MatRaW2023

Integrated Mine Planning Education for the Modern Engineer

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UNIVERSITY OF WESTERN MACEDONIA

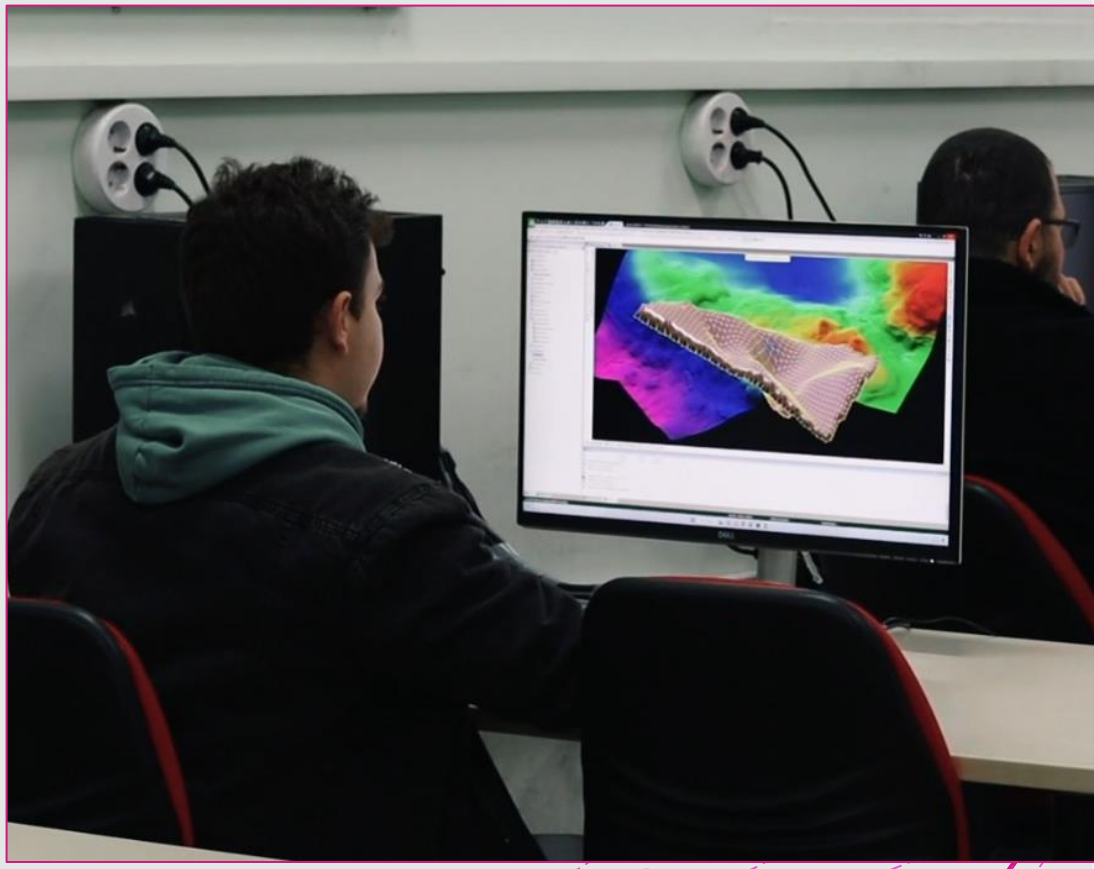
DEPARTMENT OF MINERAL RESOURCES ENGINEERING

Mine Planning

- The constant need for improved efficiency, safety and profitability has always been the driving force for the development and implementation of the latest technological advances in mining.
- Mine planning has been an area that traditionally attracted new algorithms and methods to address old and new problems.
- The importance of having trained professionals that can effectively use sophisticated mine planning software tools is largely recognised by the mining industry.

A Course in Mine Planning – Bringing Everything Together

- As a dedicated course, it covers all aspects of mine design and scheduling with specialised computer software.
- It is based on a series of hands-on lab exercises combined with supporting short theoretical lectures, allowing students to experience all major steps of the mine planning process in as real terms as possible.
- It also helps students understand how the knowledge from other subjects can be combined to design and operate a mine.



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Who is it for?

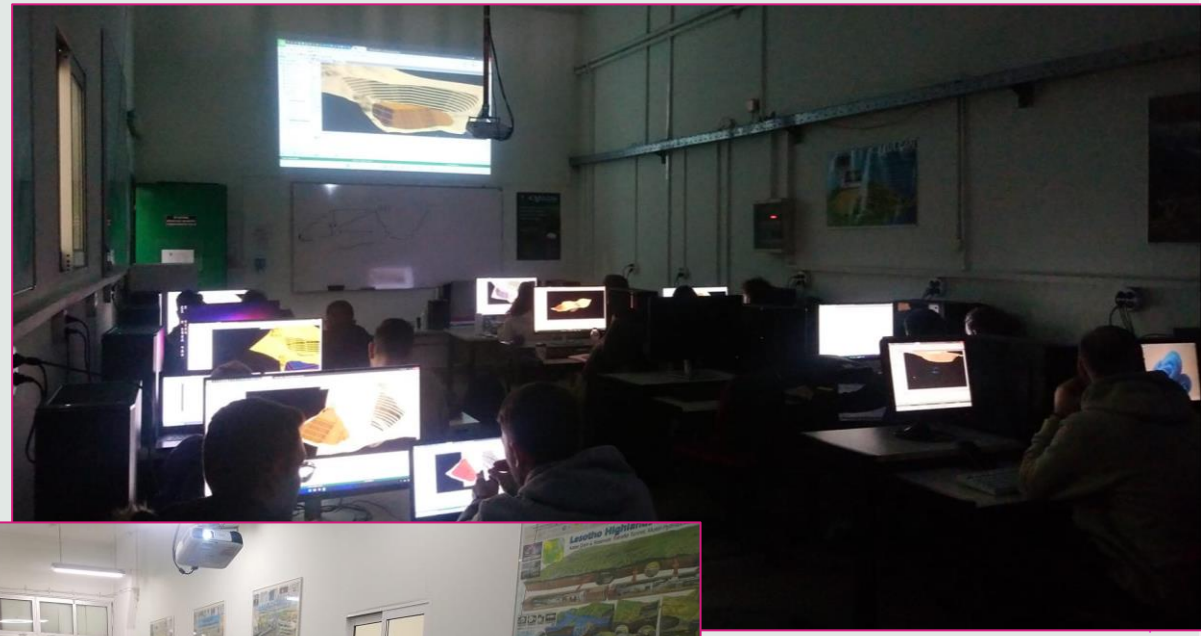
Undergraduate students in:

+Mineral Resources Engineering

+Mining Engineering

+Geology

+Mine Surveying



Course Structure (1)

Lecture	Content	Lab software-based exercise	Algorithms covered	Prerequisite modules – links to other modules
1	**Introduction**	Project setup, topographical data management	-	CAD, Geodesy
2	**Data management**	Drillhole data importing, validation and visualisation	-	Drilling Technology, GIS
3	**Model structures**	Topographical surface modelling	Delaunay triangulation	Geodesy
4	**Geological modelling and control in mine planning**	Simple geological modelling using drillhole lithology data	Delaunay triangulation, inverse distance, least squares, kriging, 3D solid triangulation, boolean operations, convolutional neural networks	Economic Geology, Geological Maps Interpretation and Analysis, Artificial Intelligence for Mineral Resources Engineers
5	**Resource modelling - grade estimation**	Block modelling, grade estimation, resource classification	Inverse distance and ordinary kriging interpolation, cross-validation	Applied Geostatistics
6	**Open pit optimisation**	Open pit optimization with the push-relabel algorithm	Push-Relabel, Lerchs-Grossman, floating cone	Surface Mining, Geotechnical and Soil Mechanics, Investment Decisions Analysis
7	**Open pit design**	Open and closed bench design incorporating a ramp, following optimum limits, pit topography modelling	2D and 3D vector data projection algorithms, Delaunay triangulations, boolean operations	Surface Mining, CAD

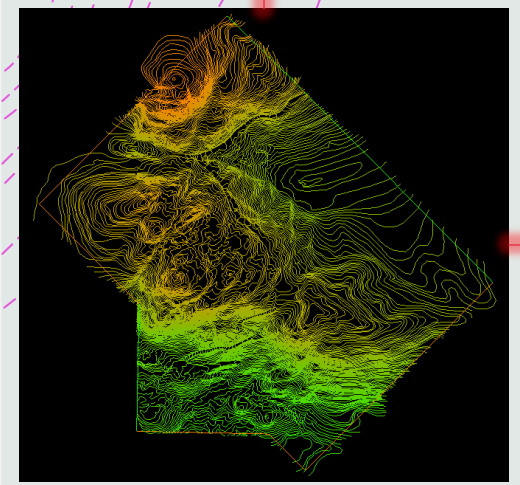
Course Structure (2)

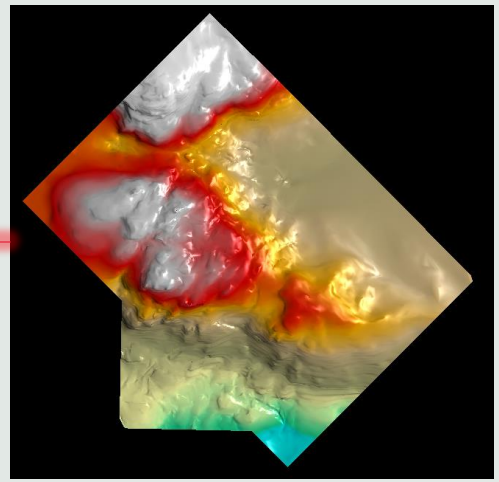
Lecture	Content	Lab software-based exercise	Algorithms covered	Prerequisite modules – links to other modules
8	**Underground mine design**	Shafts, declines, base drives and cross-cuts design and modelling, automatic and interactive ramp design	Dubins curves method, 3D solid triangulations	Underground Mining, CAD
9	**Mine scheduling**	Splitting and reserving of mining blocks (per bench and pushback), calendar, destinations, equipment and targets setup, scheduling and visualisation of results	Mixed-Integer Programming, evolutionary algorithms	Operations Research, Artificial Intelligence for Mineral Resources Engineers
10	**Cut-off grade optimisation**	Pushbacks design, grade-tonnage curves per pushback, application of Lane's algorithm to derive optimum cut-off grades	Lane's algorithm	Surface Mining, Underground Mining
11	**Haulage profile calculations**	Haul truck travel time, production time, and cycle time calculation, fleet productivity estimation for long & short term planning, sensitivity analysis to road design criteria	Haulage profile equations	Surface Mining
12	**Underground ventilation simulation**	Ventilation network design and setup, simulation, results visualisation and analysis	Hardy Cross method	Underground Mining
13	**Road and stockpile design**	Horizontal and vertical IPs and alignment design, road section design and application, cut and fill slopes design, road surface modelling, stockpile design and volumetric calculations	2D and 3D vector data projection algorithms, Delaunay triangulations, boolean operations	Road Design, Surface Mining

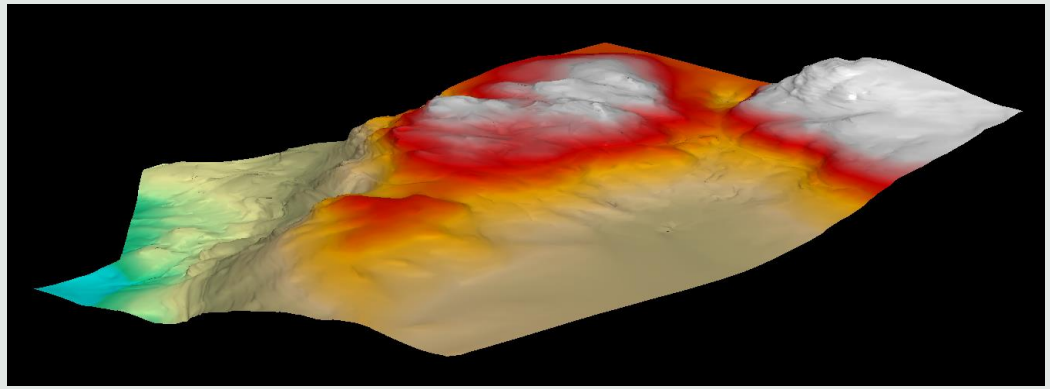
Data Importing, Validation and Visualisation

Lab 1 - 3

Name	Date modified	Type	Size
assay.csv	18/2/2023 5:55 μμ	Microsoft Excel Comma Separated Values File	46 KB
collar.csv	18/2/2023 5:54 μμ	Microsoft Excel Comma Separated Values File	2 KB
lithology.csv	18/2/2023 5:53 μμ	Microsoft Excel Comma Separated Values File	5 KB
survey.csv	18/2/2023 5:53 μμ	Microsoft Excel Comma Separated Values File	1 KB
topography.dxf	8/1/2006 11:41 μμ	AutoCAD Drawing Interchange	2,108 KB







DDFD/A7

COLLAR | SURVEY | LITHOLOGY | ASSAY

	FROM	TO	GOLD	COPPER	LITHO
1	16.100	118.360	-99.000	-99.000	MB
2	118.360	144.720	-99.000	-99.000	BP
3	144.720	145.730	1.550	2.560	SP
4	145.730	146.740	3.930	6.480	SP
5	146.740	147.750	1.370	2.260	SP
6	147.750	148.760	2.990	4.930	SP
7	148.760	149.770	1.650	2.720	SP
8	149.770	150.780	1.070	1.770	SP
9	150.780	151.790	1.620	2.670	SP
10	151.790	152.800	2.690	4.440	SP

DDFD/A7

COLLAR | SURVEY | LITHOLOGY | ASSAY

	BHID	LOCALX	LOCALY	LOCALZ
1	DDFD/A7	2127.000	2005.530	1116.610

DDFD/A7

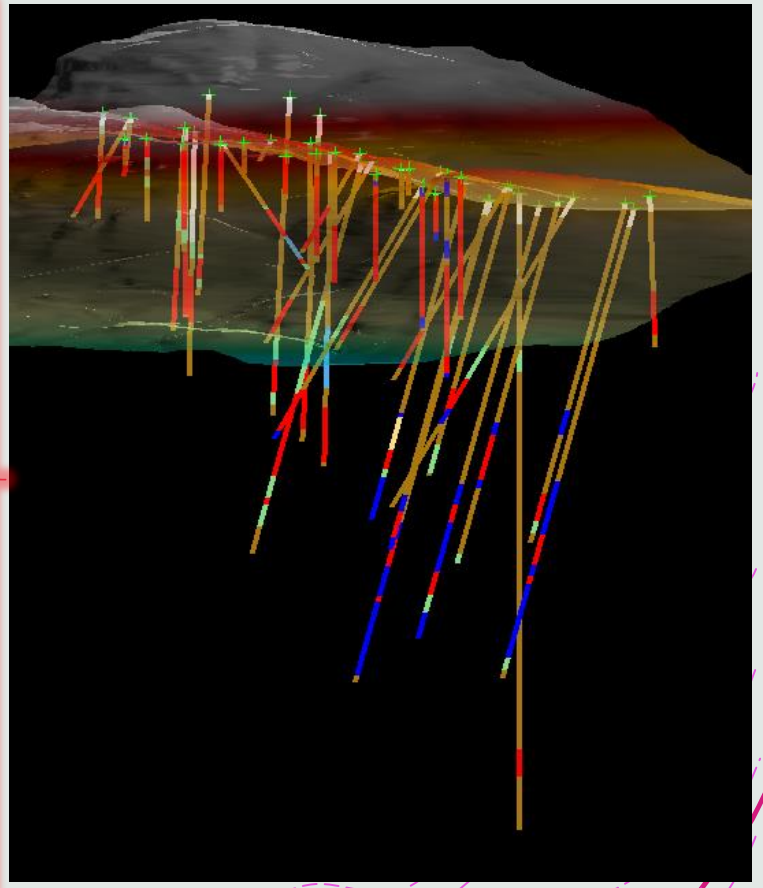
COLLAR | SURVEY | LITHOLOGY | ASSAY

	FROM	TO	ROCK
1	16.100	118.360	MB
2	118.360	144.720	BP
3	144.720	169.320	SP
4	169.320	181.500	F
5	181.500	248.140	MB
*	0.000	0.000	

DDFD/A7

COLLAR | SURVEY | LITHOLOGY | ASSAY

	SDEPTH	BEARING	DIP
1	0.00	203.00	-45.00
*	0.00	0.00	0.00



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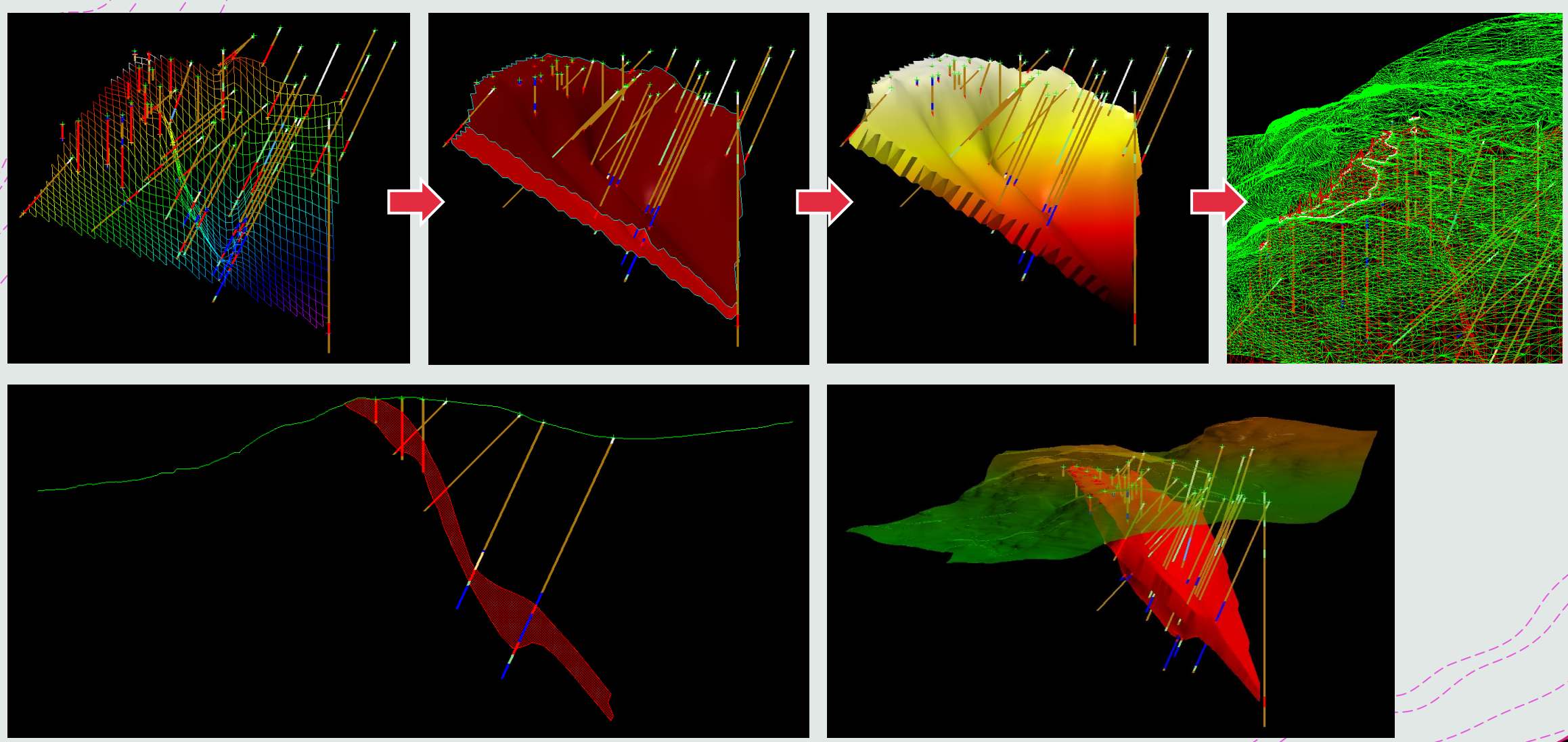
Development of a geological model of an orebody from drillhole data and grid model interpolation

Lab 4



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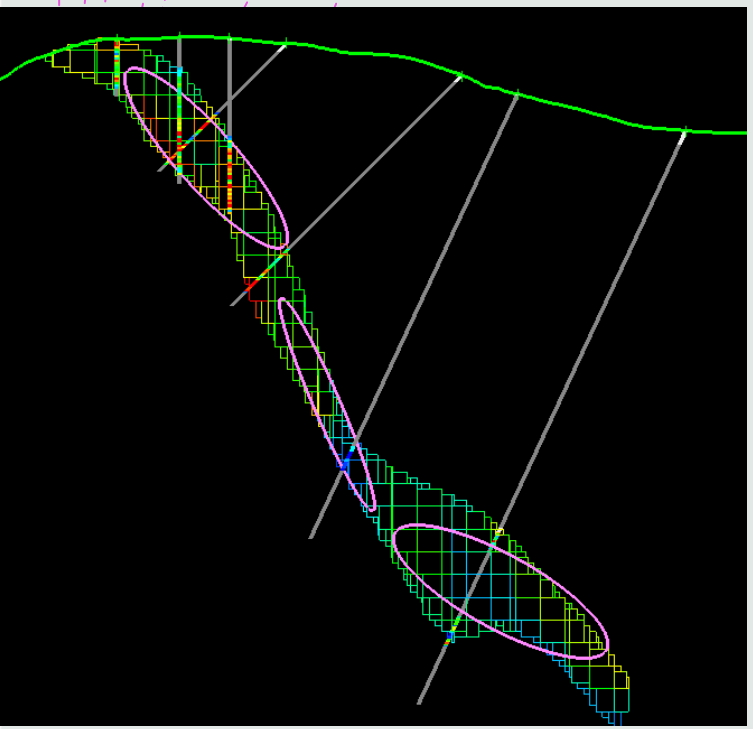
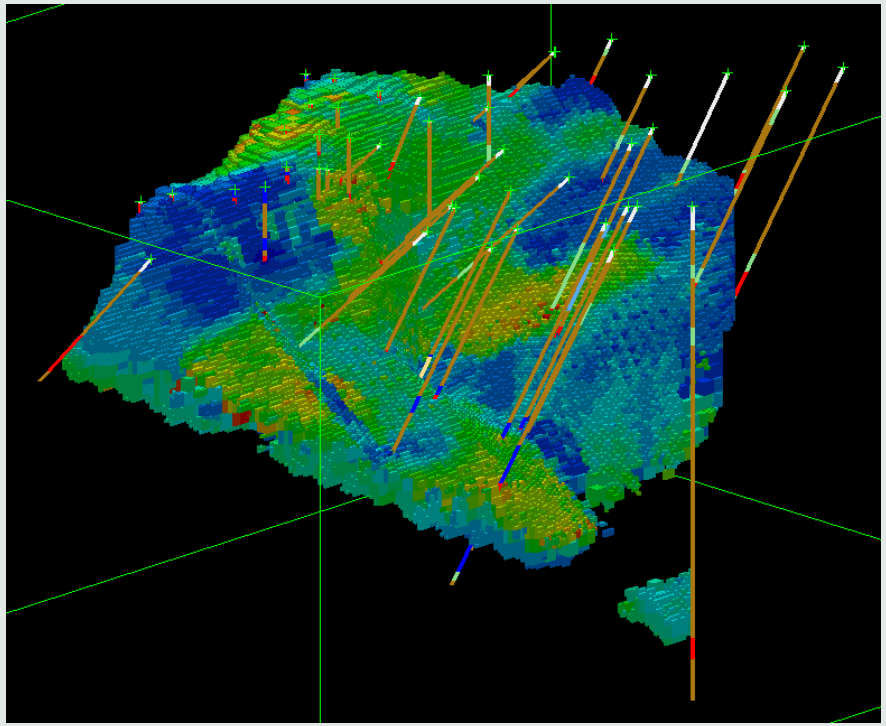
Development and estimation of a block model integrating geological, geotechnical, mining and resource information

Lab 5

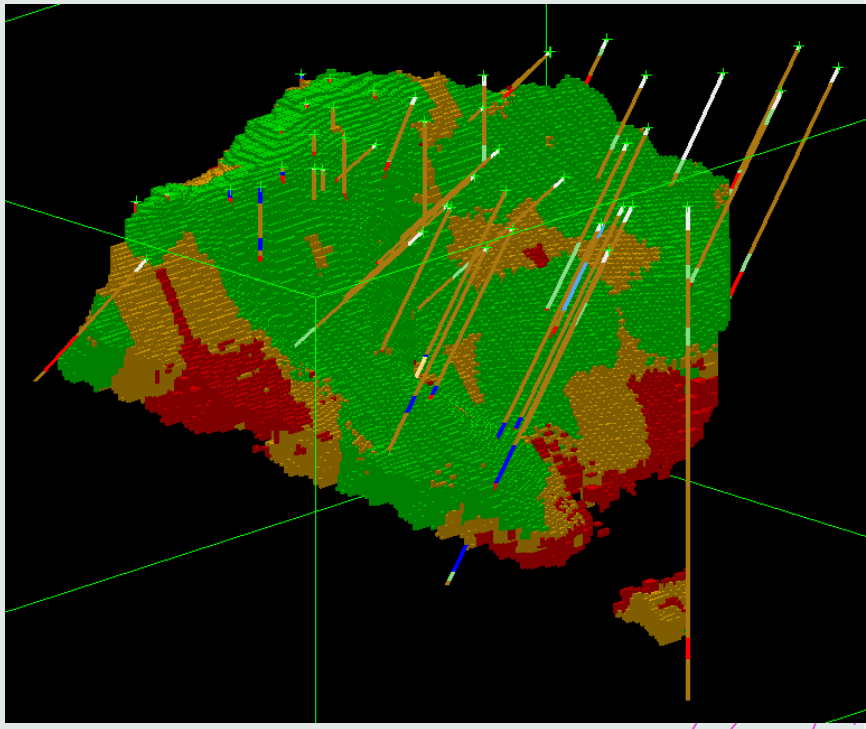
Anisotropy modelling



Grade estimation

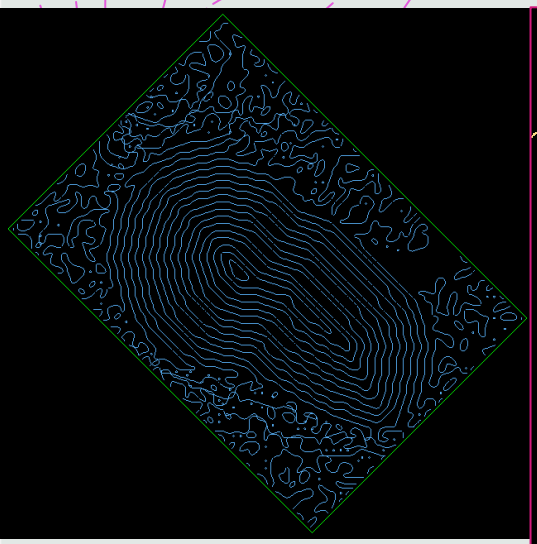


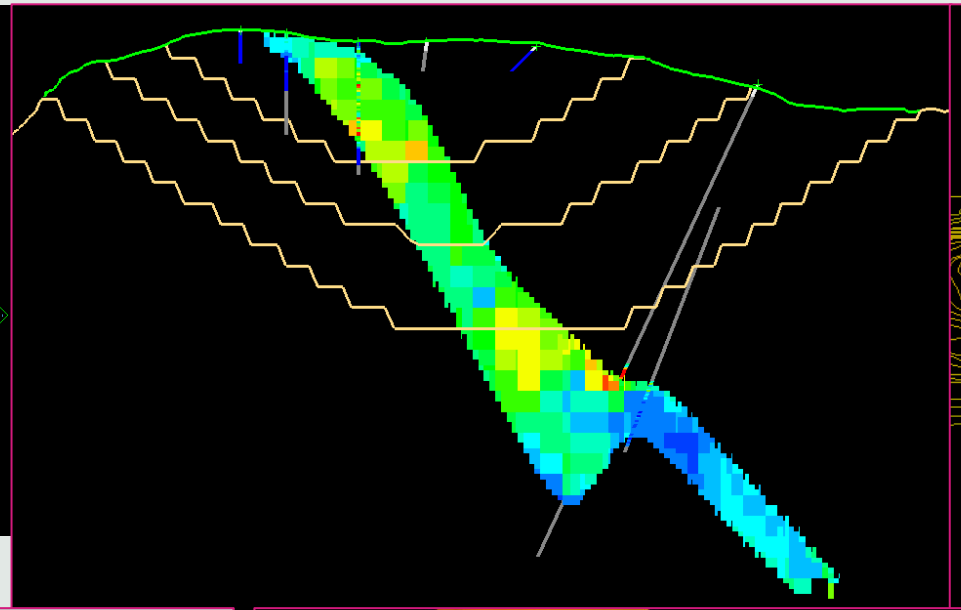
Resource Classification

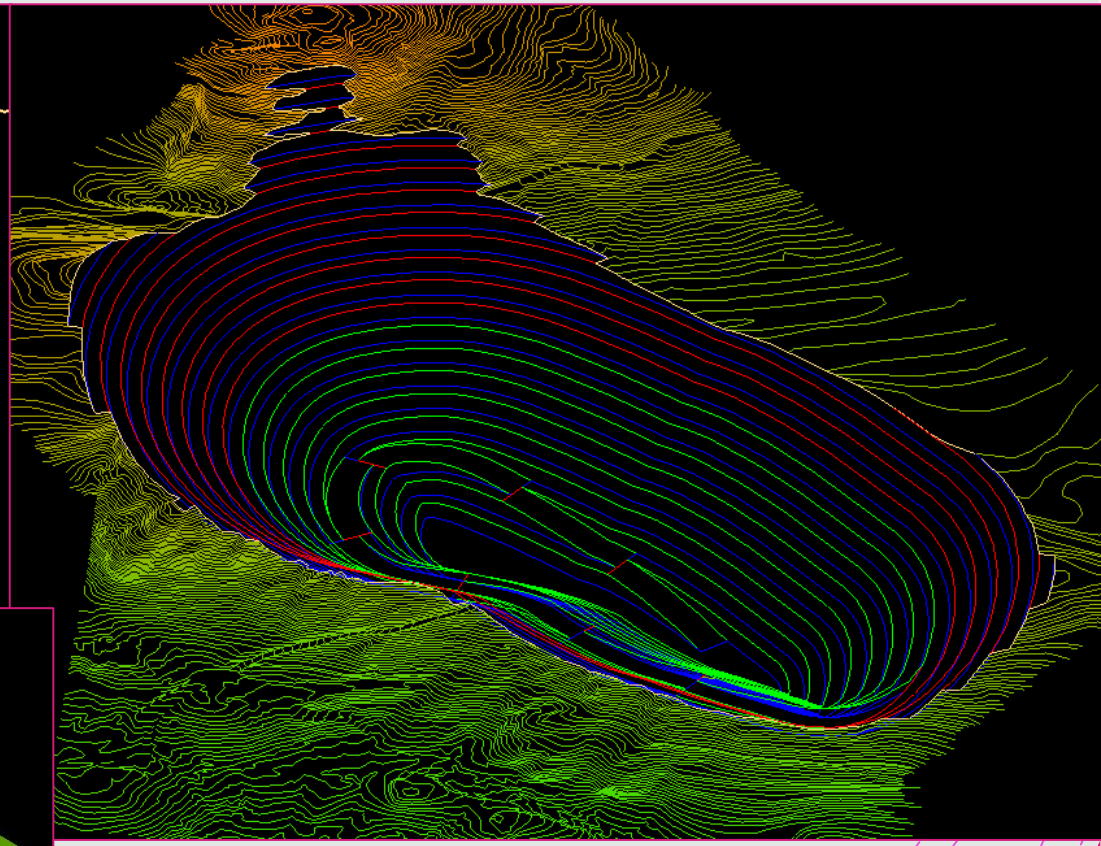


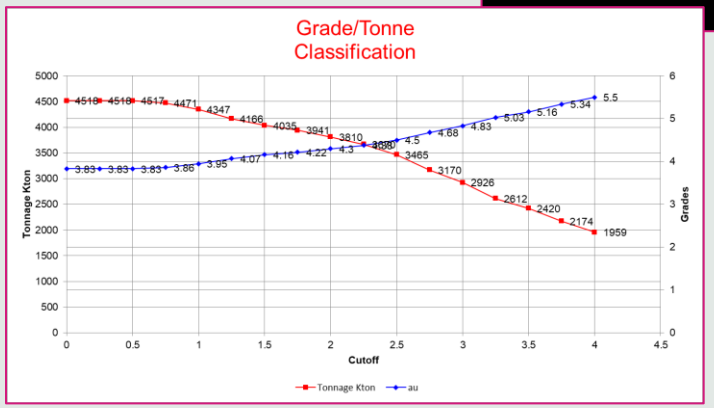
Lab 6 & 7

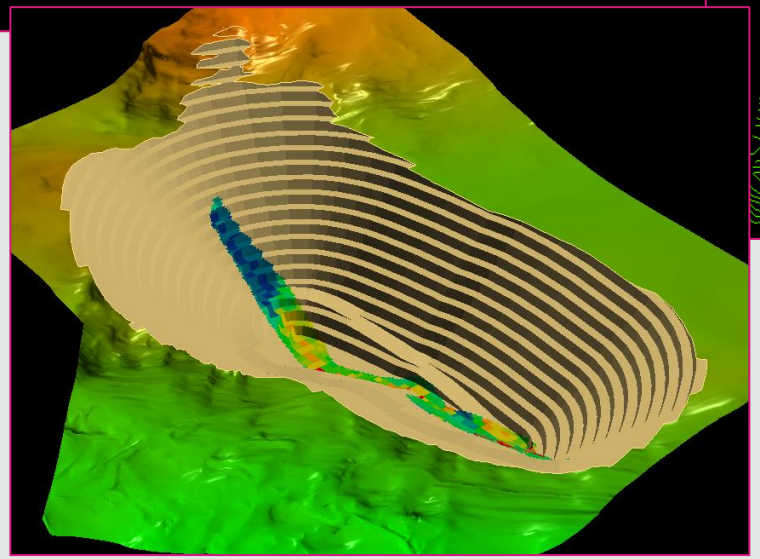
Open pit optimisation using different algorithms and parameters, pushback selection and design using operational parameters, and open pit design incorporating in-pit ramps





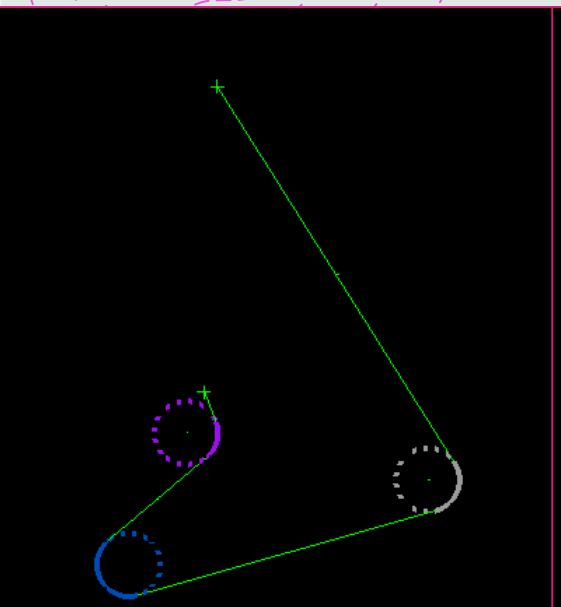


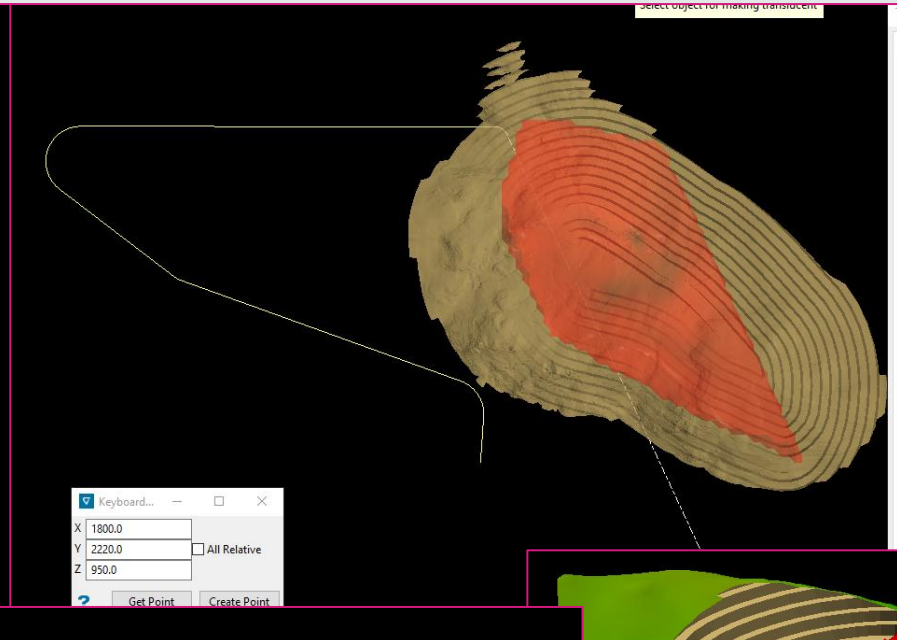


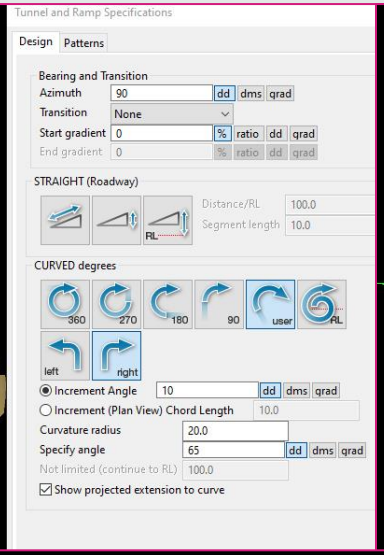


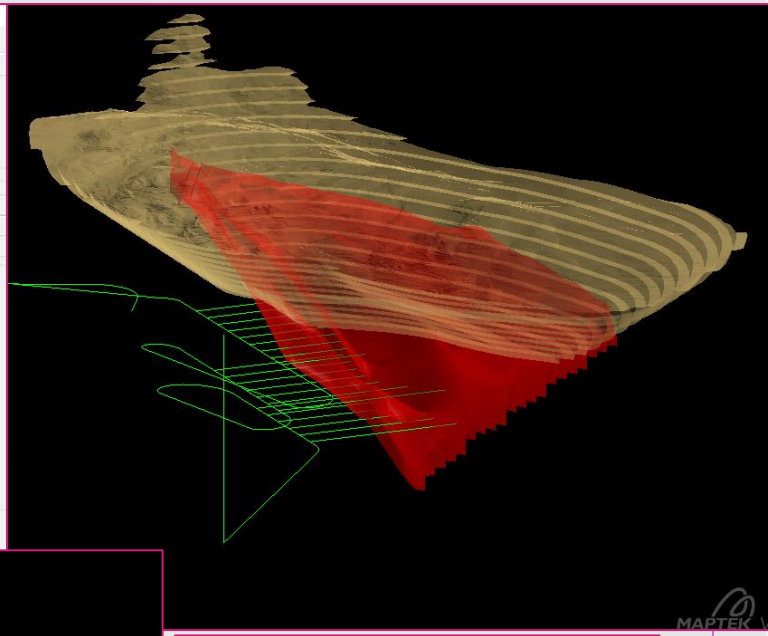
Underground design and modelling using an automated decline design algorithm, guided base drives and cross-cuts design, ventilation network simulation

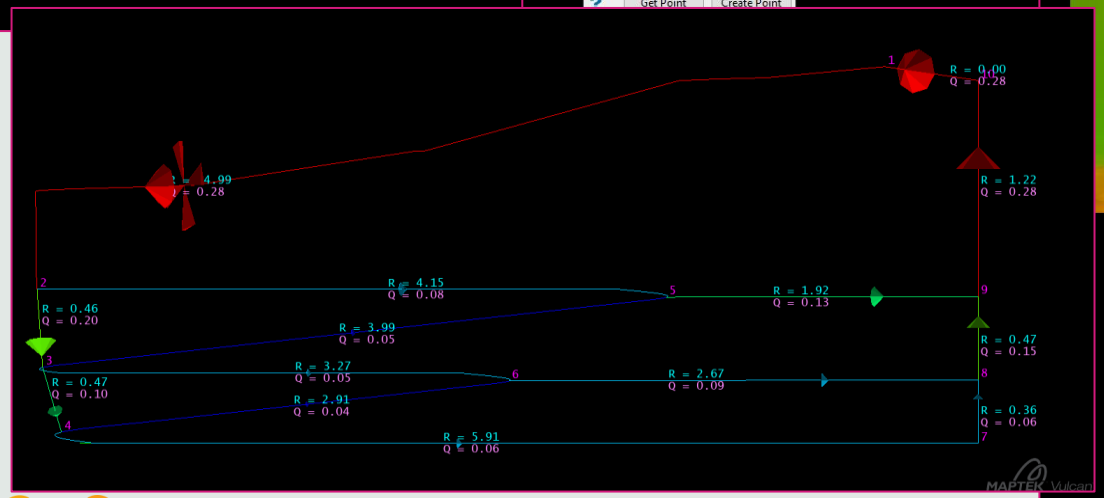
Lab 8 & 12

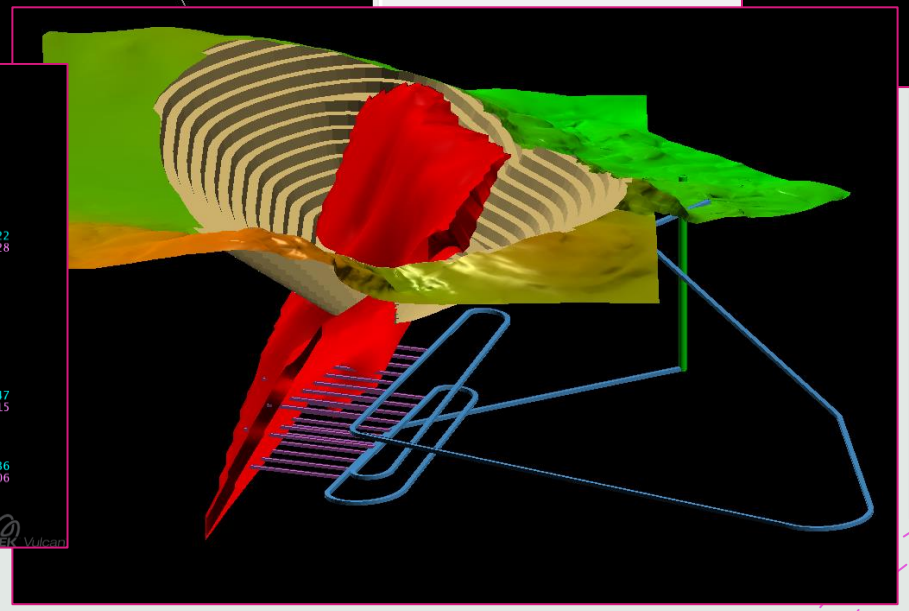












```
p0  = 100000.000000
r00 = 1.201000
Absolute Pressure at 1:  100000
Absolute Pressure at 2:  101481
Absolute Pressure at 3:  102002
Absolute Pressure at 4:  102433
Absolute Pressure at 5:  101534
Absolute Pressure at 6:  102092
Absolute Pressure at 7:  102507
Absolute Pressure at 8:  102085
Absolute Pressure at 9:  101530
Absolute Pressure at 10:  100092
```

Branch	BJ	EJ	Pressure loss	Flow	Regulator's resistance	Booster head	Contaminant
1	1	2	1.2	0.28	0	0	0
2	2	3	0.01802	0.2	0	0	0
3	3	4	0.004725	0.1	0	0	0
4	2	5	0.02962	0.085	0	0	0
5	3	5	0.008479	0.046	0	0	0
6	3	6	0.008782	0.052	0	0	0
7	4	6	0.004057	0.037	0	0	0
8	4	7	0.02362	0.063	0	0	0
9	6	8	0.02128	0.089	0	0	0
10	5	9	0.03267	0.13	0	0	0
11	7	8	0.001431	0.063	0	0	0
12	8	9	0.01095	0.15	0	0	0
13	9	10	0.09774	0.28	0	0	0
14	10	1	0	0.28	0	0	0

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Opportunity for project-based learning

- The mine planning course is an ideal opportunity for project-based learning.
- Students can be organised in teams of 5-6 and undertake a mine planning study of a different deposit, with specific roles for each one (data management, geological modelling, resource modelling, pit optimisation and design, scheduling).
- These projects can run parallel to and in sync with theoretical lectures and lab exercises, for the duration of a semester.

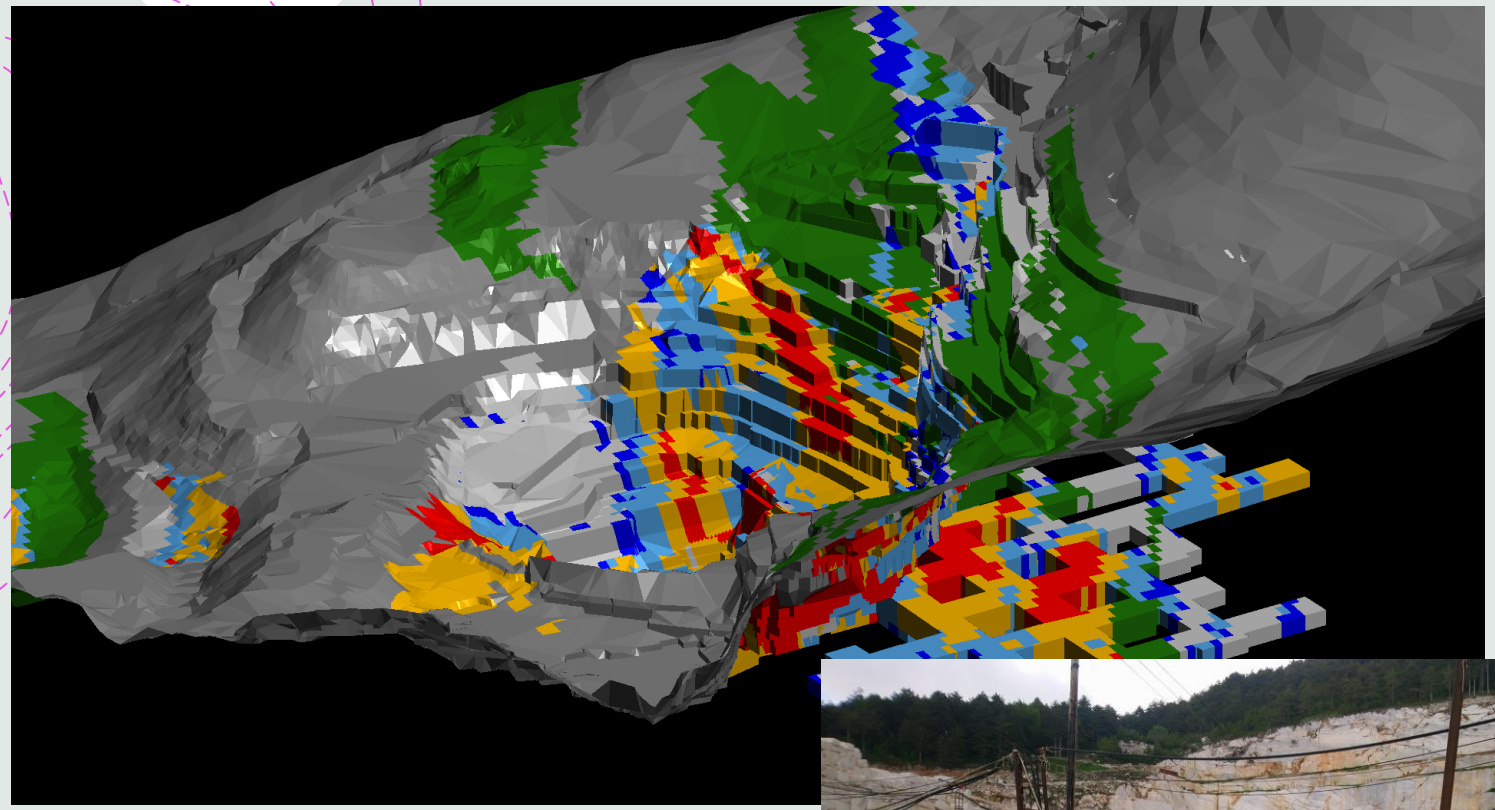
Benefits & Challenges

Benefits

+ Integration and reinforcement of theoretical knowledge from various areas
+ 3D visualisation of actual geological and mining entities
+ Learning of geology and mining terminology in English
+ Breakdown of a complex process (mine planning) in easy to approach sub-processes
+ Reinforcing of CAD skills in mining related tasks
+ Possible student certification from software vendor
+ Opportunity to inspire students to do research in a wide range of technology areas including AI/ML

Challenges

- Difficult to balance between learning specific software vs learning procedures and algorithms
- Time limitations
- Complex UI, computer graphics, and algorithmic terminology
- Hard to follow software progress from one version to the next
- Lack of in-depth training and reference material
- English UI and online help



Estimate, design, model,…

…and then visit!

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