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Squaring the Circle – Scheduling of Circular Lignite Excavations in Chronos

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Presentation Outline

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- Introduction - Lignite Mining in the Amyntaio – Ptolemais Basin (NW Greece)
- Stratigraphic Modeling and Resource Estimation of Thin-Layered Lignite Deposits
- Circular Mine Design and Reserving
- Scheduling of Circular Lignite Excavations in Chronos
- Key Points
  - Compositing of Uncorrelated Lignite Seams
  - Batch plotting
  - Modeling and Circular Splitting of Benches
  - Naming Convention and Mining Block Precedences for Circular Mining
  - Chronos Workbook Setup
  - Schedule Reporting

Lignite Fields – Location Map

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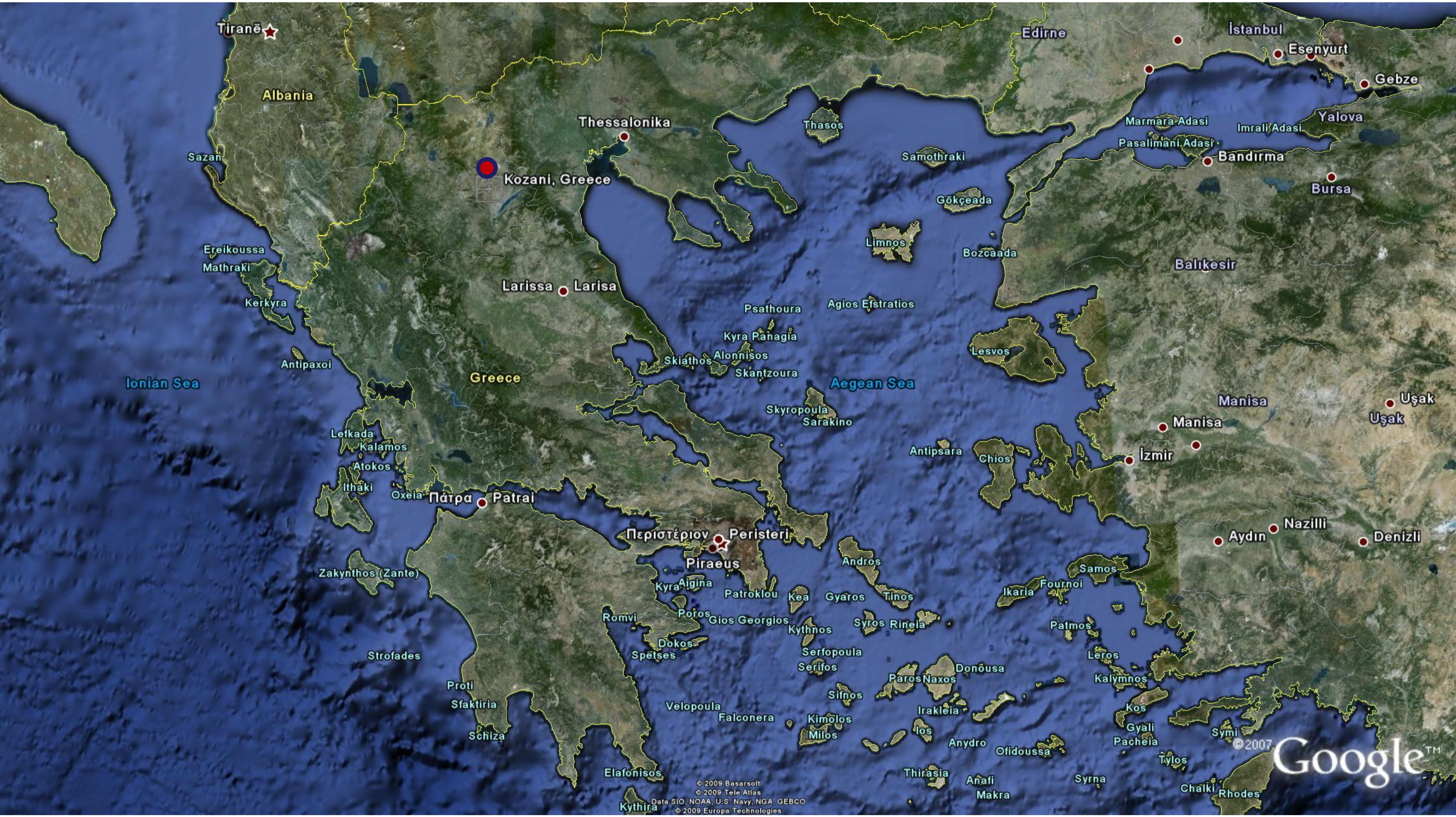

SW Field Location

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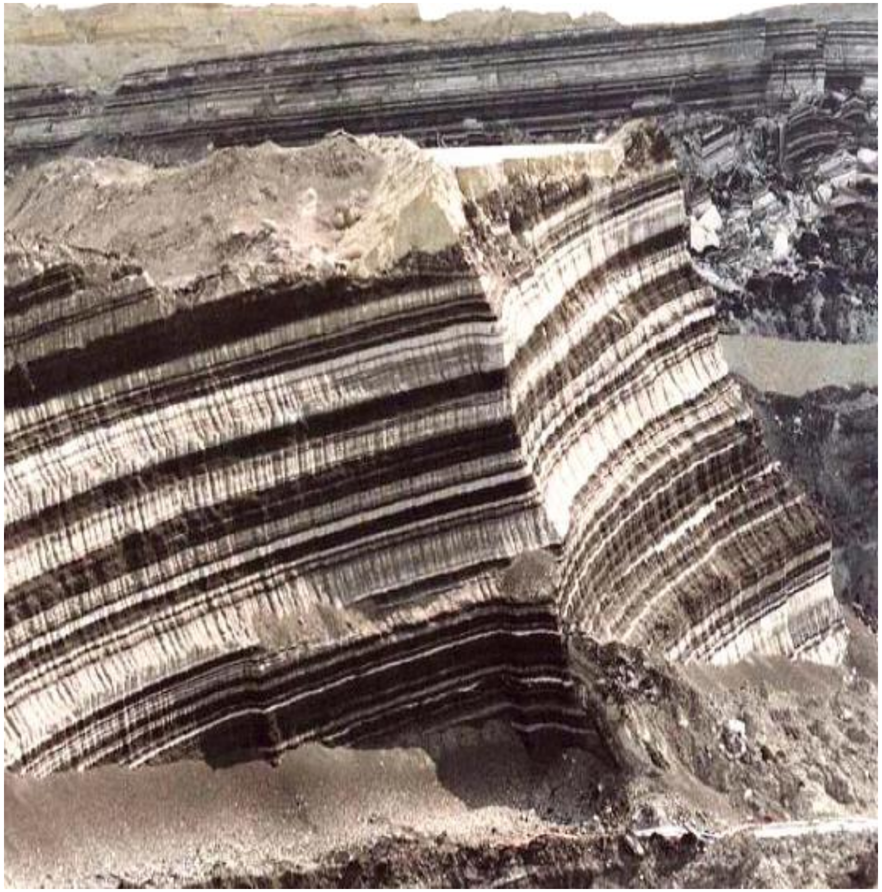
Thin-layered Structure of the Ptolemais-Amyntaio Lignites

- 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.



Stratigraphic Correlation

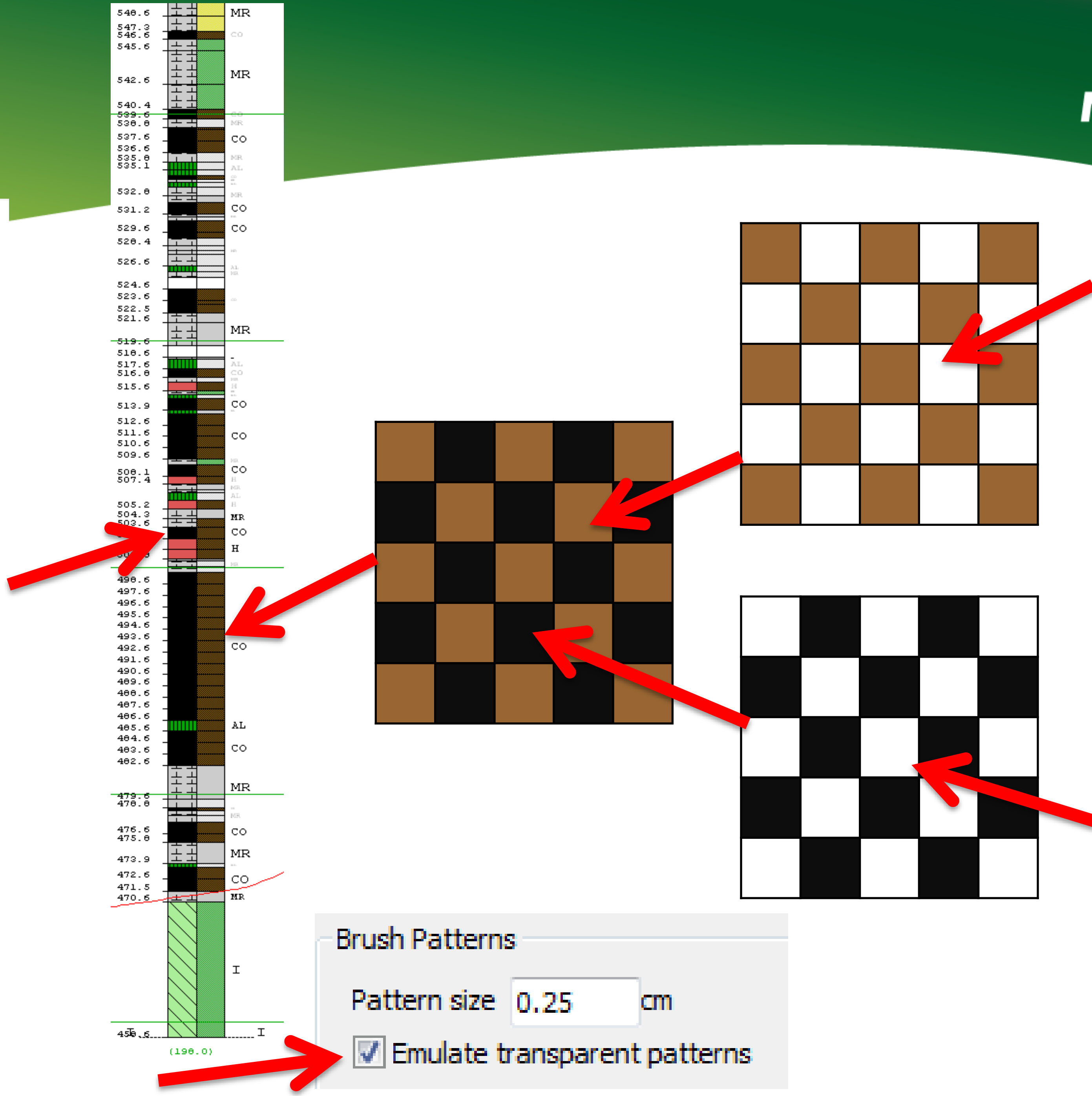
- Correlation of characteristic horiznos was based on a number of drillhole section plots prepared in Vulcan, and the original drillhole logs.
- Plotting was performed using Vulcan's Batch Plotting utility which allowed quick generation of very complex plots combining information from multiple databases and tables.
- Lignite seams were grouped in two main bands, the lower and upper band.

Compositing Material Colour in Plots

- Two of the descriptive fields in the database 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 and hatched 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

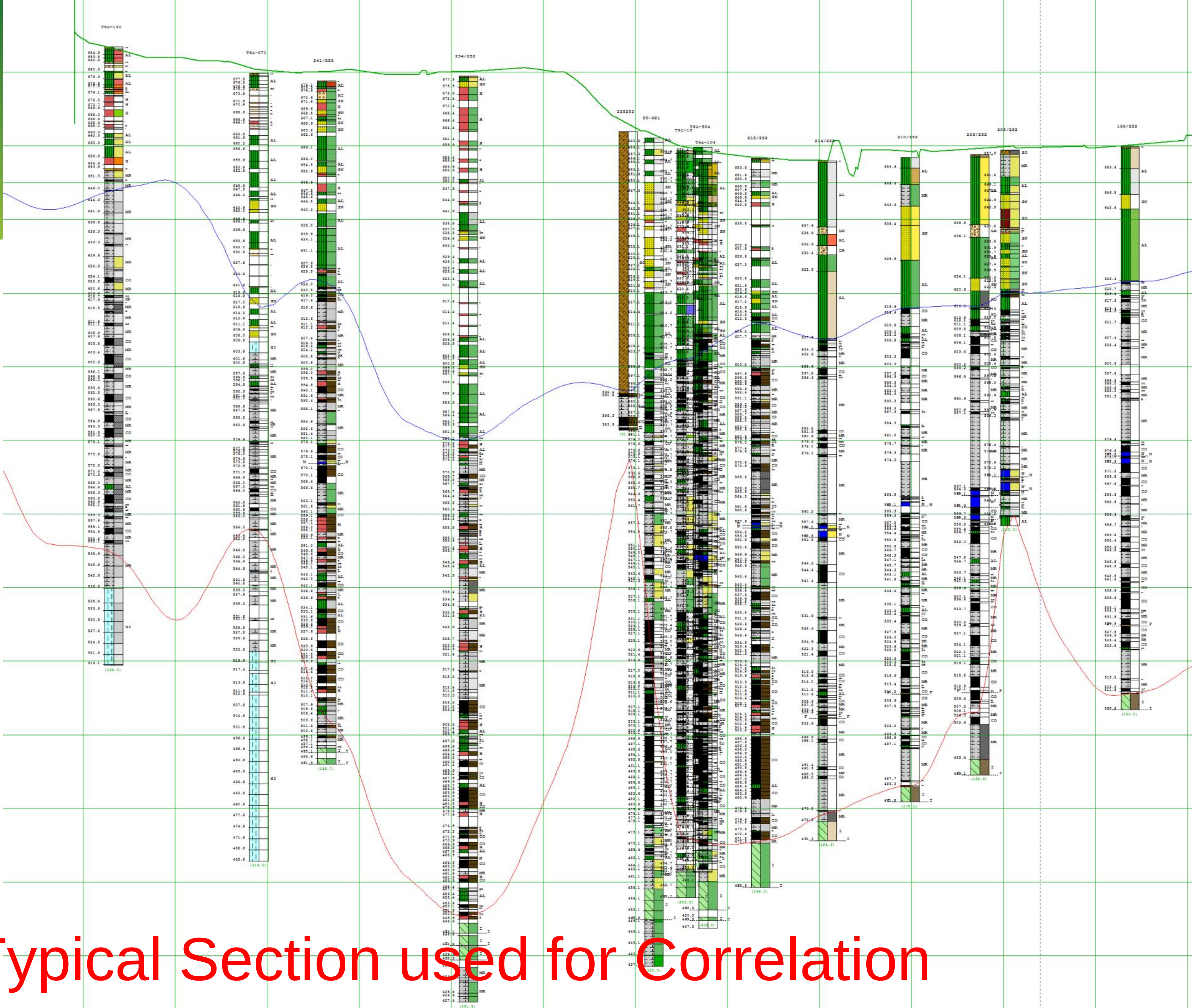


DRILL : R2

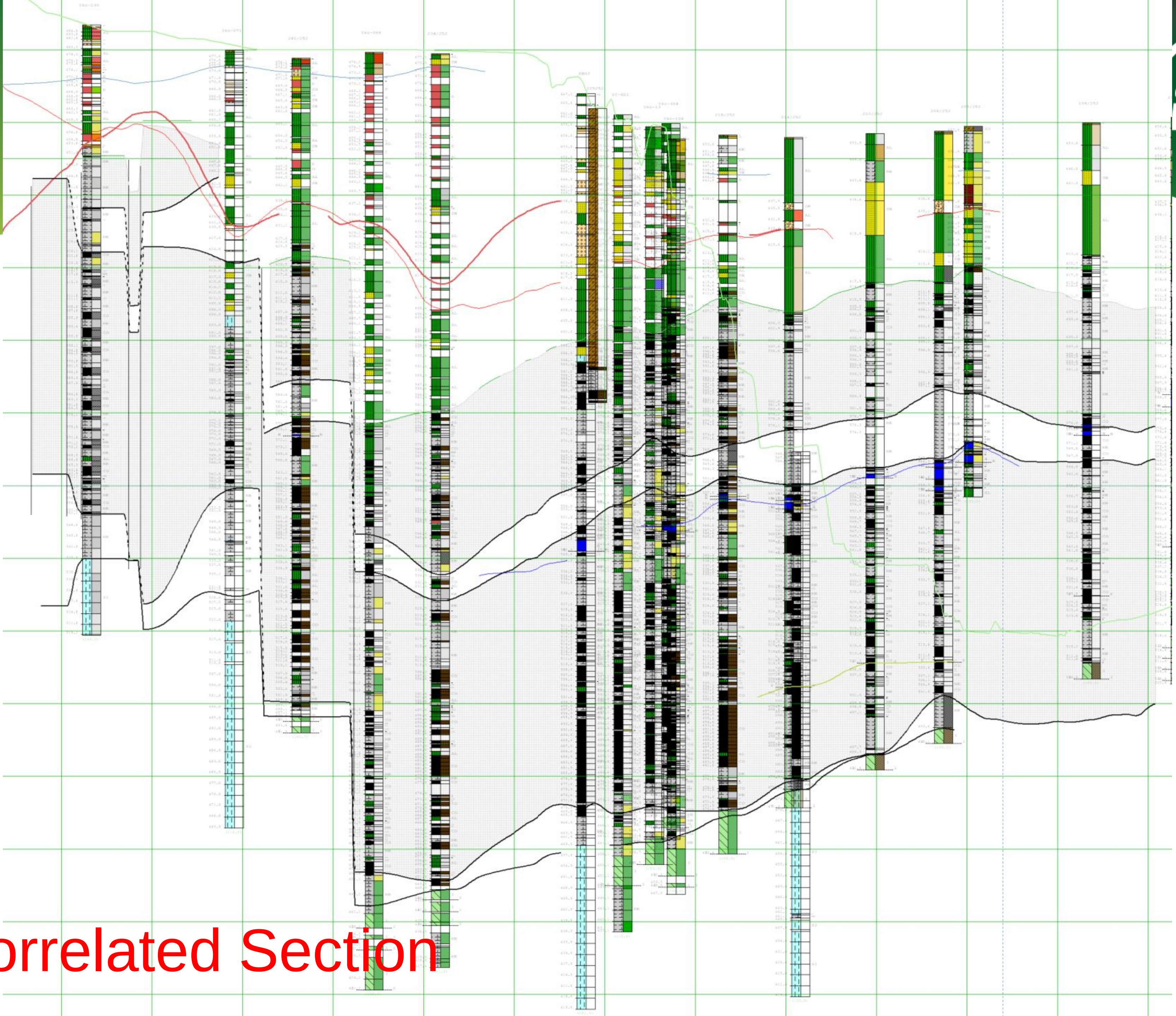
- B
- I
- O
- T
- G
- Y
- W
- R
- V
- M

DRILL : R4

- B
- I
- O
- T
- G
- Y
- W
- R
- V
- M



Typical Section used for Correlation



Correlated Section

Faults and Structural Modelling

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- 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.
- 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.

Fault Modelling

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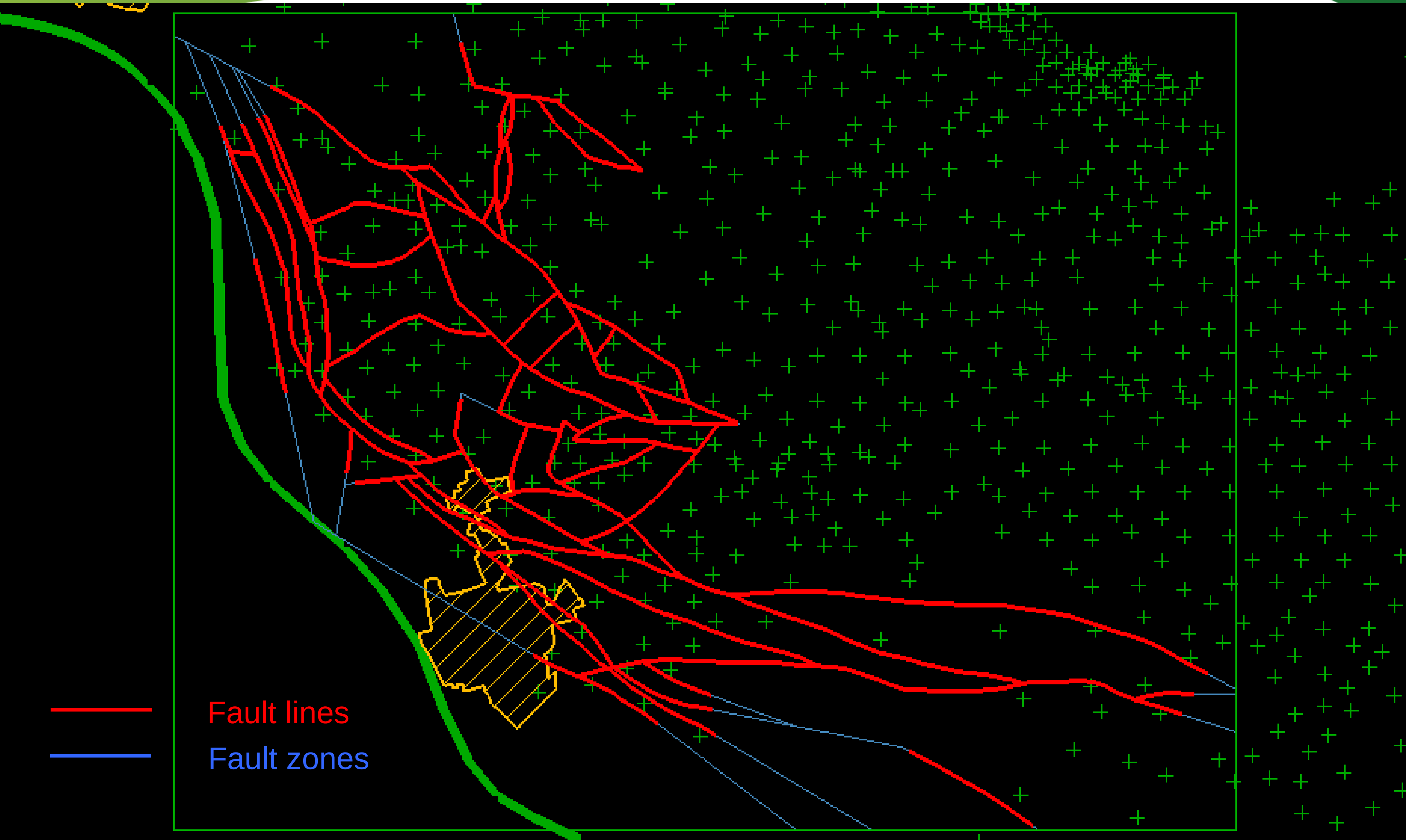

Structural Modelling

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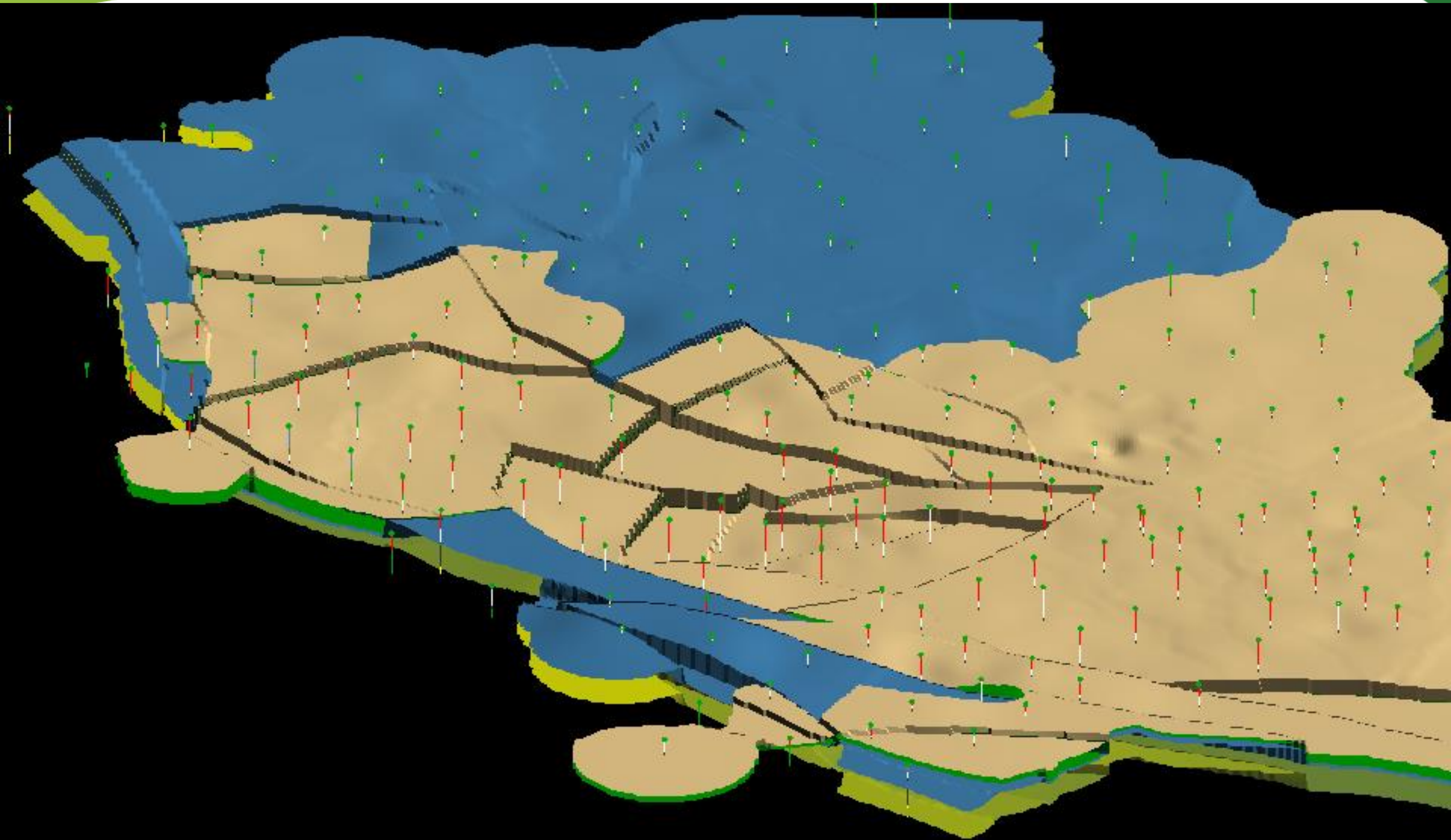

Circular Mining

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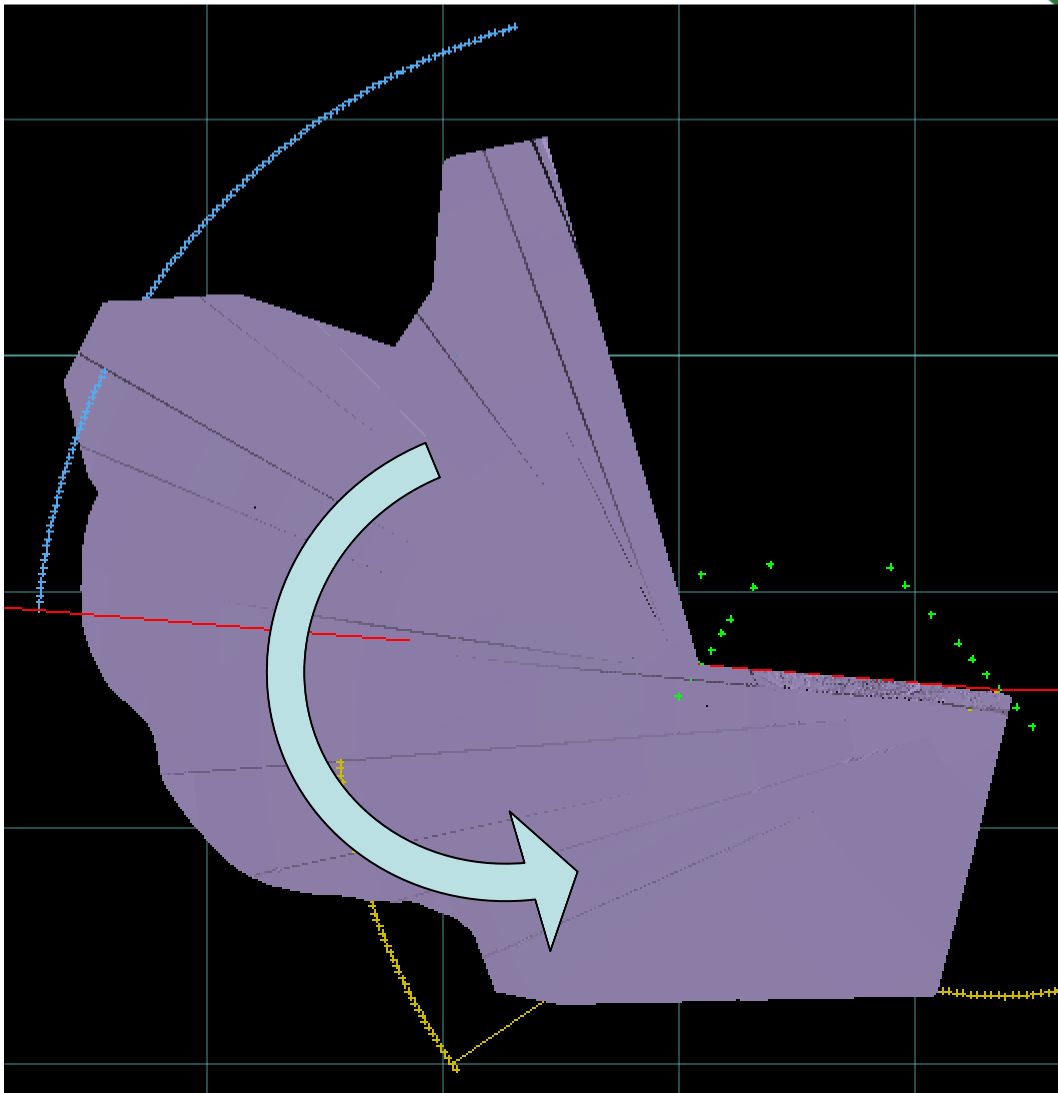
- Lignite mining is mostly performed by a system of bucket wheel excavators and conveyor belts.
- Each bench has its own excavator-belt system rotating around a central point.
- Each bench has a different rotation point.
- Higher benches have to keep a certain advance for stability purposes.



Bench Splitting in Angular Strips

- All benches were modelled as solid triangulations
- These had to be split into angular strips to reflect the movement of bucket wheel excavators.
- The **Model > Triangle Solid > Shells** option was used for the splitting and naming of the strips in combination with arch objects of 30m point interval.
- The arches were centred on the excavator-belt system rotation point.
- In the areas where the centre of rotation of the excavator-belt system fell inside the bench solid, the later had to be edited to avoid problems with splitting

Bench Splitting in Angular Strips

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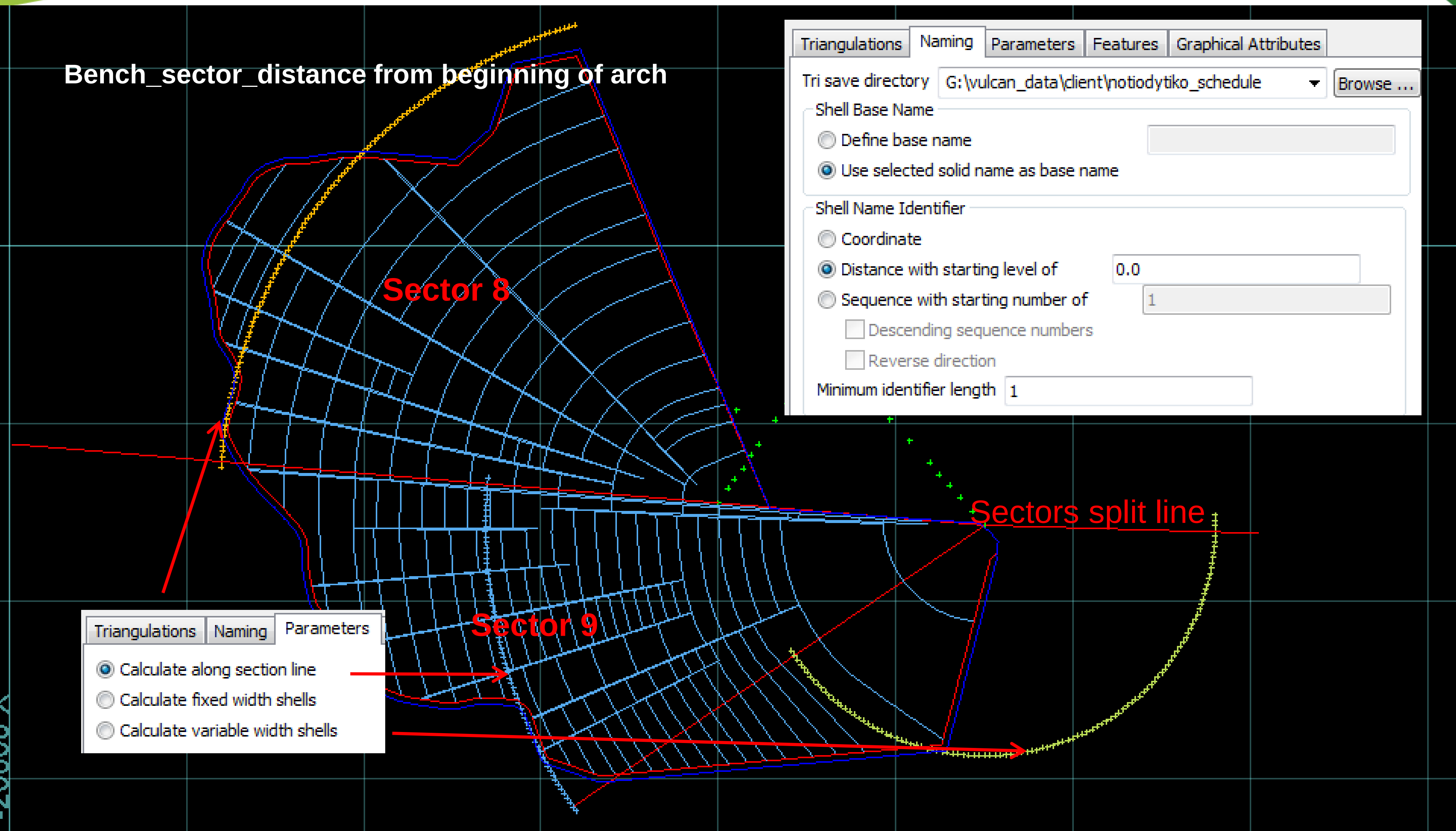

Bench Splitting in Angular Strips

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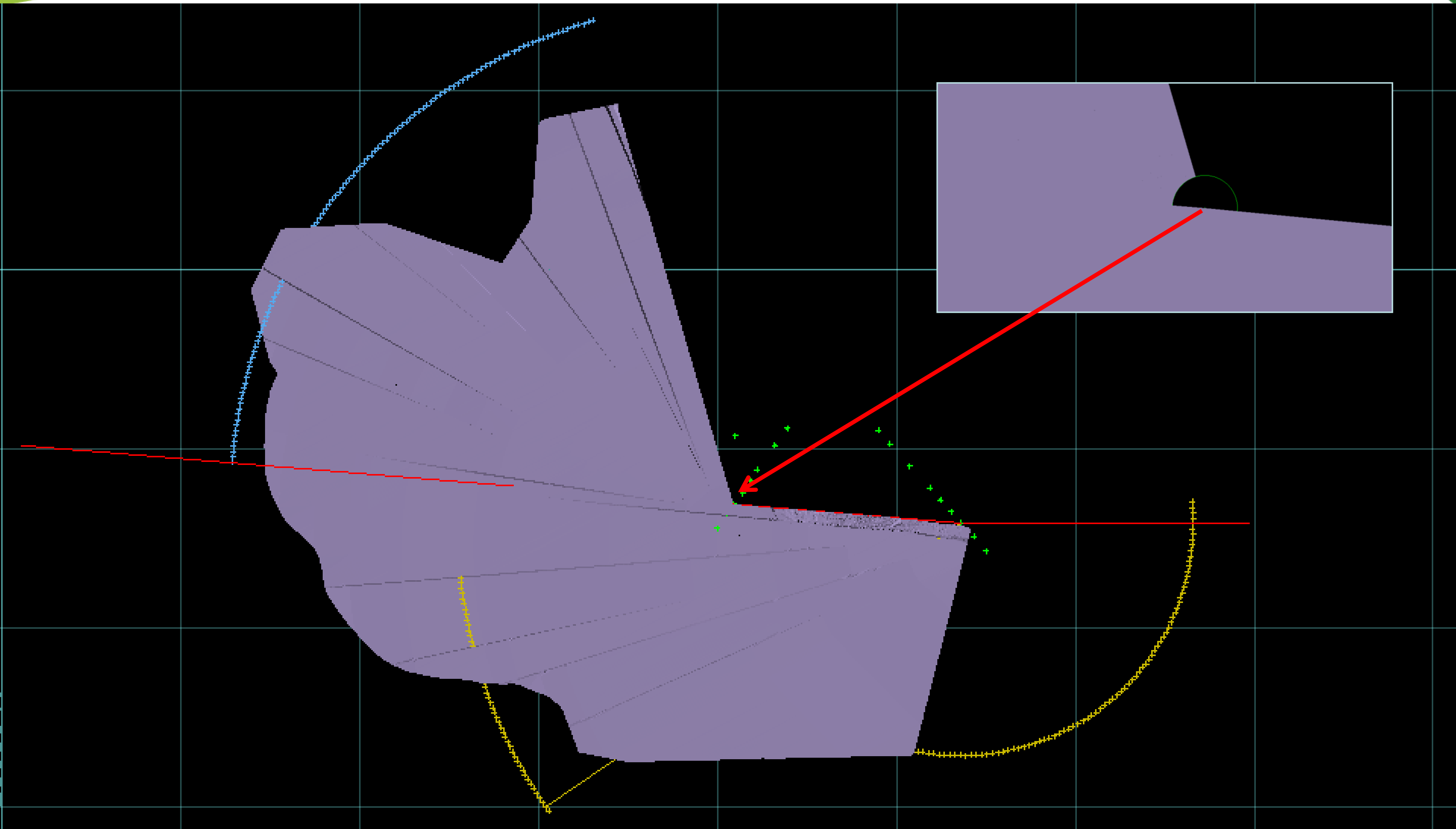

Reserving of Angular Strips

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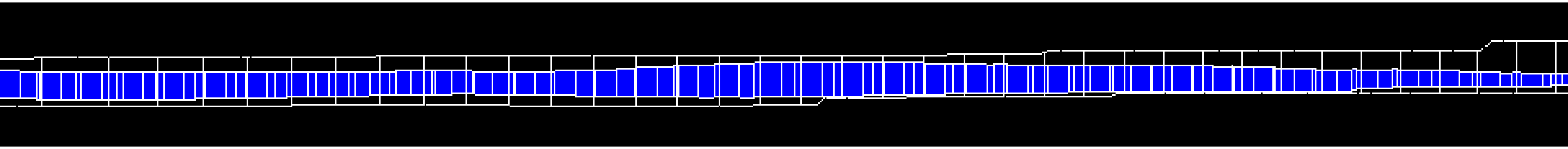
- A separate mineable lignite block model was generated for each bench and was used to calculate reserves for each angular strip.
- Reserve calculations included over, mid and underburden, mineable lignite and three quality parameters (ash, heating value and relative humidity).
- Using the Advanced Reserves option, a number of DMP files were generated for scheduling purposes.



Reserves Importing to Chronos

- All reserves DMP files were imported to a single Chronos workbook.
- Reserves were folded around a material type field (OB, MB, UB, CO).
- A number of extra columns were added for strip locating and precedence setting purposes.
- Accumulation and weight fields were updated for all columns necessary.
- The final reserve sheet contained reserves information for 3,349 strips.

General Workbook Setup

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- A separate process and destination was setup for each bench, i.e. for each bucket wheel excavator.
- There were 26 benches and an equal number of processes and destinations.
- This allowed separate setting and monitoring of each excavators production per period.
- A lookup table was setup to ensure that the correct process was assigned to each destination.
- A period calendar was defined, organized in annual periods of production and with a total of 28 periods.

Precedences

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- Precedences was the hardest issue in scheduling of the circular mining production.
- Chronos precedence setup is mostly suited to orthogonal mining directions.
- The distance from the beginning of the arch used to split the angular strips, stored in the solids names, in addition to a specific advance for each bench, was used to generate precedences.

Precedences – Bench Advance

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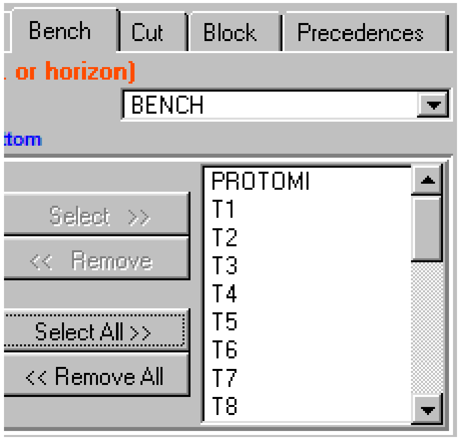

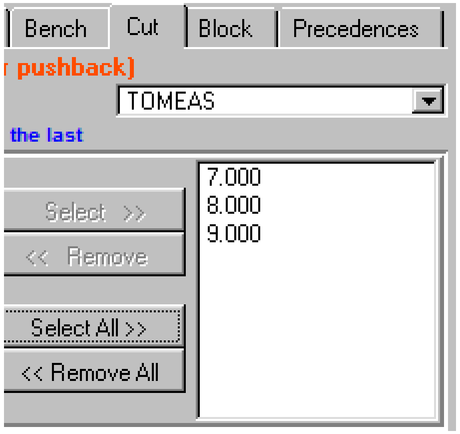

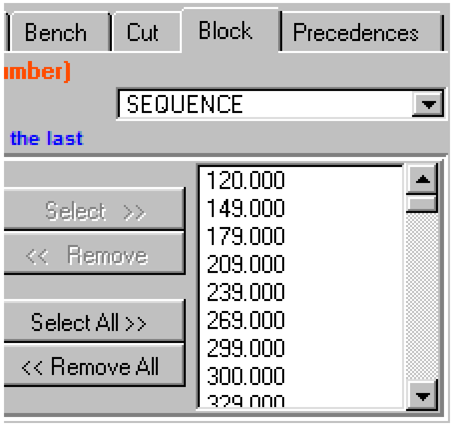

- The SEQUENCE field was calculated using the distance from the beginning of the strip defining arch and the bench advance.
- The bench advance was stored in a general sheet and referenced from the reserves sheet.

Scheduling Using Tasks

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- Production in all benches depended on the maximum advance of one of the middle benches (T9).
- This meant that all benches above had to keep a certain advance while benches below should keep a minimum distance.
- T9 was scheduled using the required annual production targets.
- An appropriate period field was calculated for all strips in the other benches according to precedences.
- Strips from particular periods according to this calculated period field were added to separate tasks.
- These tasks were scheduled in period sequence.

Original Topography

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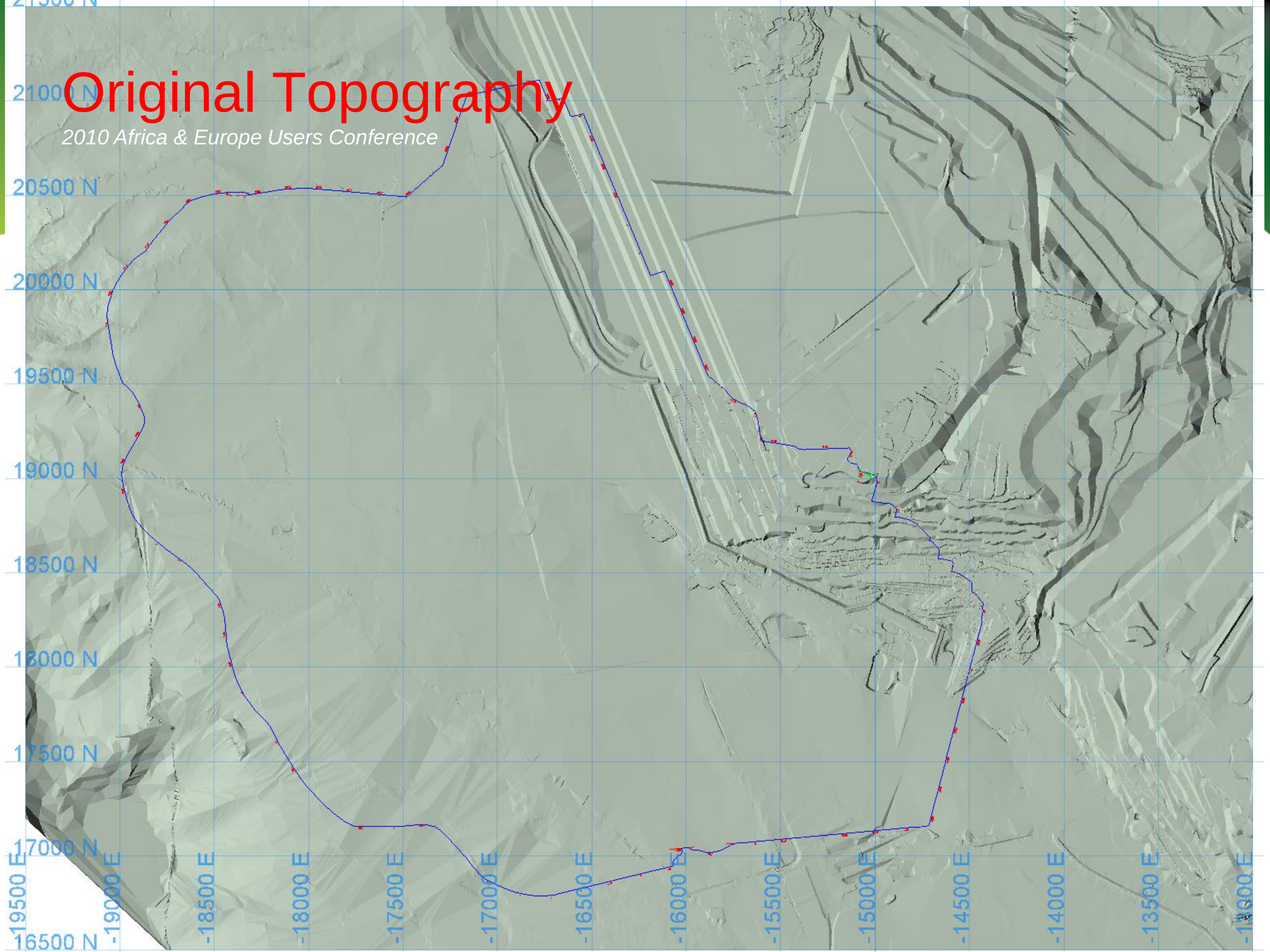

After 5 years

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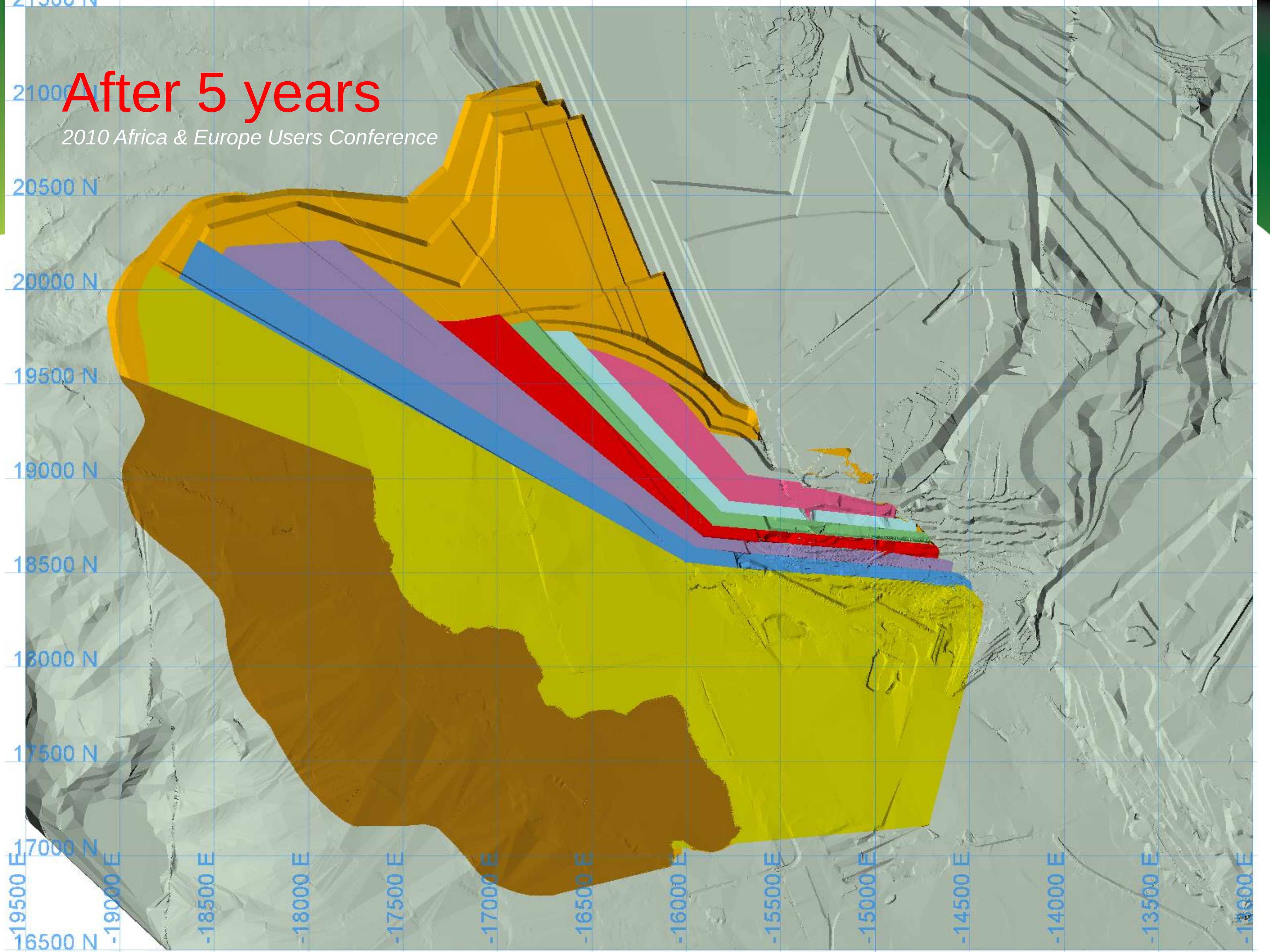

After 10 years

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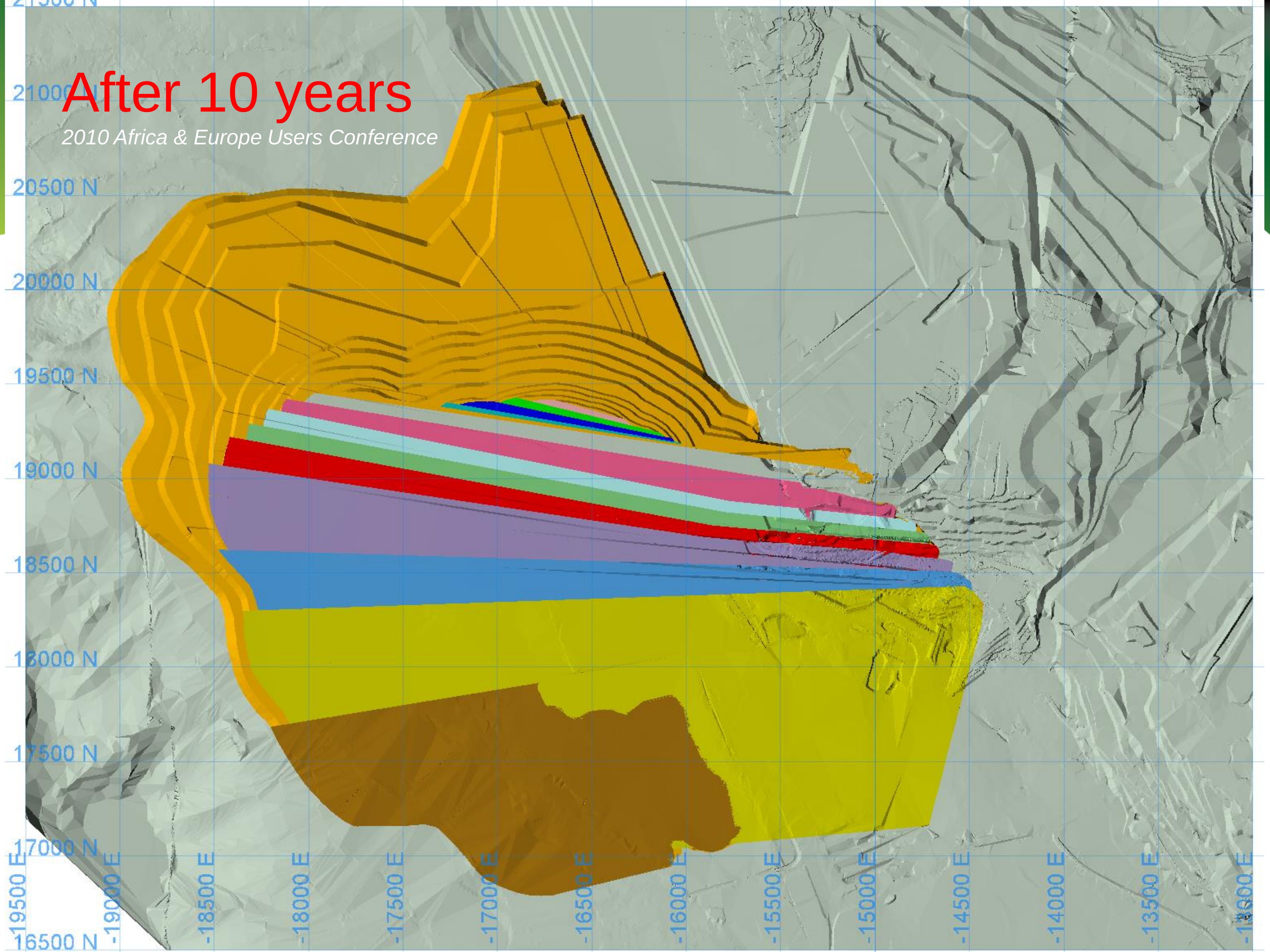

After 15 years

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After 20 years

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After 25 years

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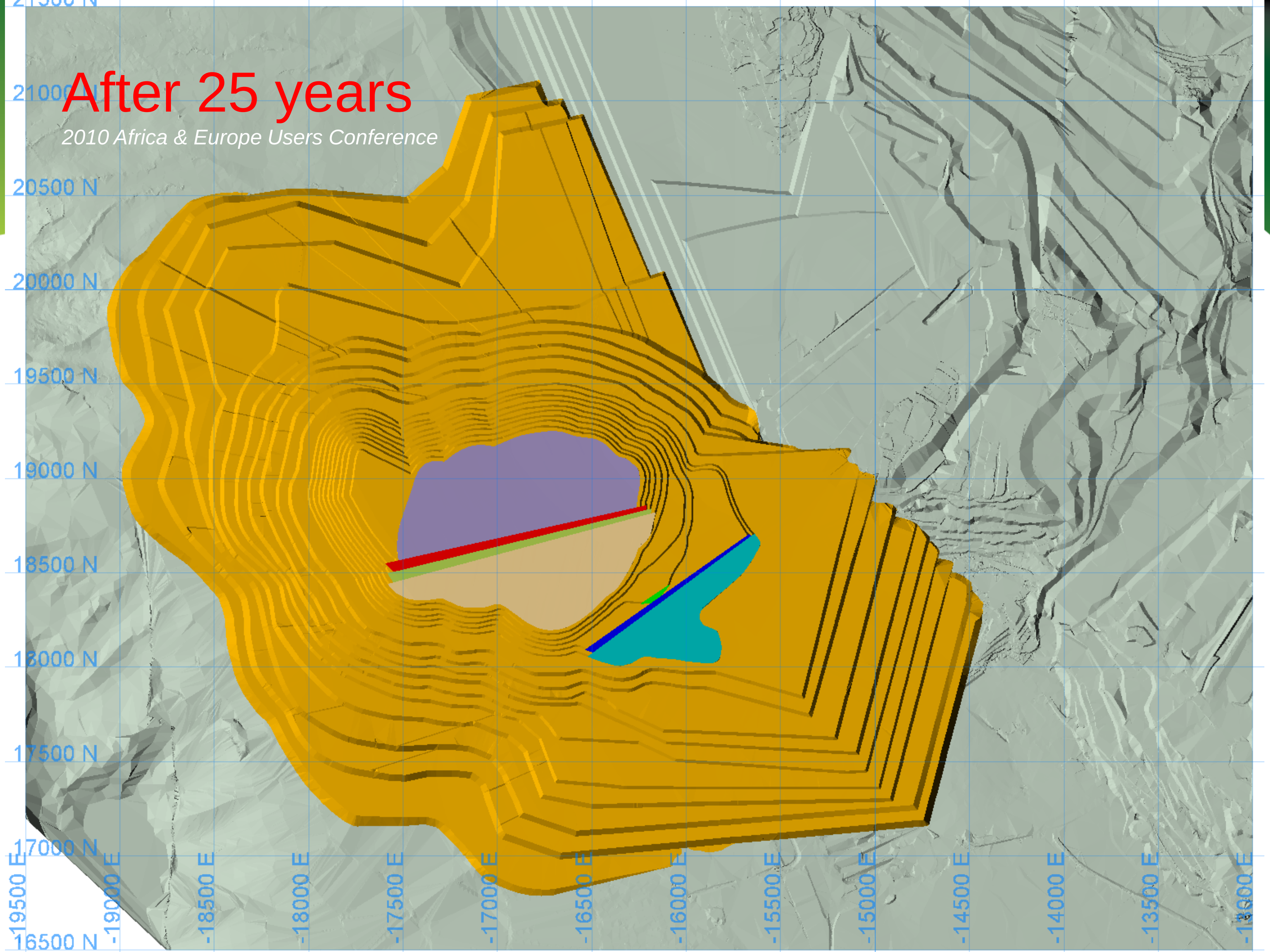

Final Pit

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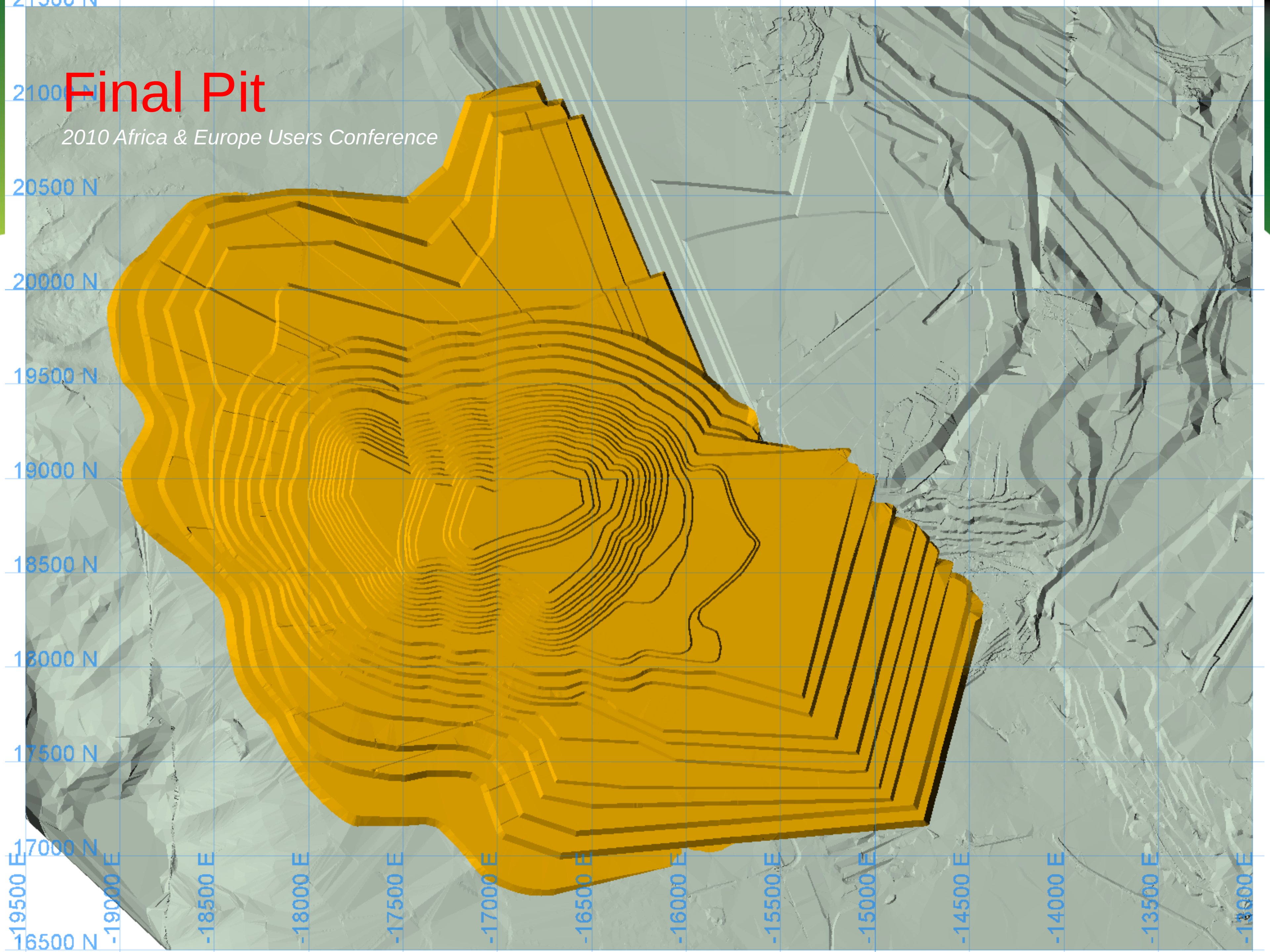

Schedule Reporting

- A number of reports was produced in Chronos after scheduling was completed, including:
  - Volumes and tonnages per sector, bench and period.
  - Qualities per sector, bench and period.
- The flexible reporting facilities of Chronos enabled the production of detailed reports quickly and with little effort.
- All reports were further processed in Excel for charting purposes.

Thank you for your attention!

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