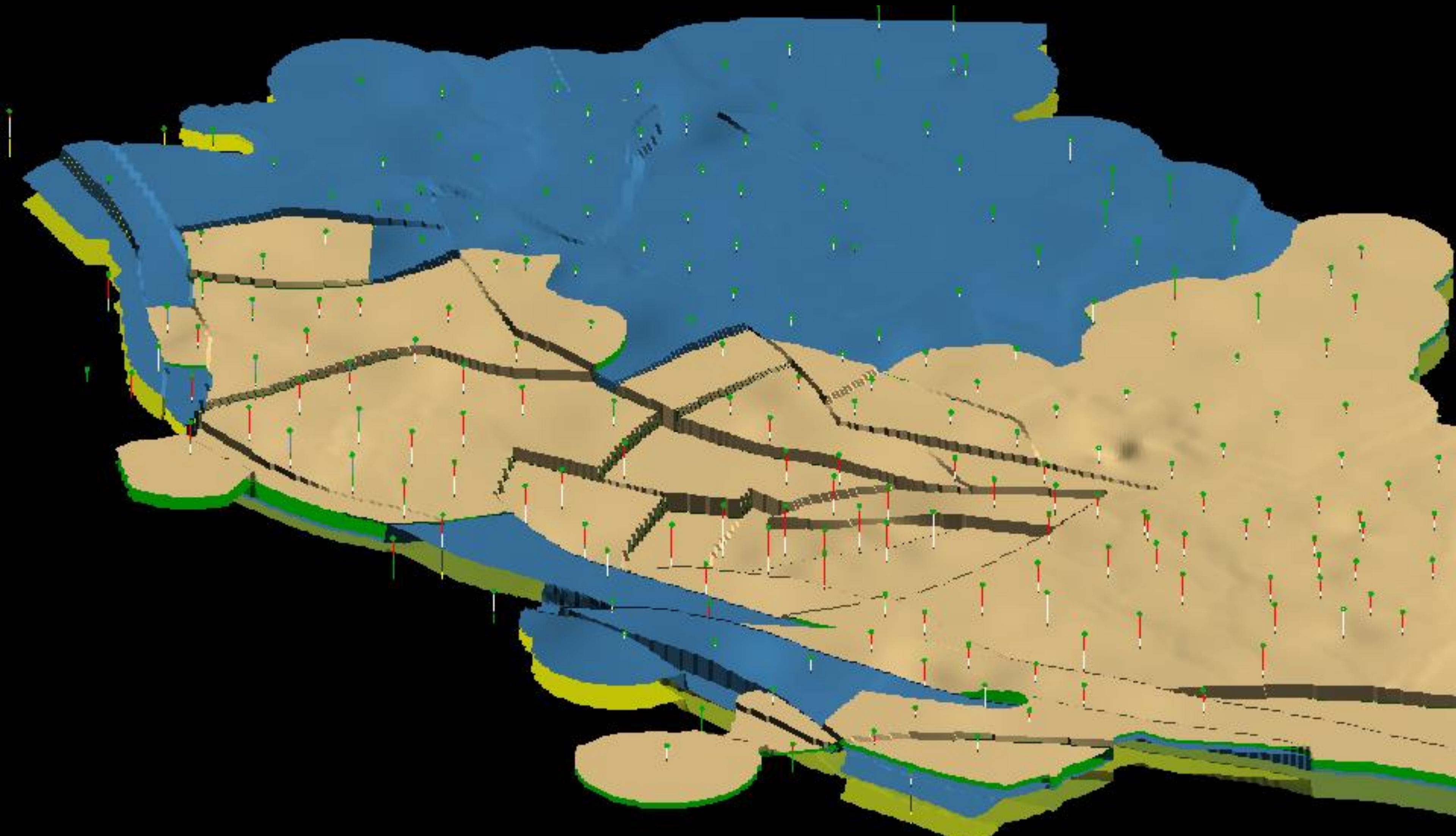
Faults and Fault Zones



Structural Modelling

- Inverse distance (ID^1) was used to model all structural surfaces (roofs and floors) while inverse distance squared (ID^2) was used to model thickness.
- Four samples were used for each estimation point within a search area of 300m radius.

Lignite Bands – Structural Roofs and Floors



Modelling Lignite Quality Parameters

- Three quality parameters were of interest in this study: ash, mean relative humidity, and mean calorific value of the mineable lignite intervals.
- A single grid model was generated for each of them using weighted average values from the composited drillhole intervals.
- Inverse distance squared was used for generating the quality models and the same number of samples and search radius used for structural modelling.
- The quality estimates produced were only used to get a general picture of the resource quality.

Modelling Hard Formations

- Hard formations within the overburden zones needed to be modelled for mining equipment selection and scheduling purposes.
- Hard horizons and their thickness were identified in the descriptions of drillhole intervals.
- These intervals were also classified as per overburden zone.
- Separate models of hard formations within each overburden zone were generated in GridCalc and their volume and mass was calculated.

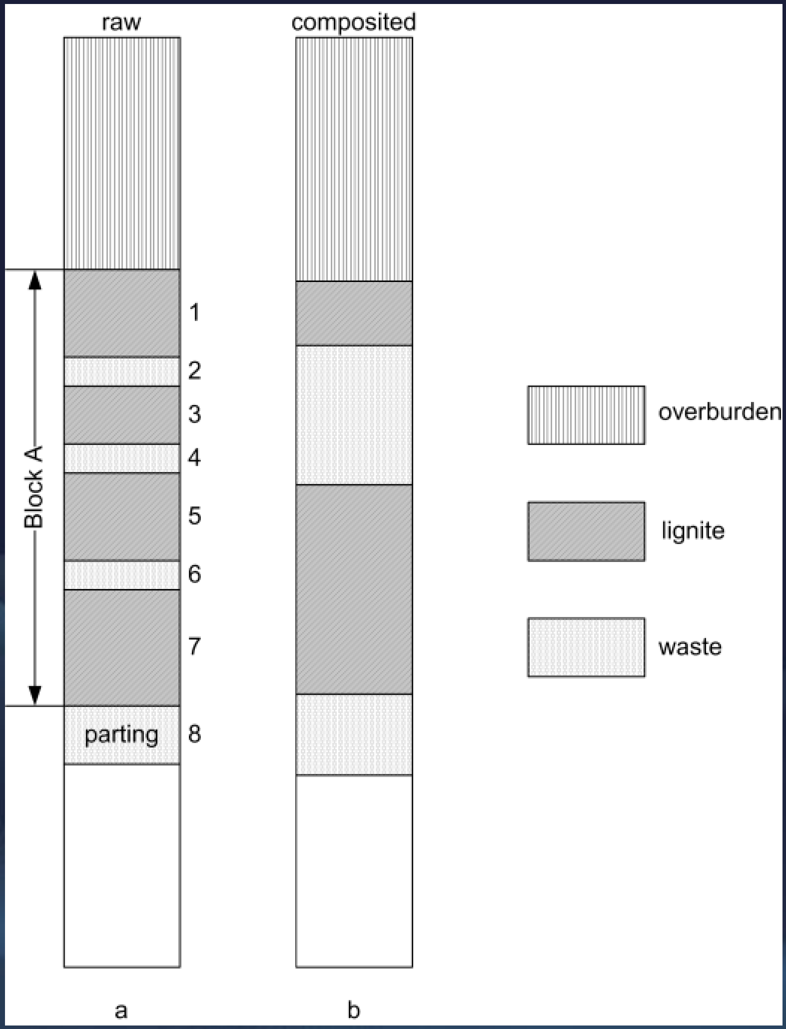
Evaluation of Mineable Lignite Intervals

- The borehole evaluation criteria were especially developed for the specific kind of deposit, exploited by the specific type and size of equipment and aiming to produce lignite quality acceptable by the power plant.
- Blocks of recoverable lignite include thin layers of barren rocks, having a thickness of some centimeters.
- Such waste layers are too thin to be selectively excavated by the bucket wheels, and constitute “pollution” to the original “geological” lignite.
- The average quality of the resulting blocks of “recoverable lignite” should meet certain specifications, depending on the requirements of each plant.

Compositing Algorithm

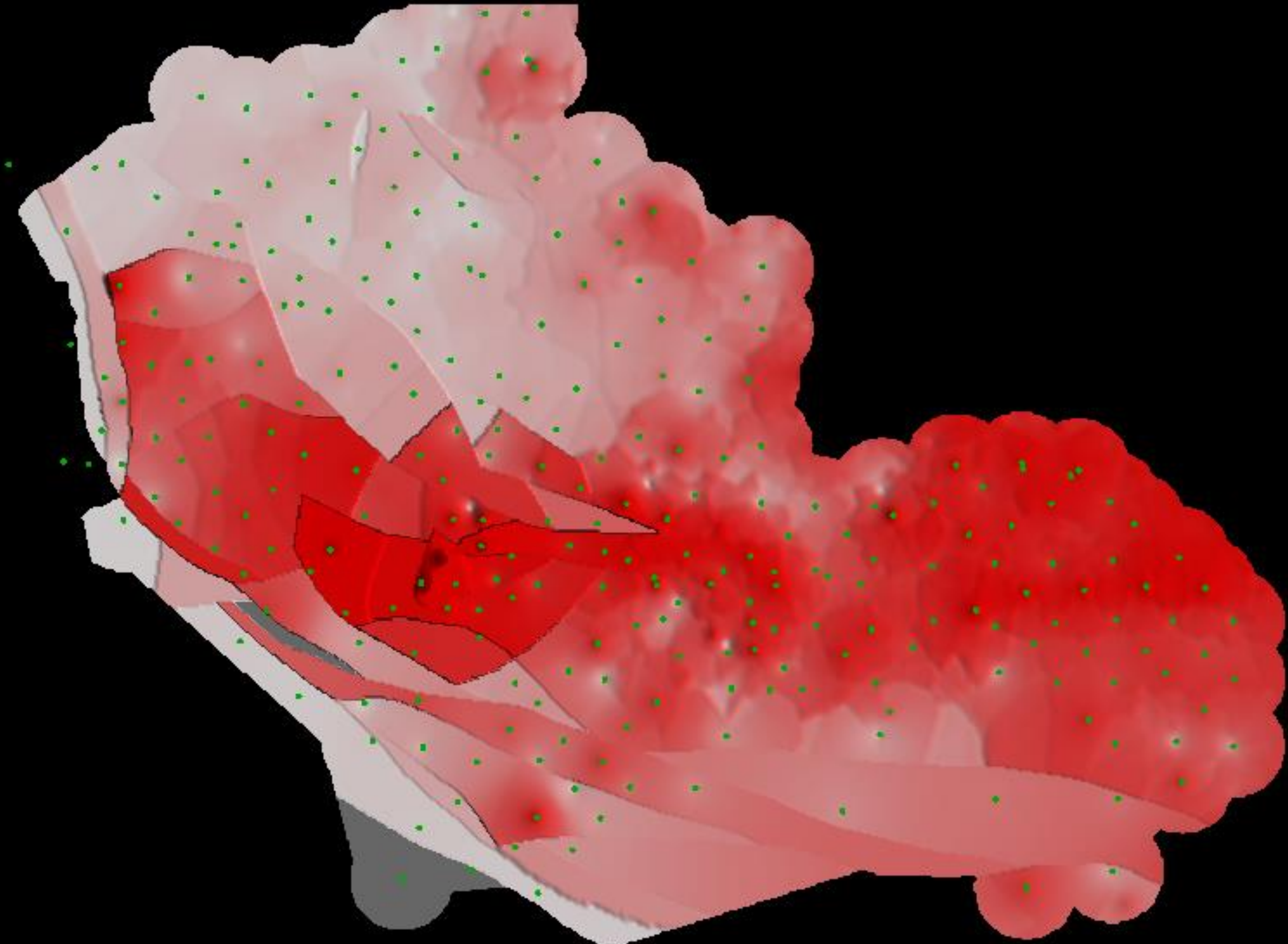
The evaluation algorithm goes through the following main steps:

1. *Initial raw seam coding*
2. *Waste seam compositing*
3. *Compositing lignite down to next parting*
4. *Compositing consecutive waste seams*

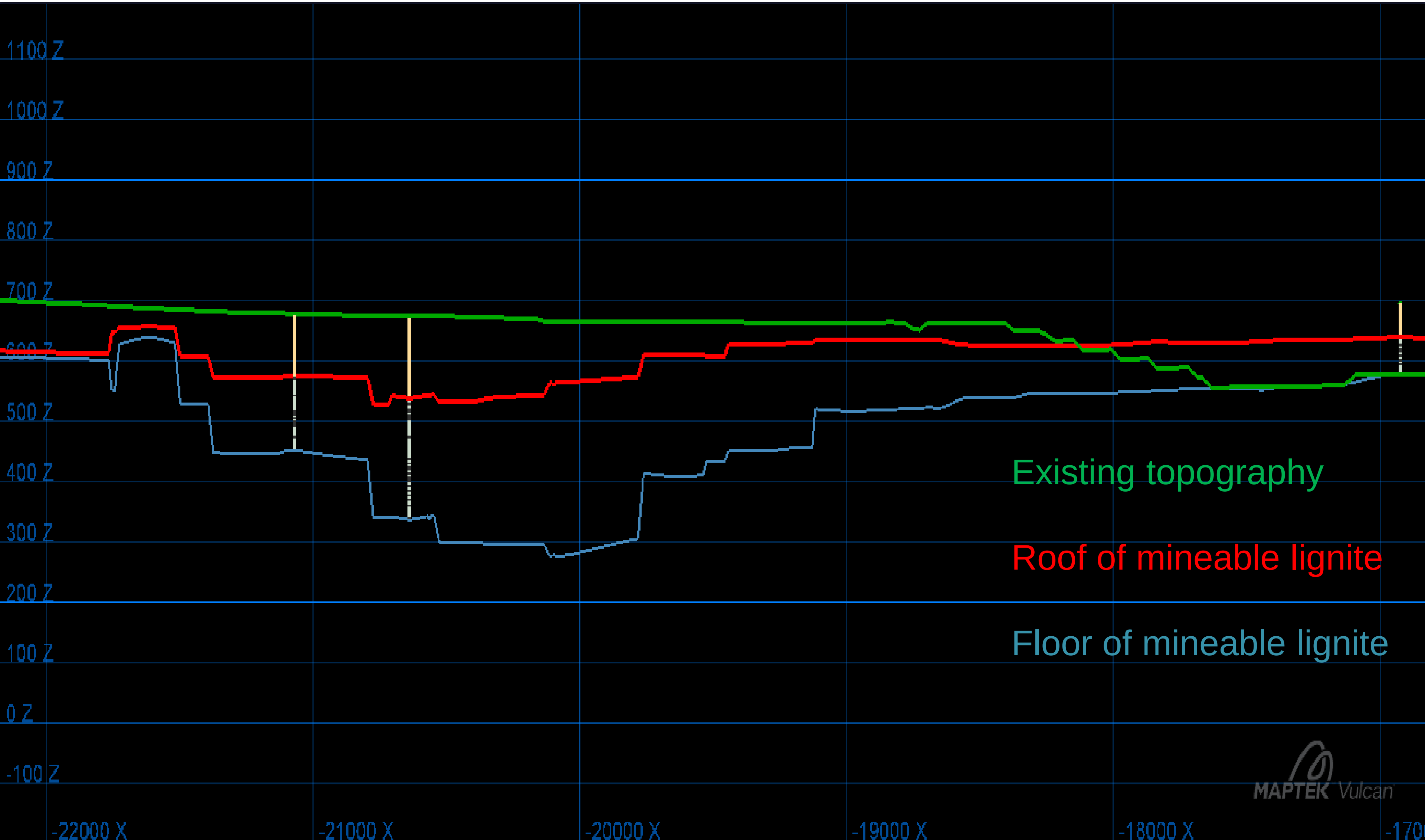


Resource Estimation

- Estimation of lignite resources for the SW Field was based on the structural floor and total thickness model of the mineable lignite intervals .
- The total thickness model was adjusted to exclude any lignite that is already mined or scheduled to be mined by existing operations.
- The higher thickness appears in the deep area of the deposit where a number of faults bring the lower lignite band much deeper than usual.
- This is an area where the mining method will possibly have to differentiate from the common bucket wheel excavators used as the main excavating equipment in PPC lignite mining operations.



Section through the Deep Area



Thank you for your attention

Any questions?