Resource estimation

ENSG- Marie-Cécile FEBVEY, Zélie JANNEL

Using a case study developped by P. Marchal

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Geological context

Stratiform Zn-Cu-Ag-Au volcanogenic massive sulfide (VMS)

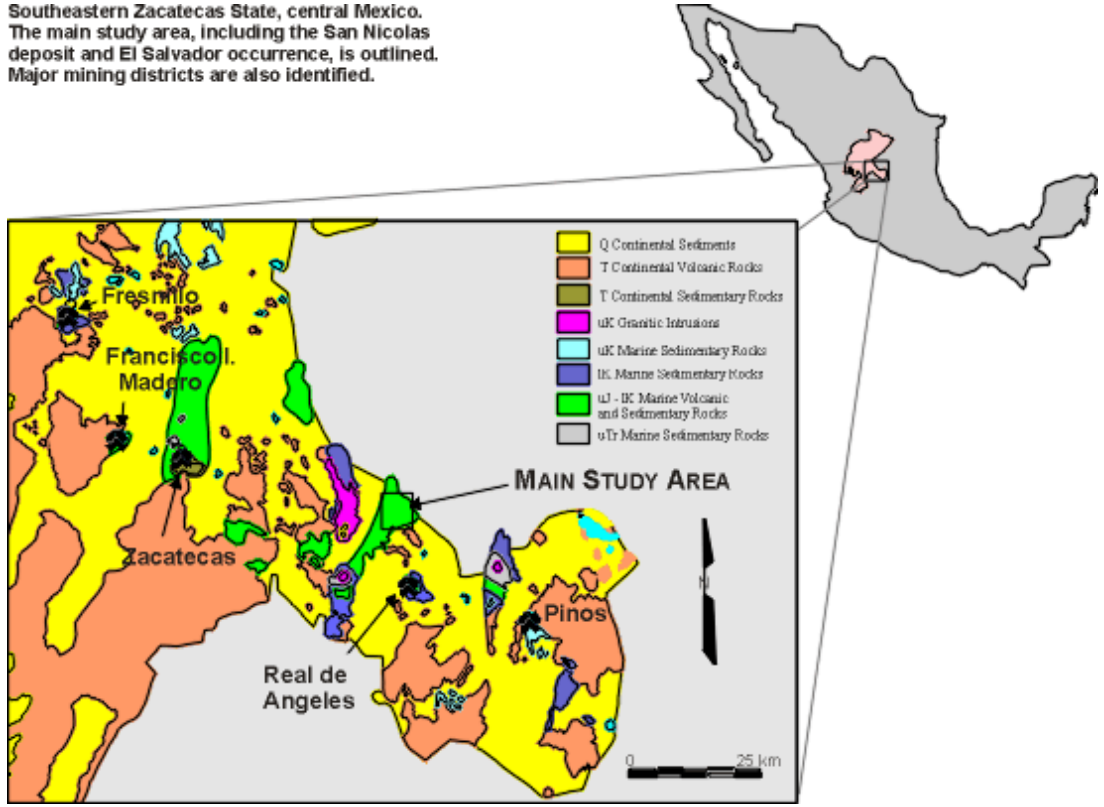
Located in central Mexico, southern Zacatecas.

Late Jurassic-Early Cretaceous

Mineralization age (U/Pb) ~ 148 Ma

Resource estimation: 100 Mt at

- **1.36% Cu,**
- **1.64% Zn,**
- **0.15% Pb,**
- **0.41 g/t Au,**
- **24.0 g/t Ag**



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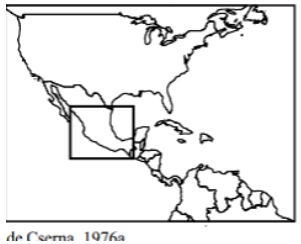
Geological context

Geological setting

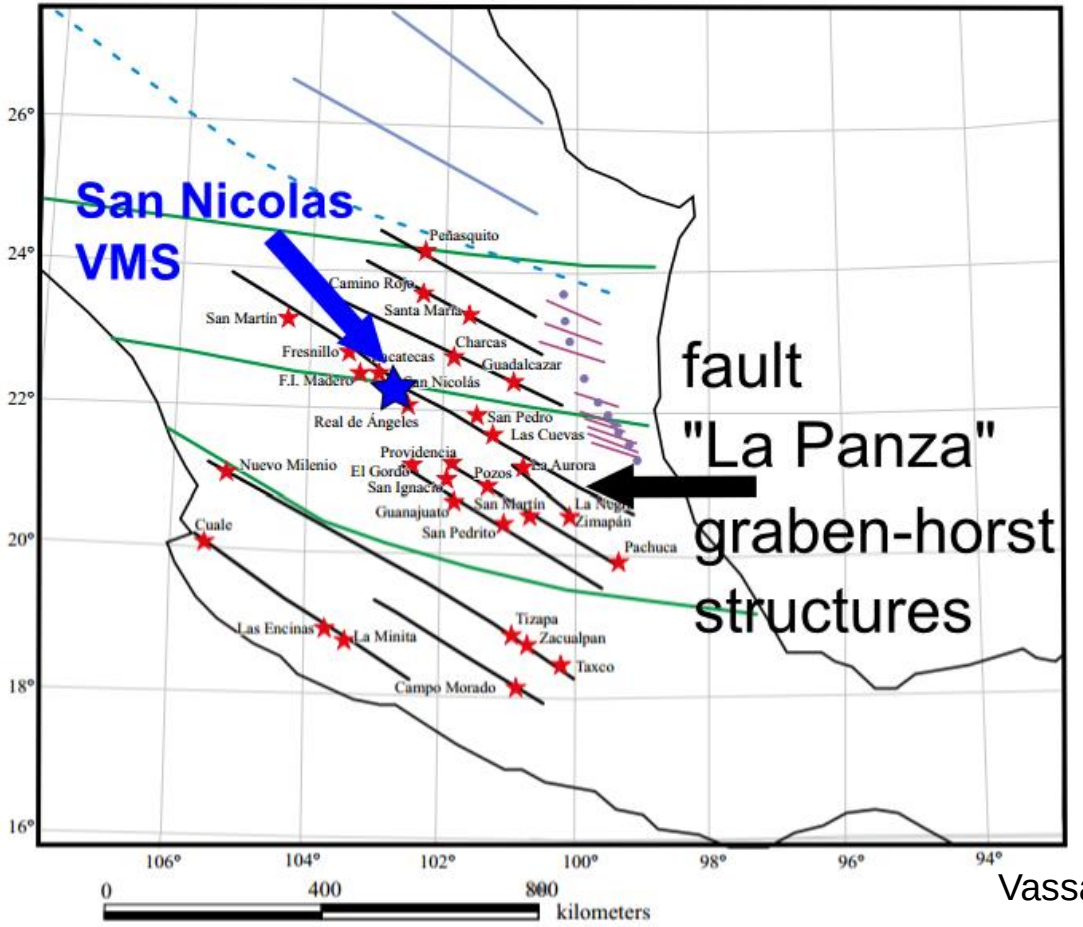
Related to a graben-horst – extension – opening of the Gulf of Mexico

The « *LaPanza* » fault

control the mineralization

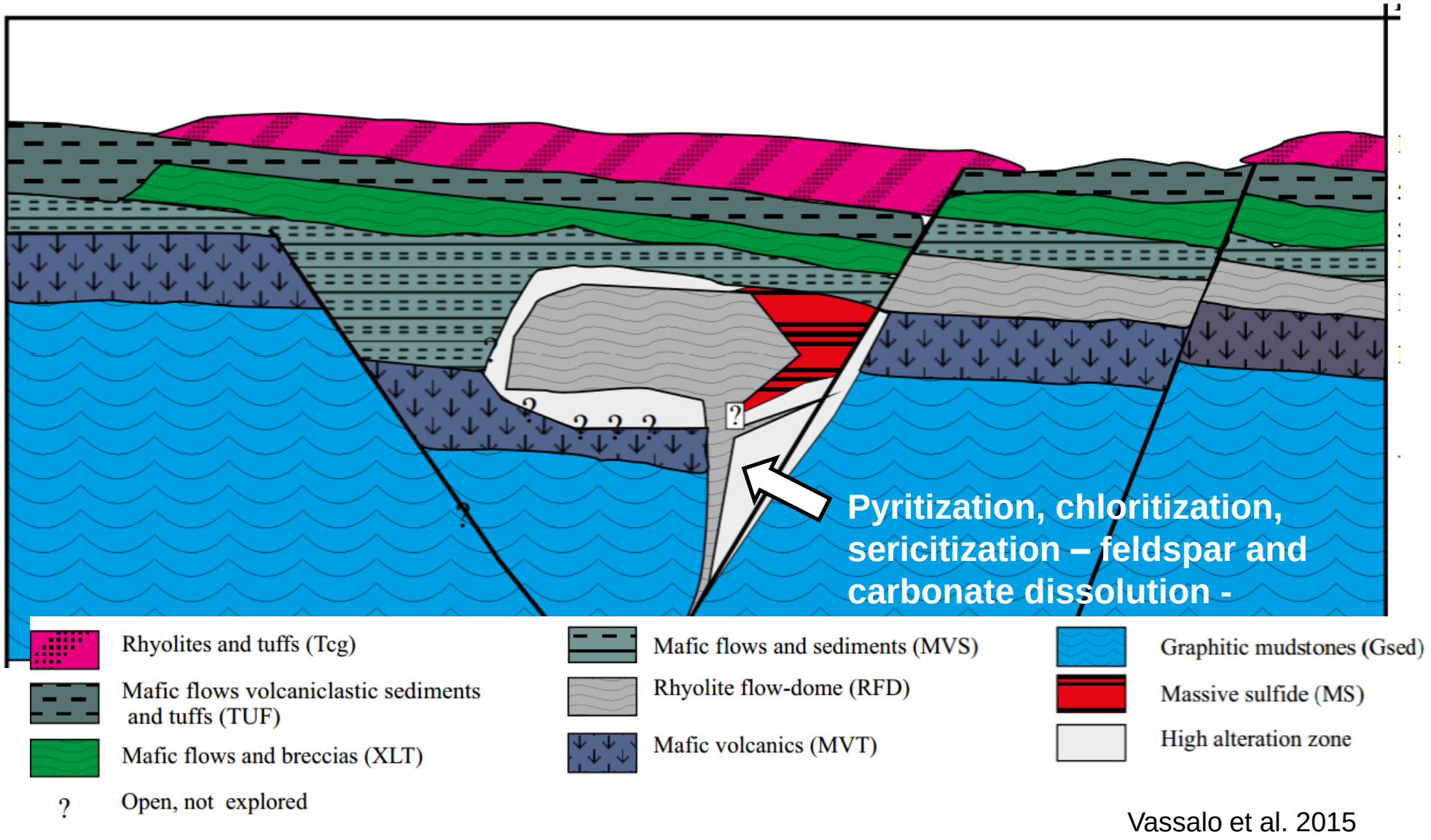


de Cserna, 1976a



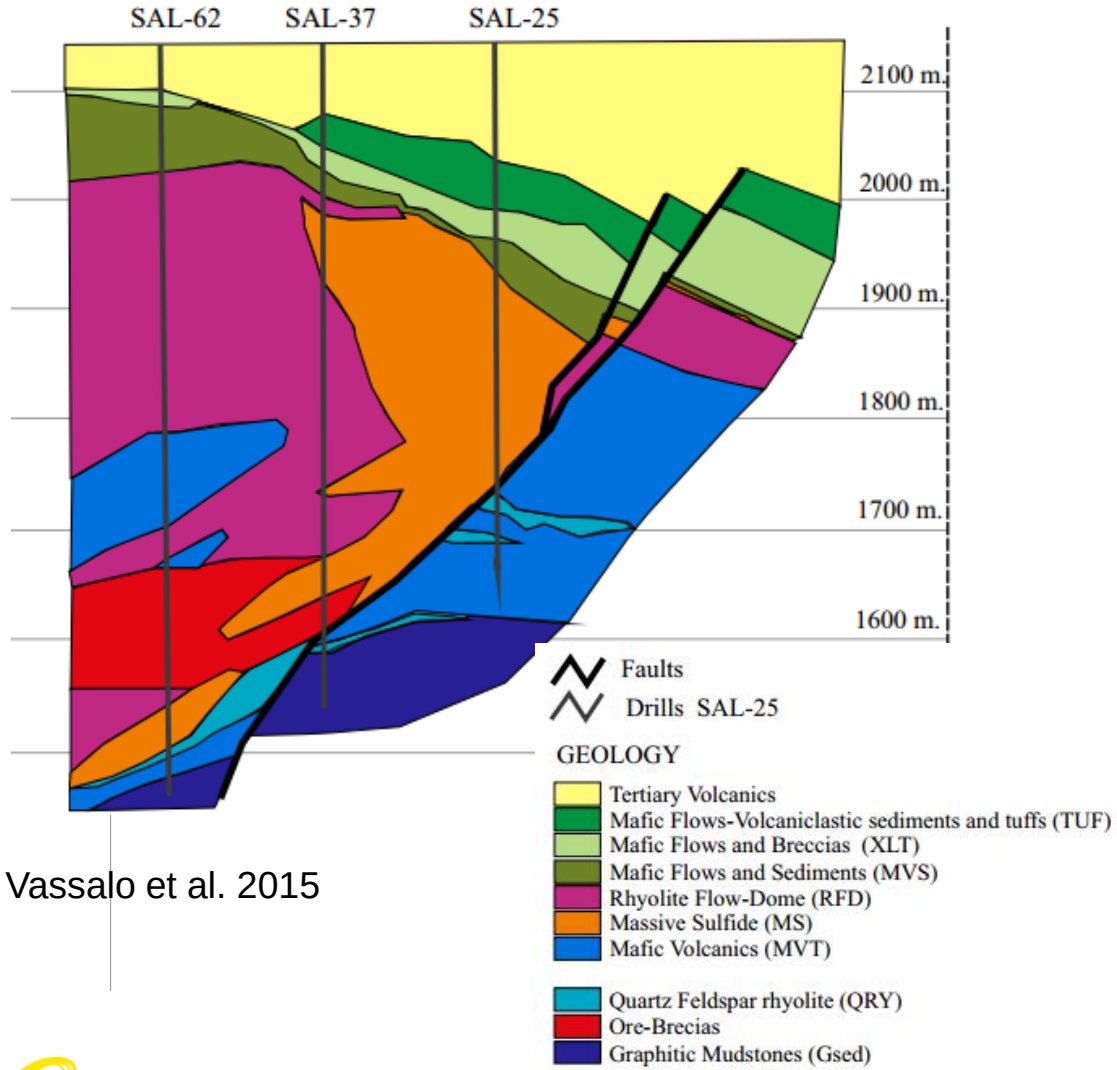
Vassalo et al. 2015

Proposed model for the volcanic structure



Vassalo et al. 2015

Case study



Vassalo et al. 2015

Johnson et al.

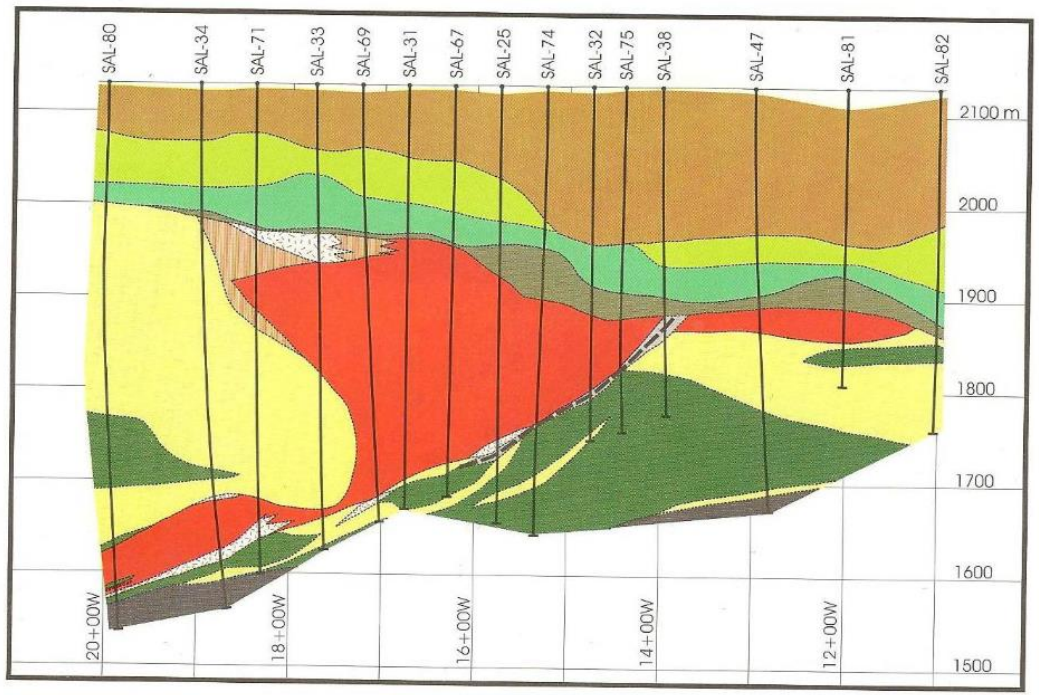


Figure 5. Geological cross-section, line 4+00S. See Figure 4 for grid location.

Tertiary conglomerates and volcanoclastic breccias (Tcg) (32,3Ma)

Mafic Flows and Tuff (TUF)

Mafic flows & breccias (XLT) (117,94Ma)

Mafic flow & sediments (MVS)

Rhyolite Flow-Dome (146.5 Ma) (RFD)

Massive Sulfides (MS or ore)

Mafic volcanics (MVT) (≈149Ma)

Late Triassic Graphitic mudstone (Gsed)

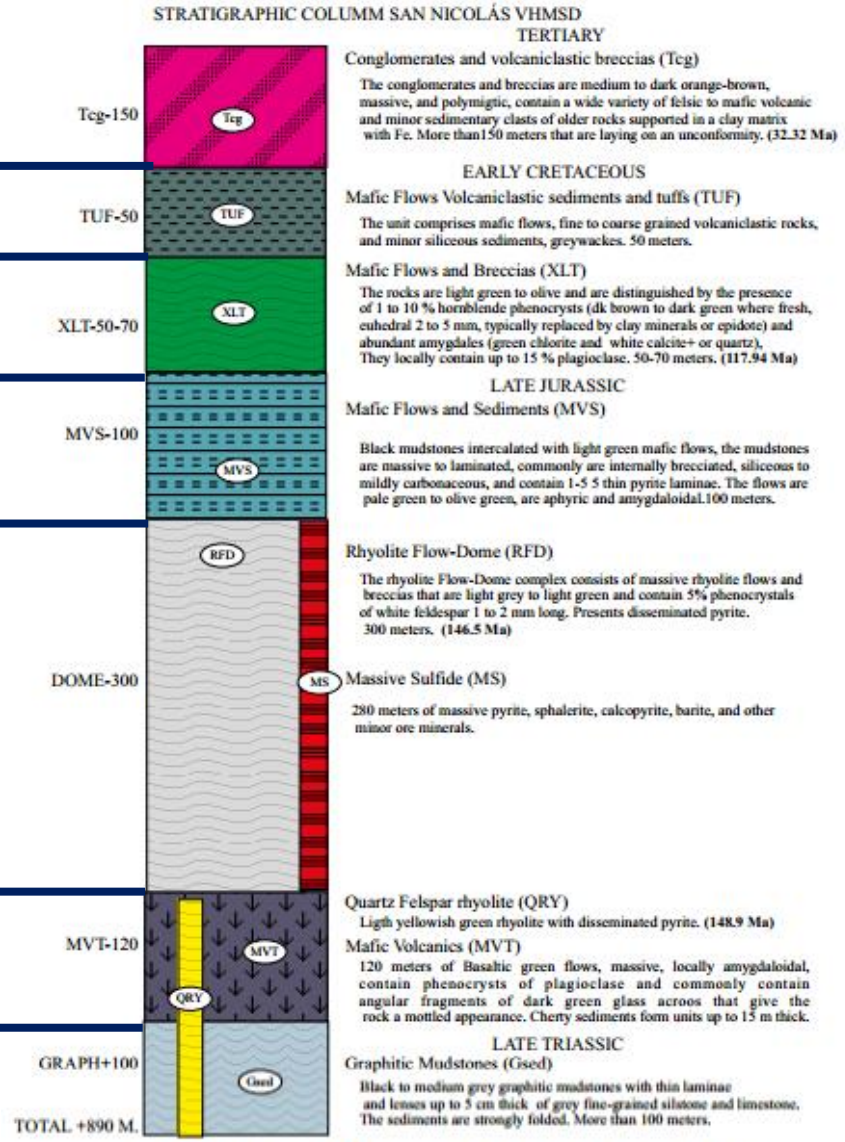


Figure 4. Stratigraphic columm VMS San Nicolás. Modified after Johnson *et al.* (2000).

Vassalo et al. 2015

TD – 5 groups of 4 students and 2 groupS of 3

- Concerning Cu mineral body, compare different estimations of grades (OK, inverse distance, nearest neighbor)
- As you did with Cu grade, estimate Ag, Au, Pb and Zn grades in the grid. Justify your choices of interpolation, variograms if needed, …
- Compare ore tonnage for other metals. Economic grades are 0.5 g/t for Au, and 30 g/t for Ag. Is it worth changing the processing unit to extract Au and Ag in areas mined for Cu (>1.4%Cu) and Zn (> 2% Zn)?
- And what if you change Ag/Au cut-off values?
- What about Pb?
- Where would you drill (< 2500m) to have a better idea of mineable reserves of Cu/Zn? Of Au/Ag?

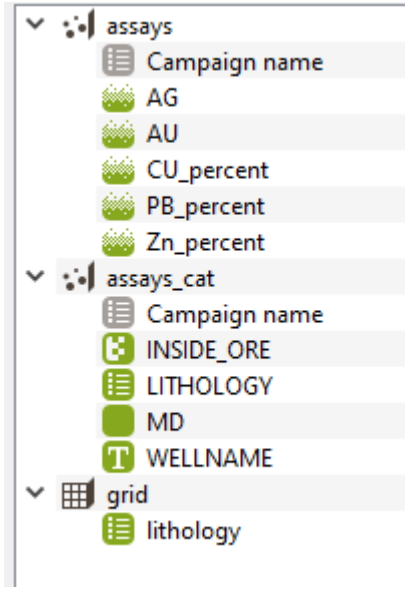
RQ: density around 4500kg/m3

Context

Work with the San Nicolas VMS dataset

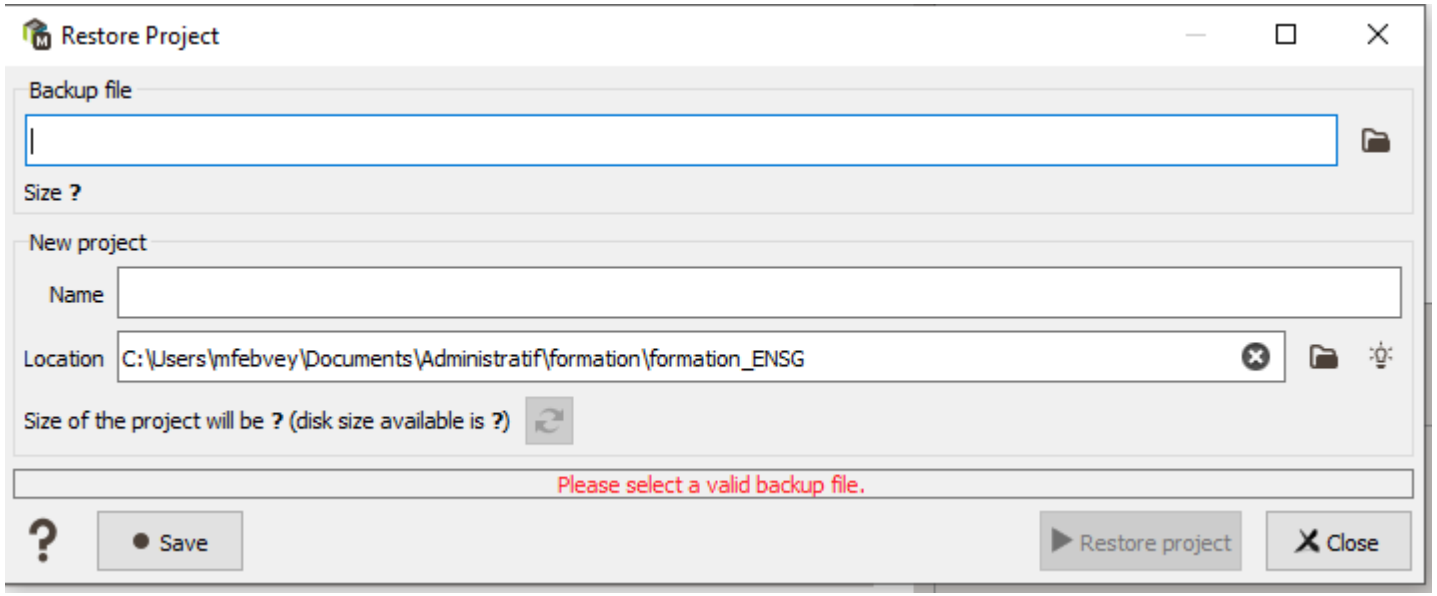
In Isatis.Neo: we will do the resource estimation

You have a backup available with the dataset (assays and grid)



Project restoration

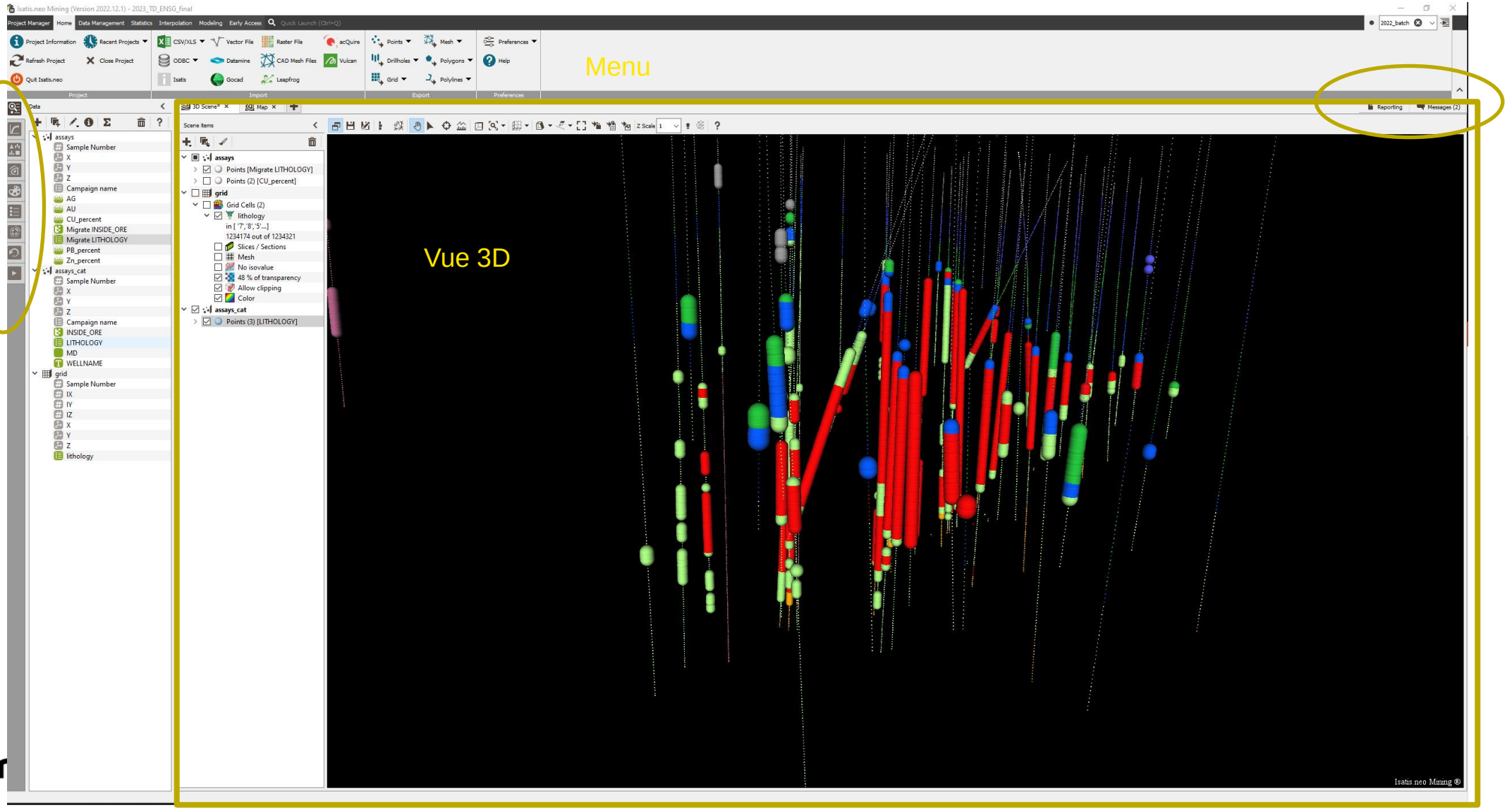
In Project manager →To restore the backup 



Select  **to choose the backup file**

Don’t keep a safety copy

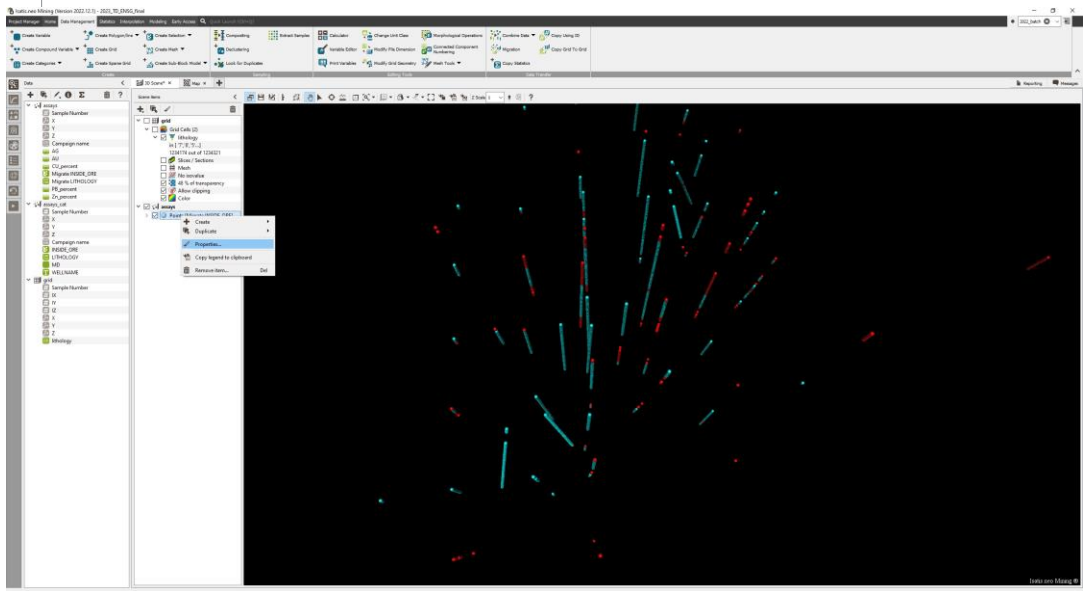
Isatis.Neo

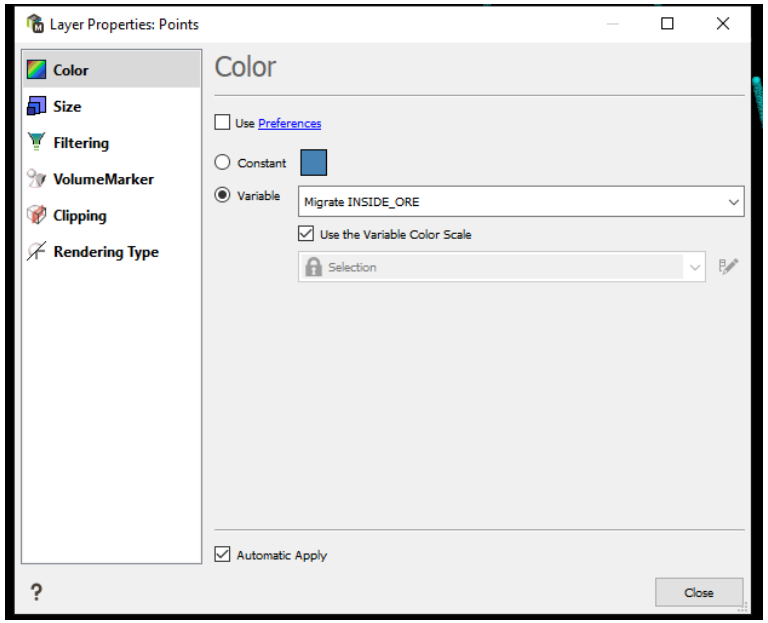


Display of the data

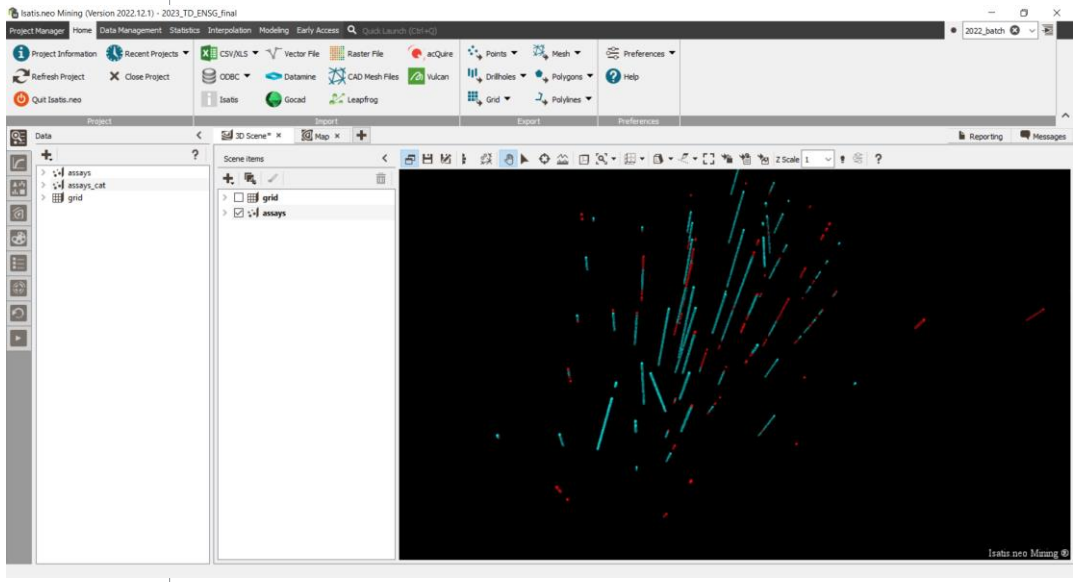
Drag and drop the data from the data tree to the 3D Scene or 2D Scene

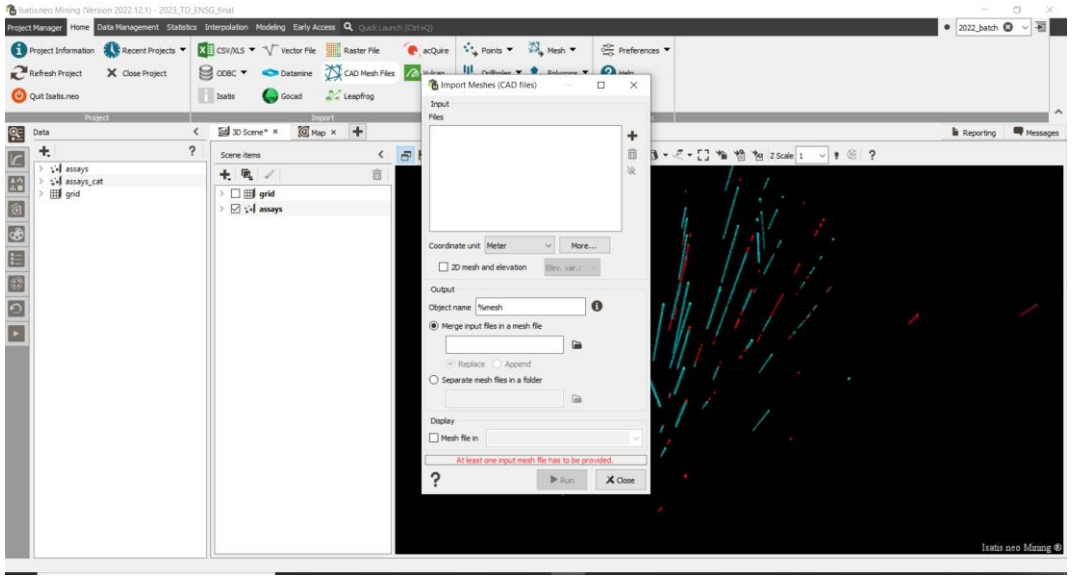
In the scene items, right click on a layer

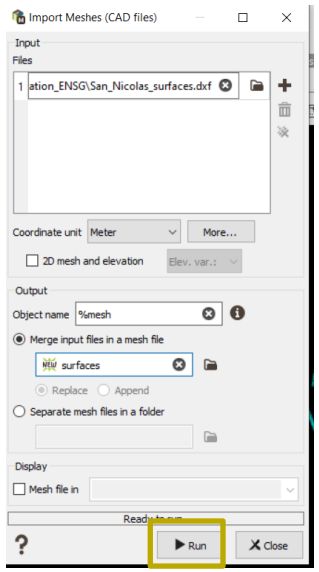




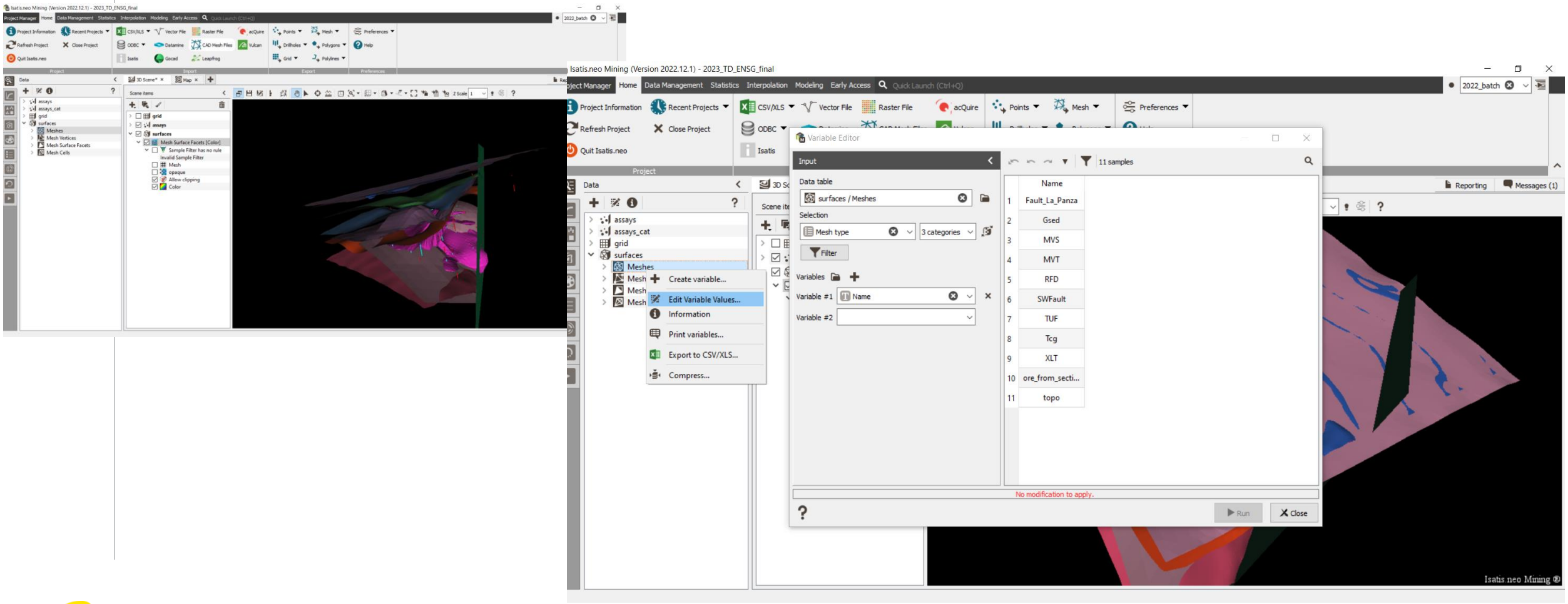
DXF file import



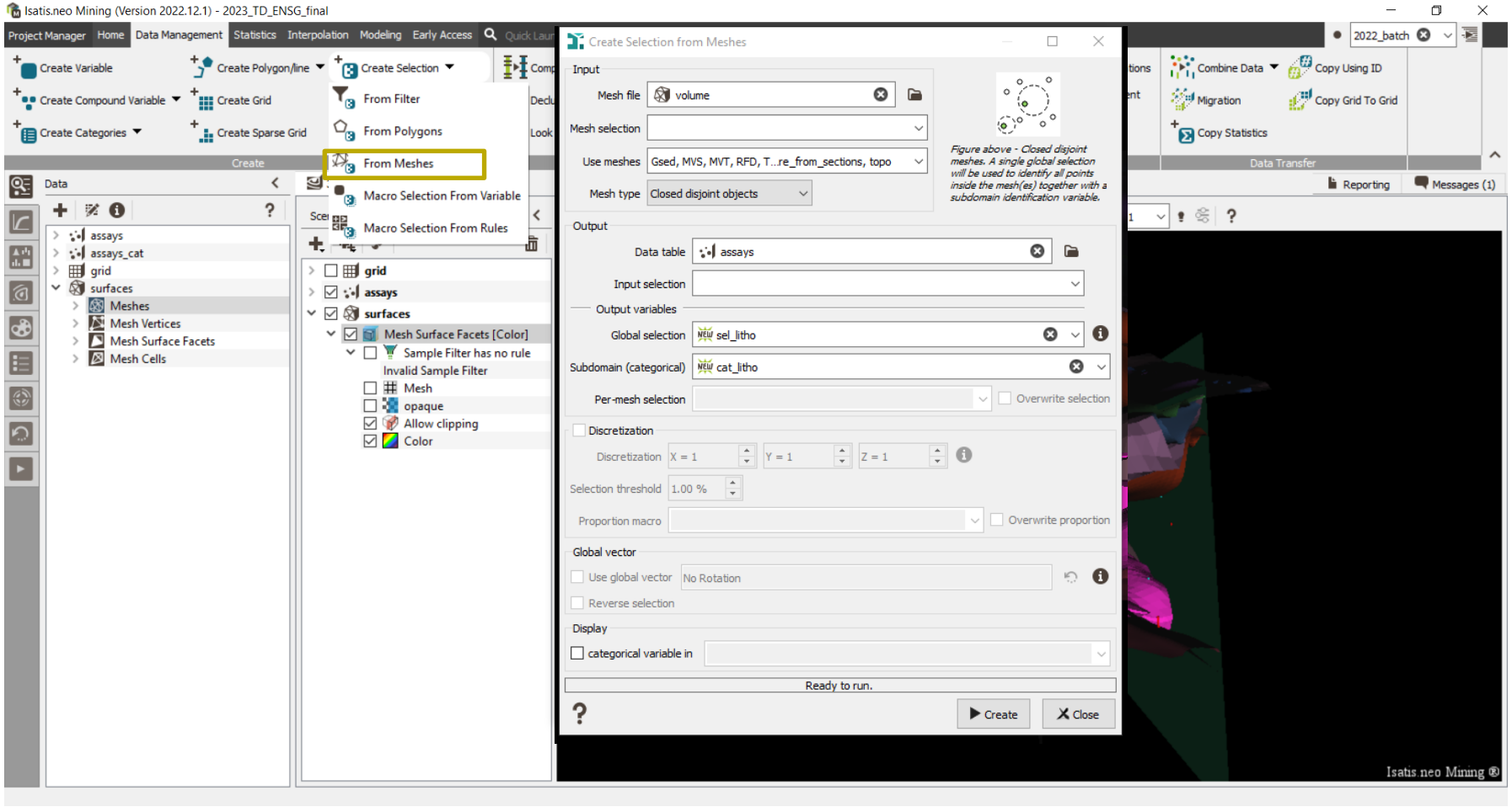




File visualisation

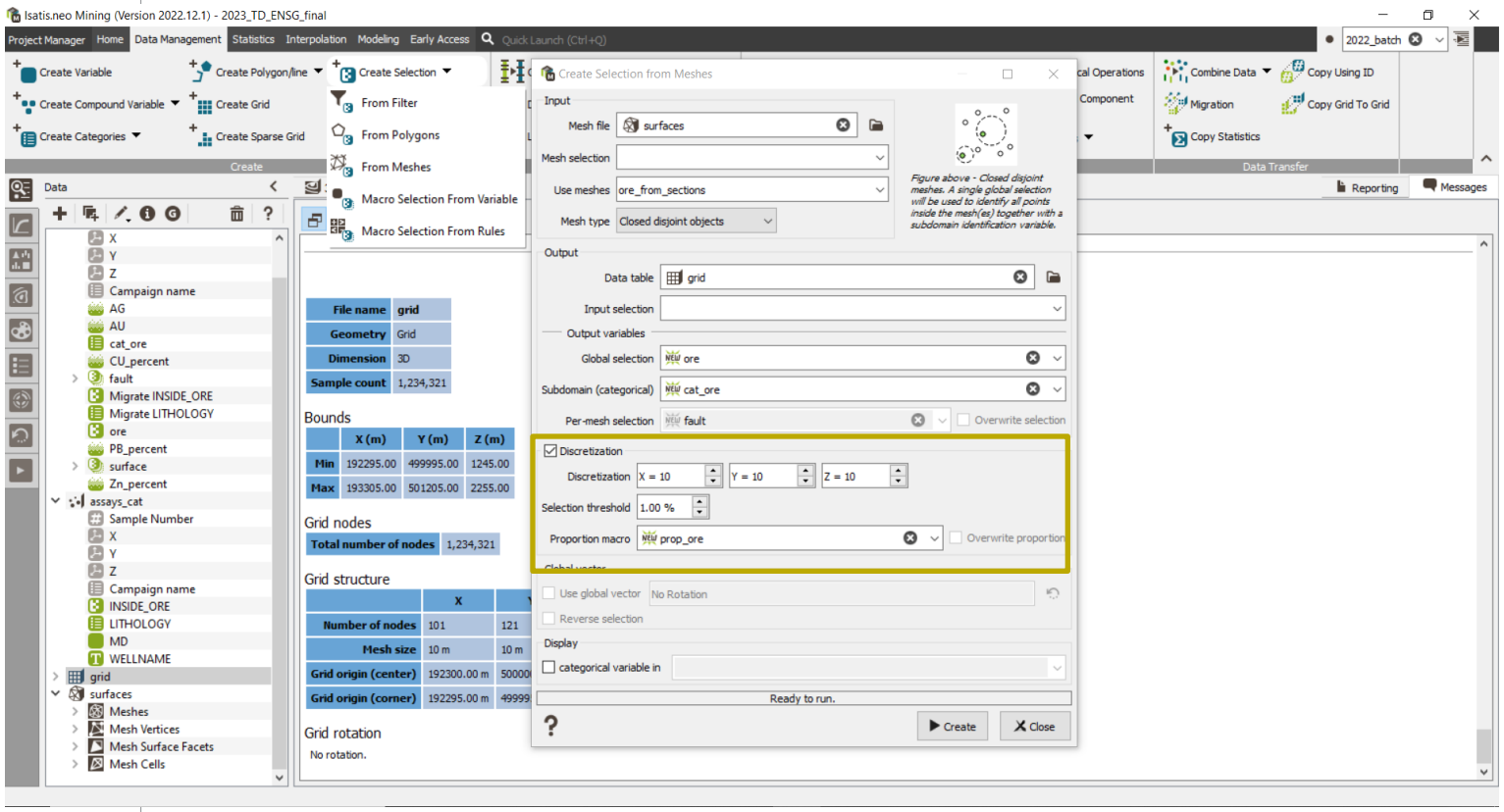


Create selections



+ Create only a selection for the ore on the assay, same on the grid

Creation of the selections on the grid



Only create a selection for the ore on the grid

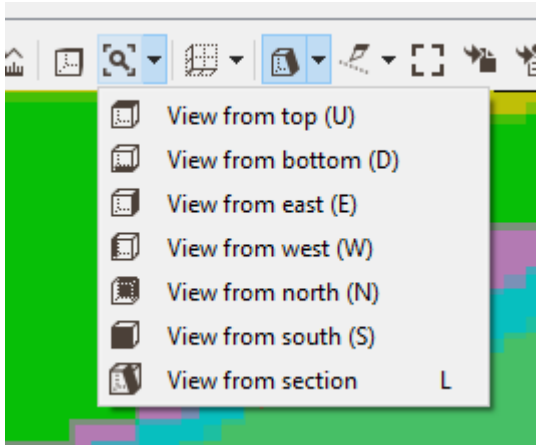
Be cautious when intersecting proportions!

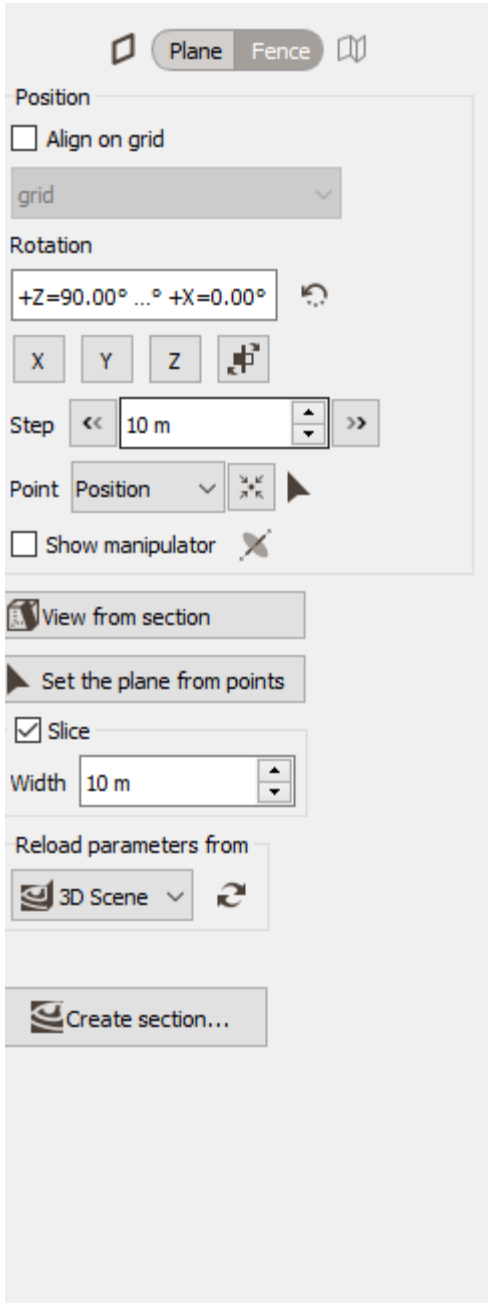
Data validation

Do cross sections all over the deposit

Two options: plan and fences

You can go from one view to another by pressing the keyboards letters (E, U, W, N)



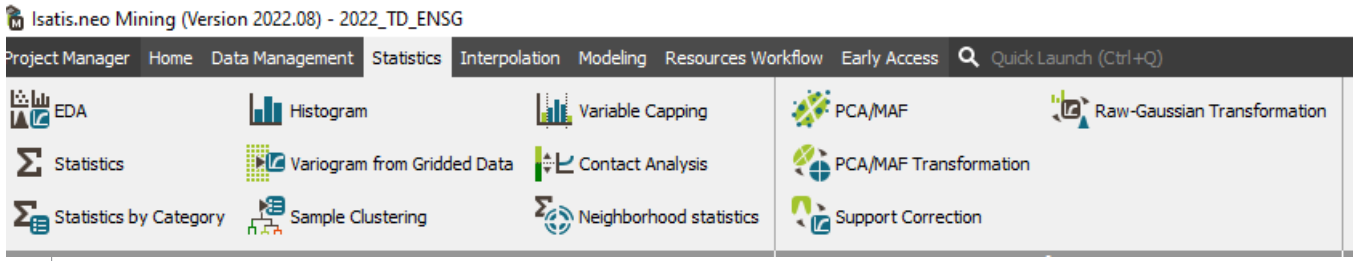


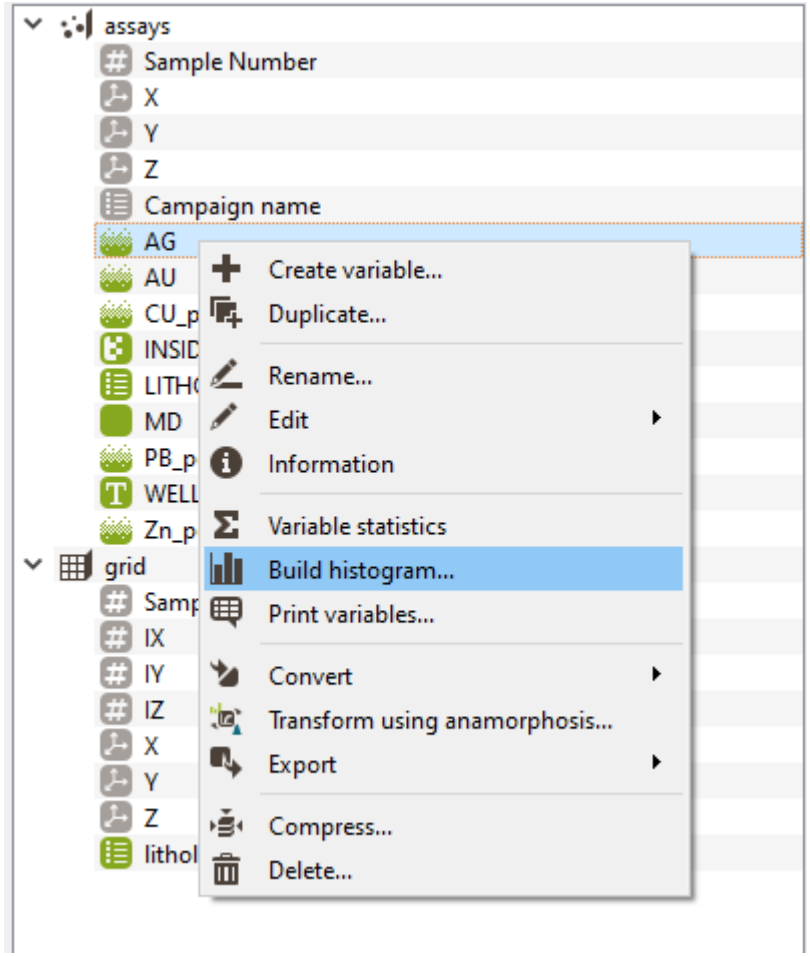
Data validation

Compile statistics on the different variables

Right click → Build histogram…

→ Variable statistics



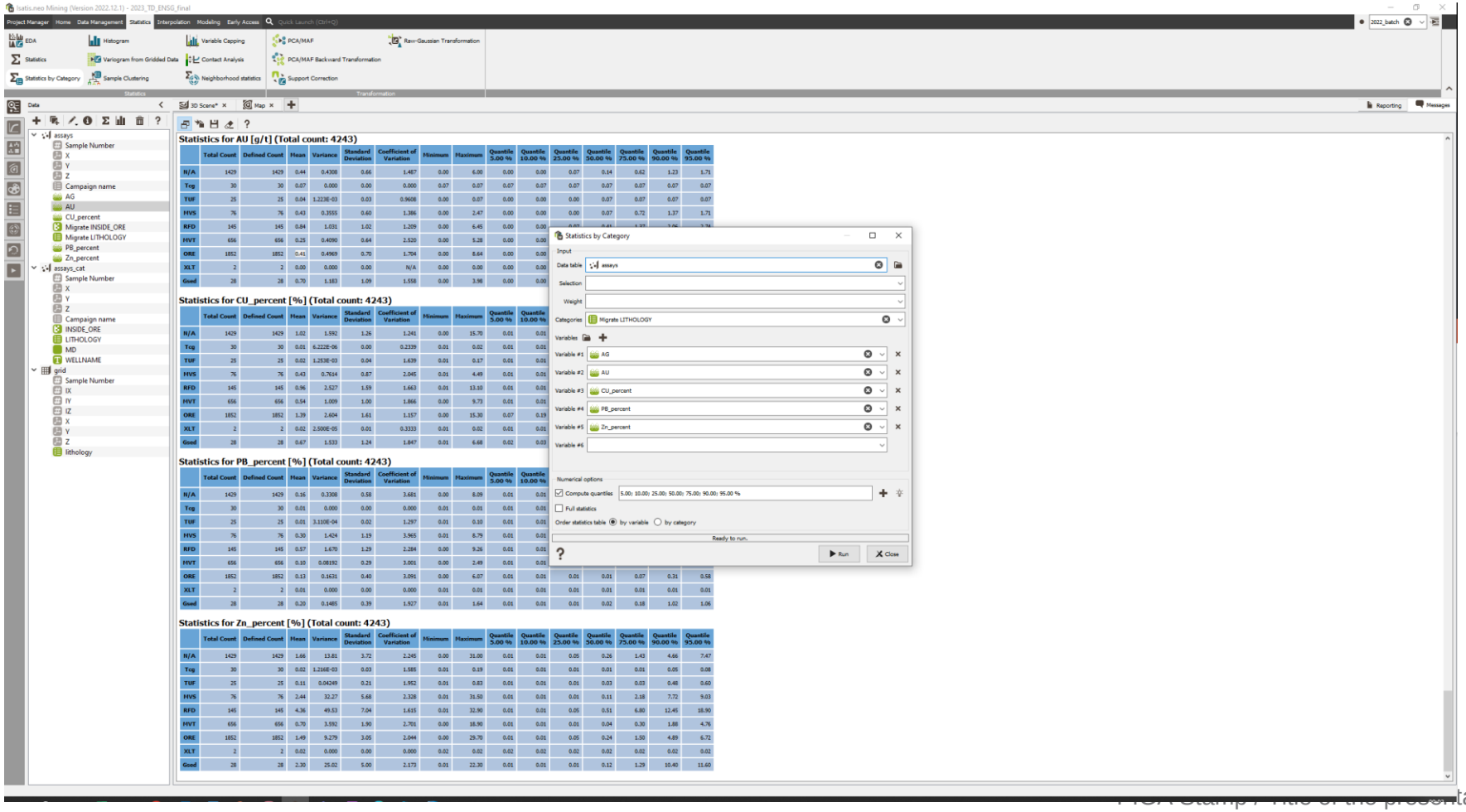


What do you notice in the statistics?

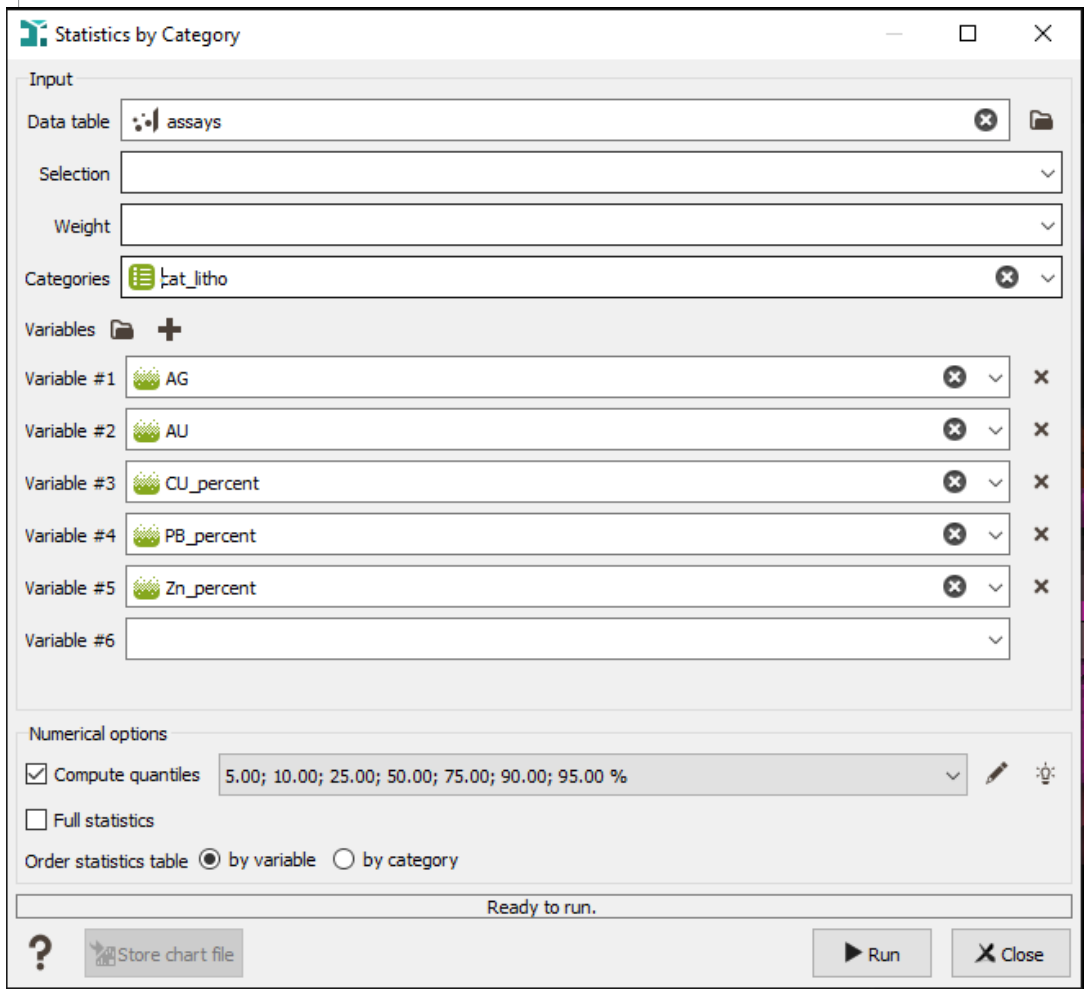
You can do statistics by category

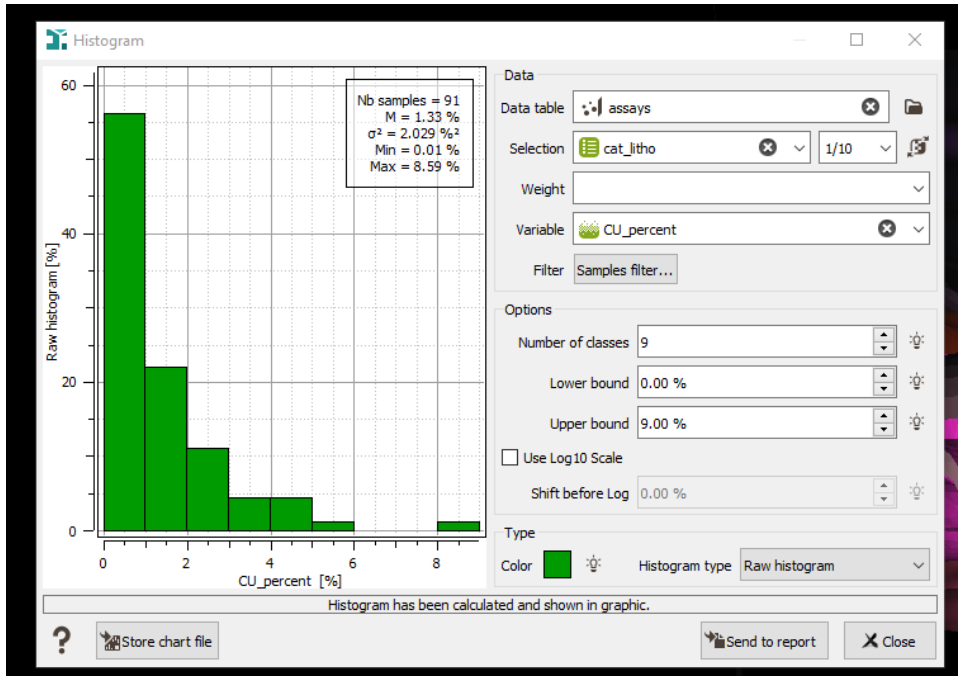
Data validation

Statistics by category → Statistics



Statistics using these selections





Then we will only use a selection « ore »

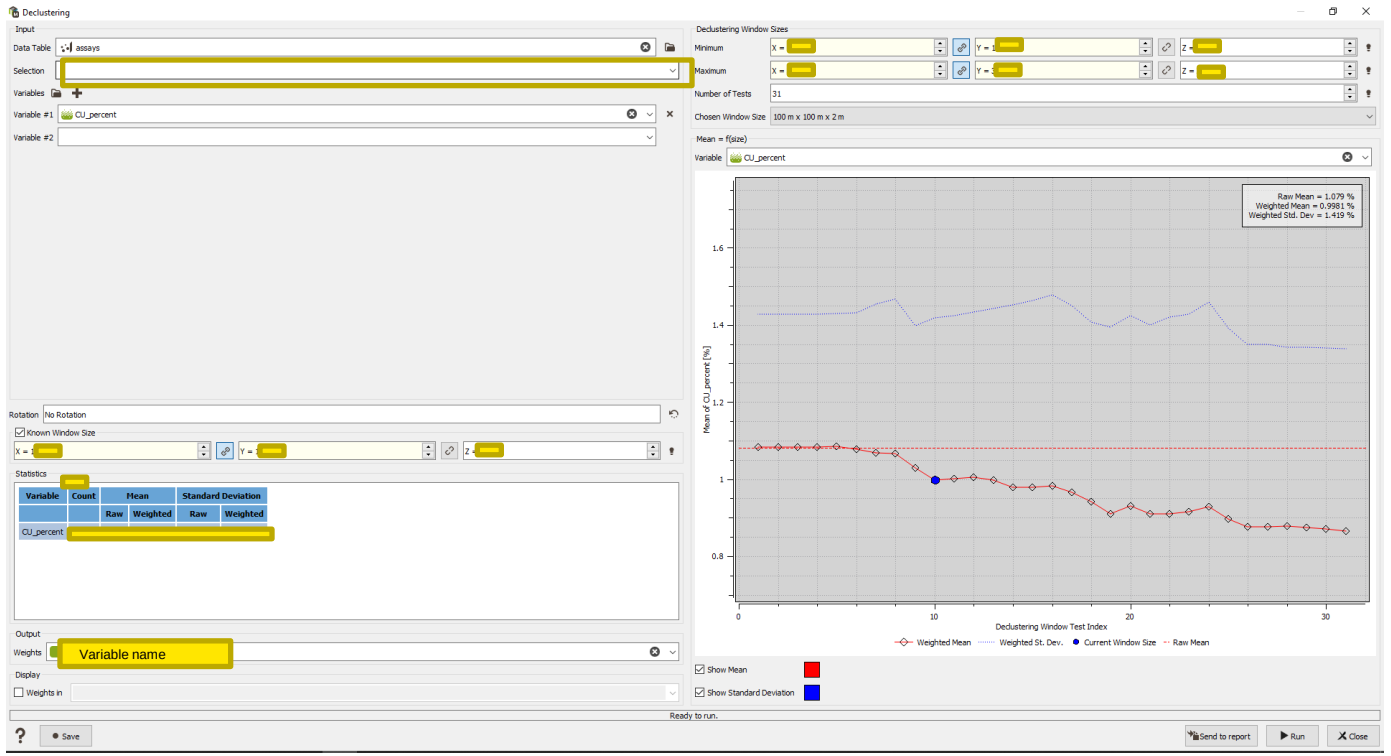
Declustering

Are the data clustered?

- **Measure the drillhole spacing (if any) in the 2D map**

- **Play with the declustering tool to see if the mean and standard deviation evolves**

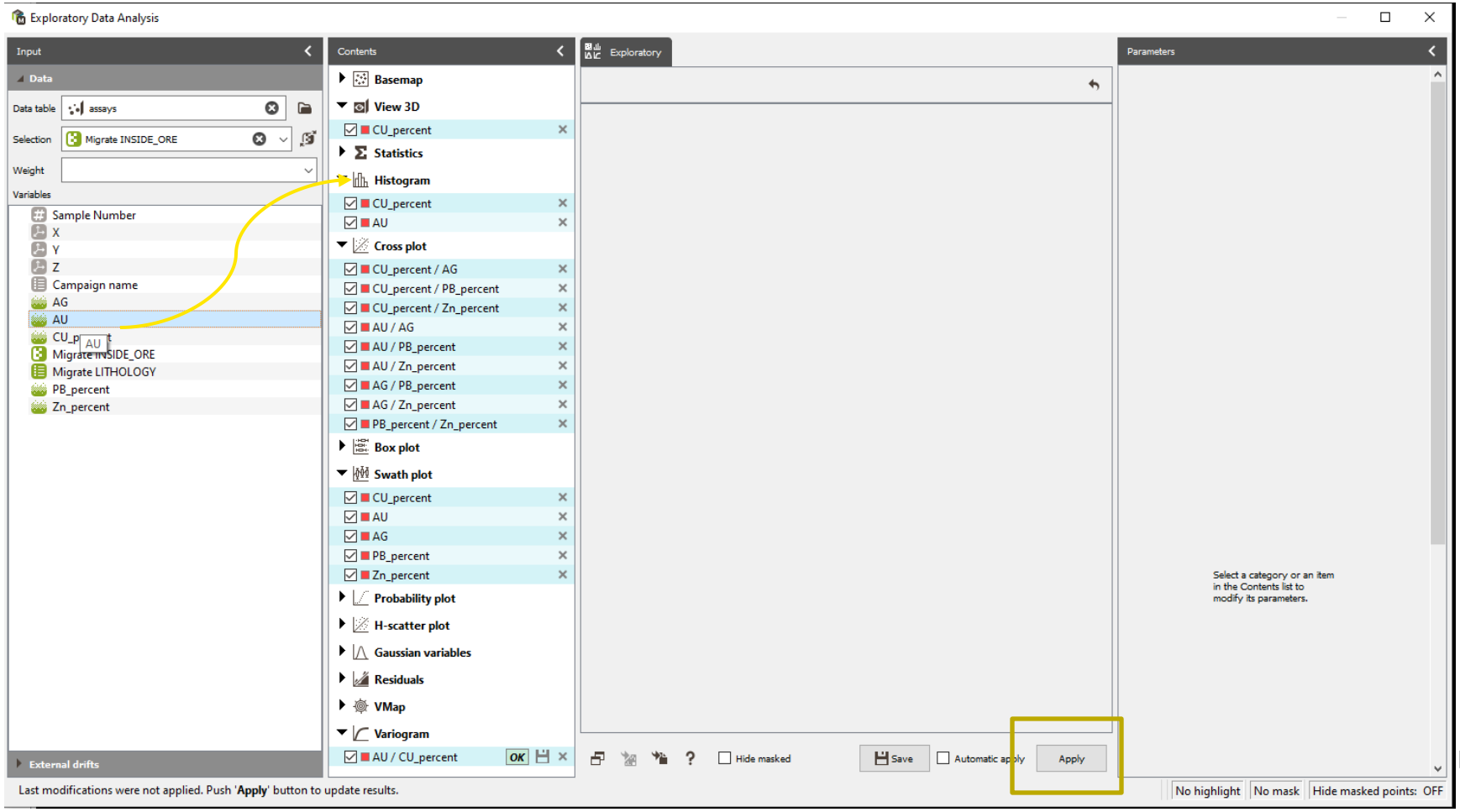
You can use a selection



Exploratory data analysis

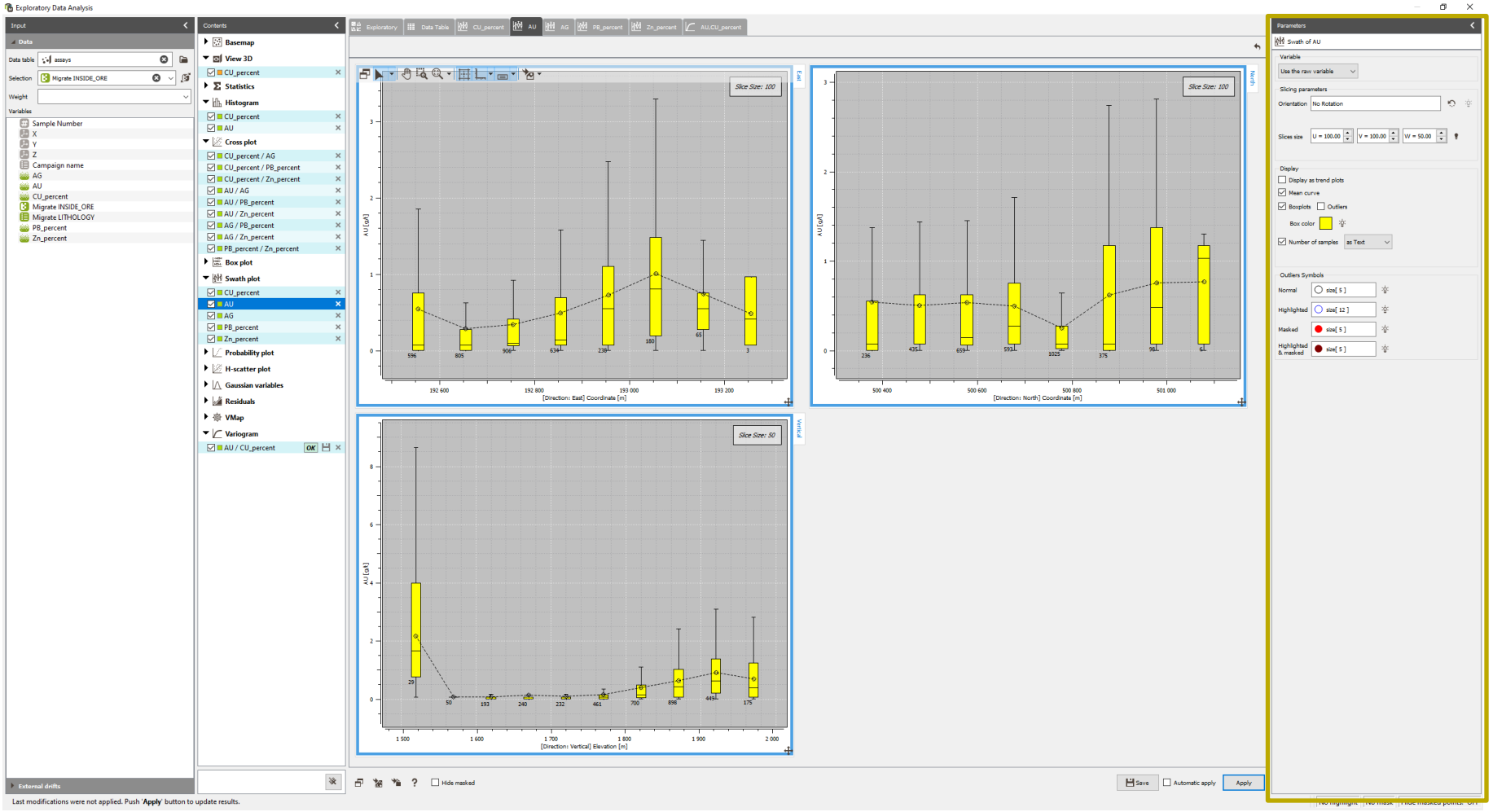
EDA is working with drag and drop functionalities, apply is to compile the graphs

You can use another selection



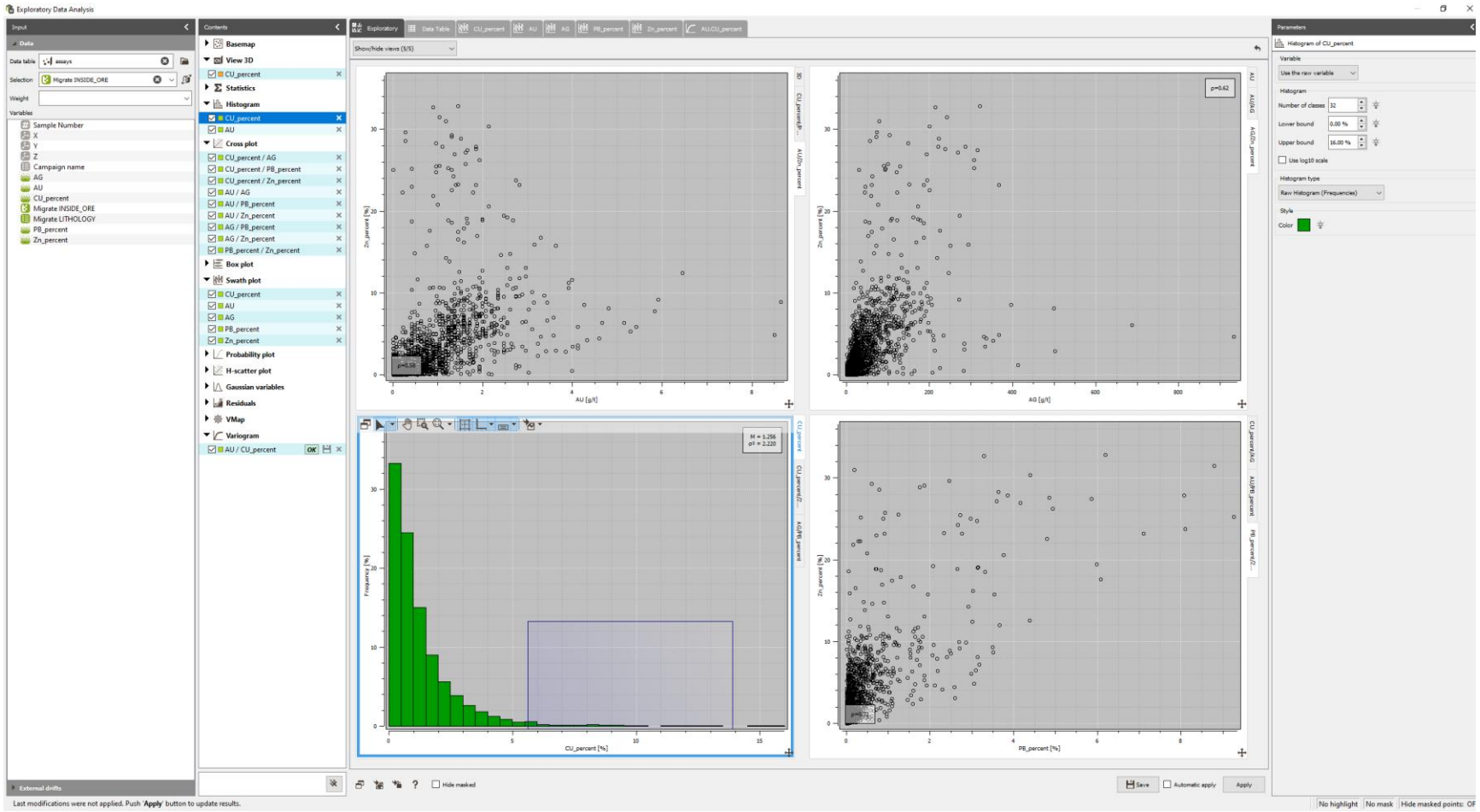
Exploratory data analysis

For each window, a parameters part can be displayed and graphs can be customized

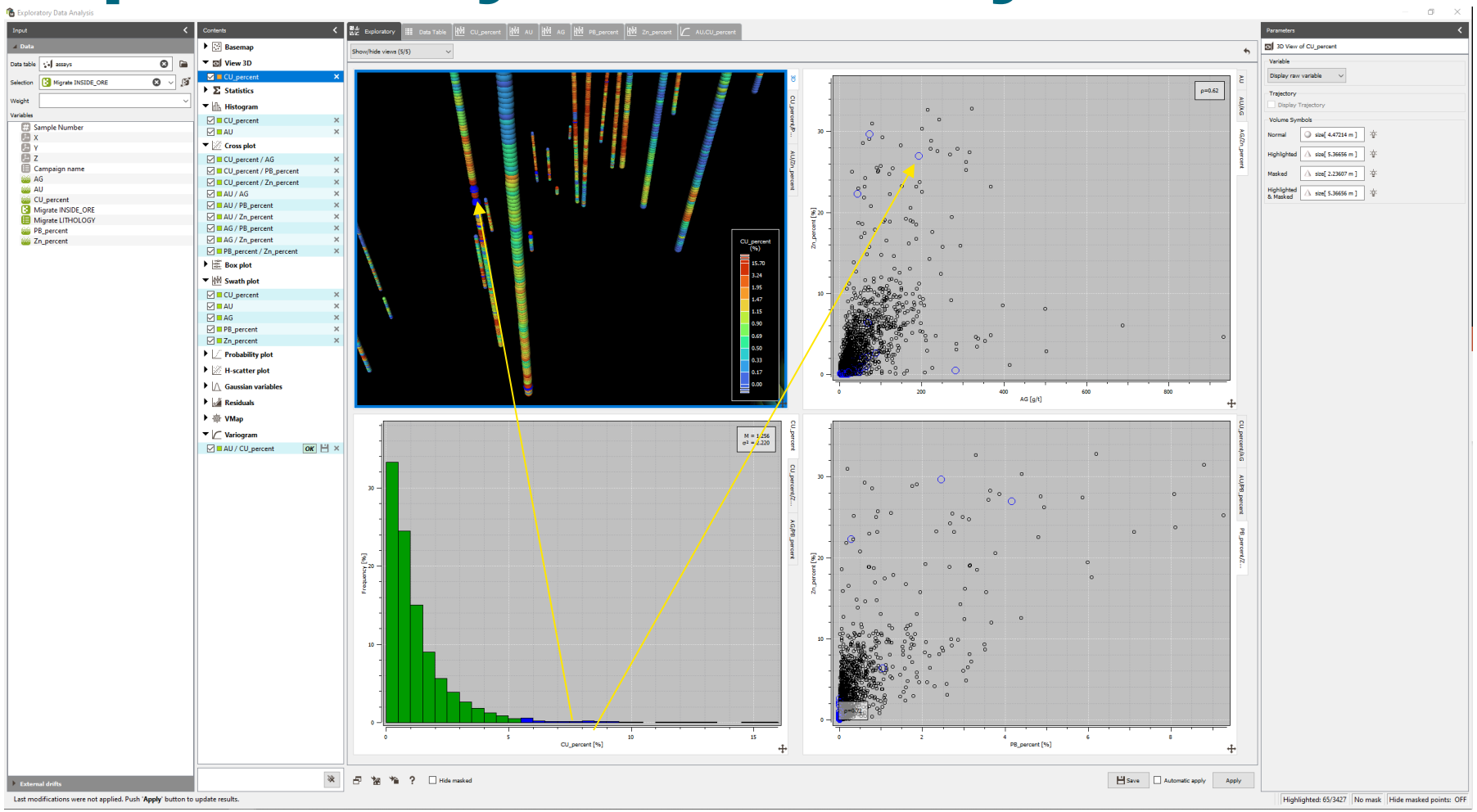


Exploratory data analysis

Data can be selected, and then highlighted in other graphs or masked (Right click → mask highlighted points)



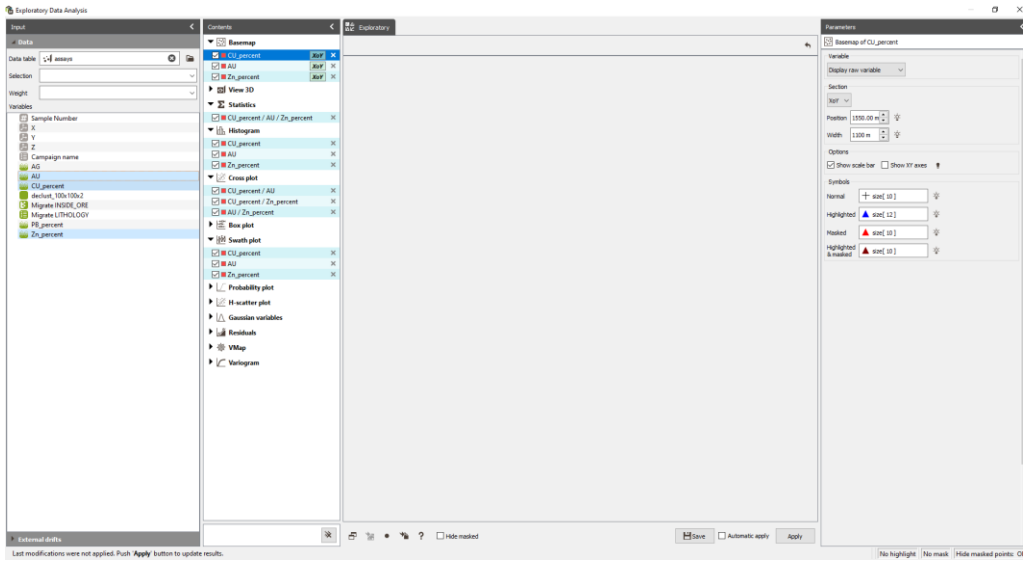
Exploratory data analysis



Exploratory data analysis

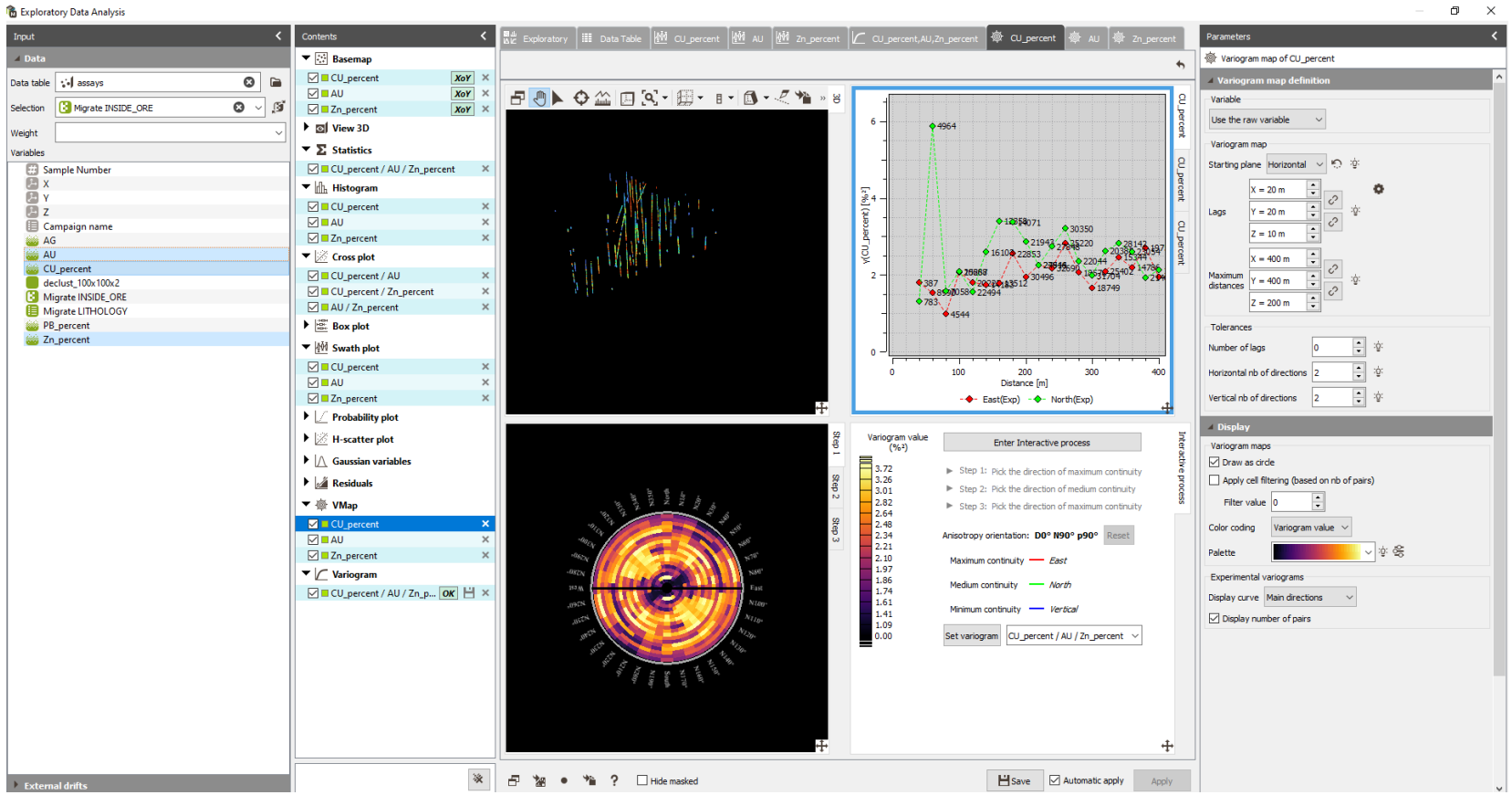
First, realise a kriging of the Cu and then, choose only 3 variables to do the co-kriging (Cu + 2 other between Ag, Au, Pb and Zn)

Check the statistics and the stationarity for the choosen variables (Menu statistics → Exploratory data analysis ou EDA)



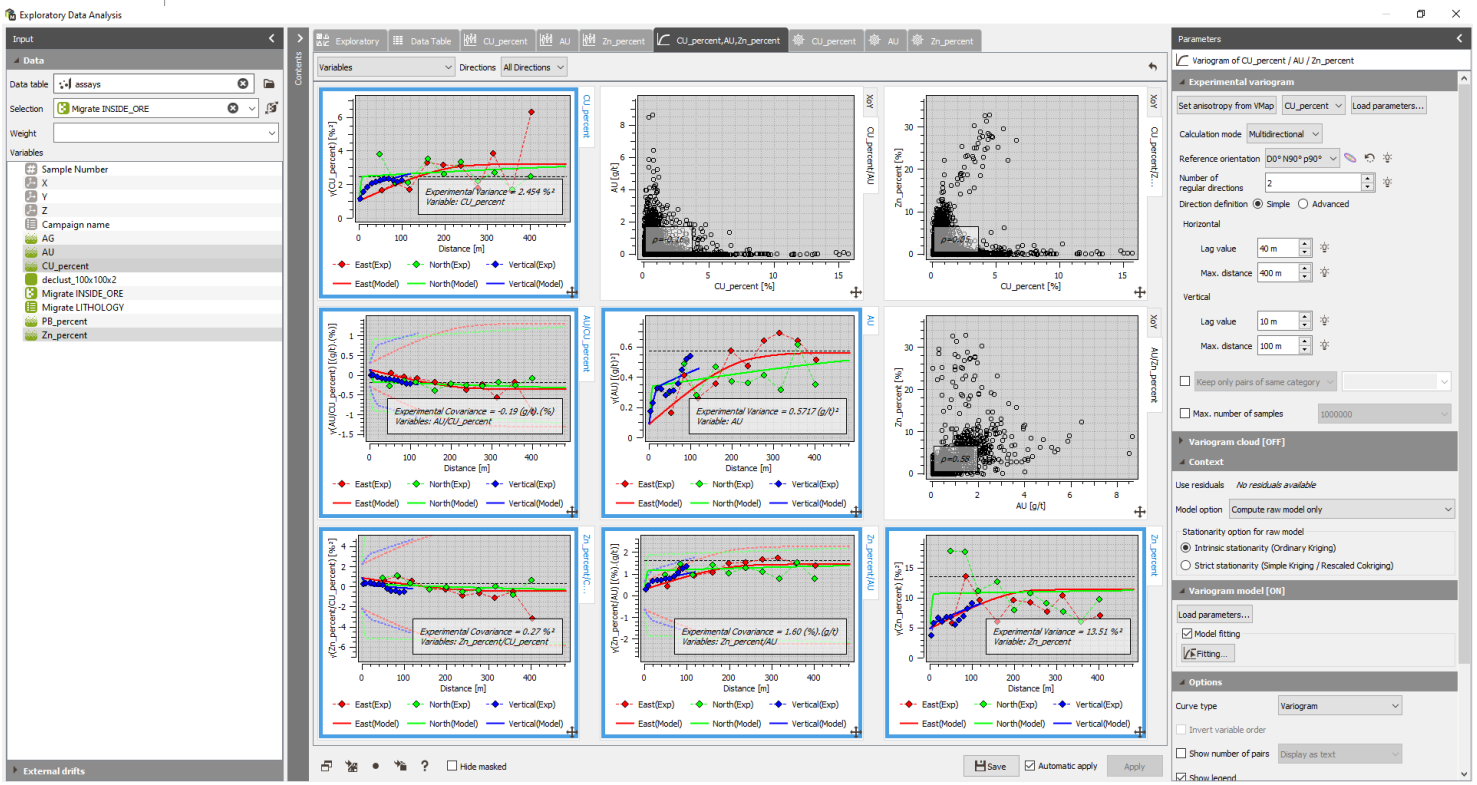
Exploratory data analysis

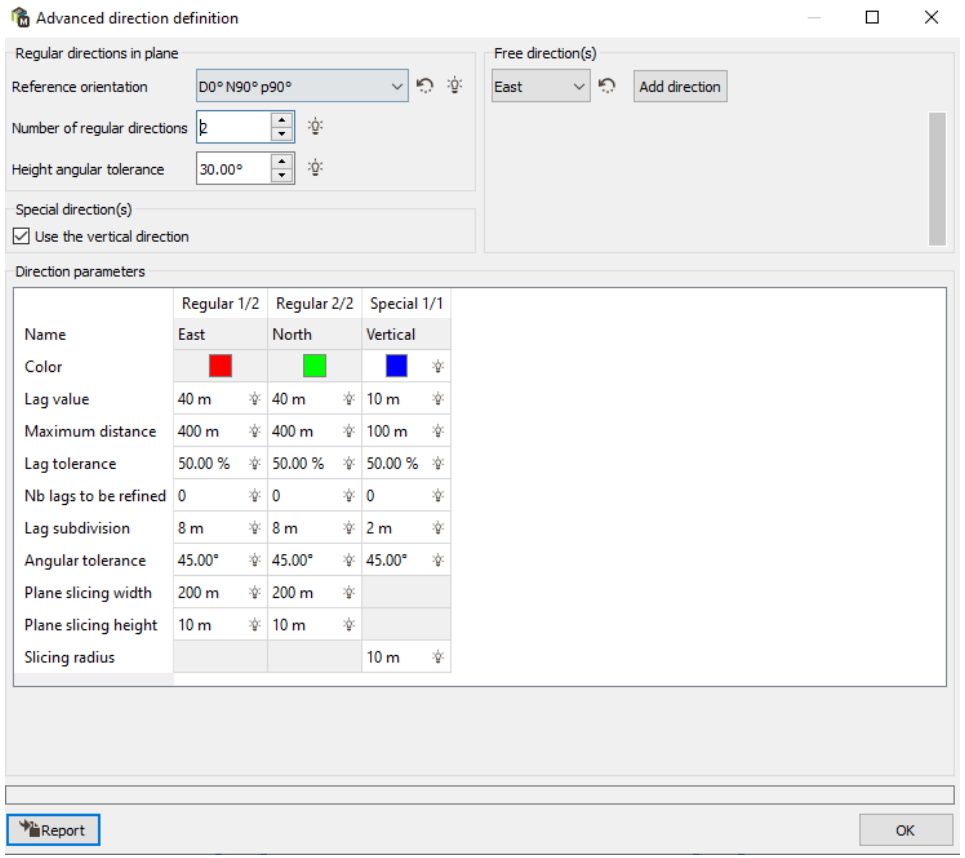
When the domain has been choosen, look at the experimental variogram and co variogram, you can look at the variogram map to see if you observe an anisotropy. *Do you see an anisotropy?*



Exploratory data analysis

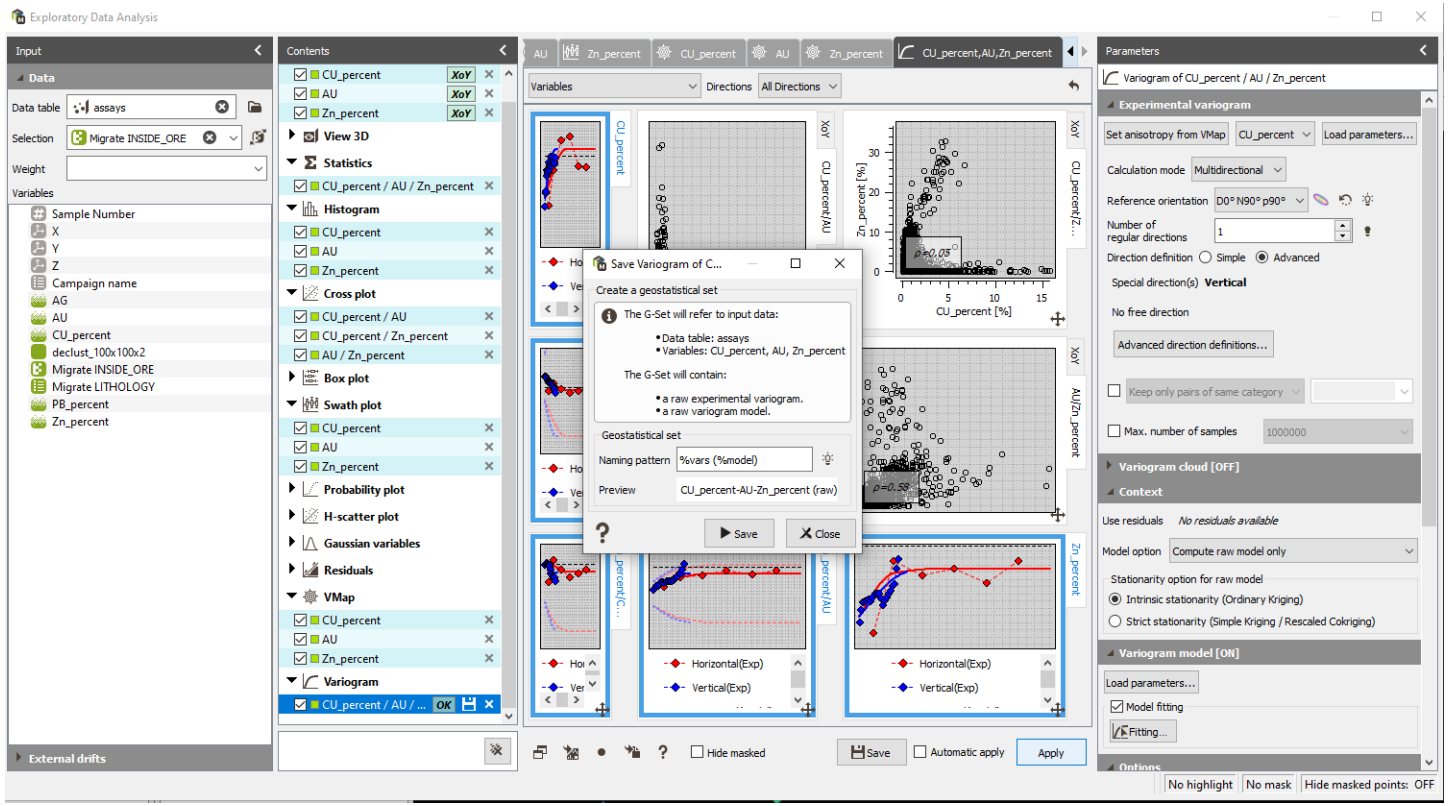
Then go to the variogram to model it : you first have to review the experimental variogram parameters. Two modes for the direction definition: simple or advanced





Exploratory data analysis

When the variogram fitting seems OK, remember to save the geostatistical set

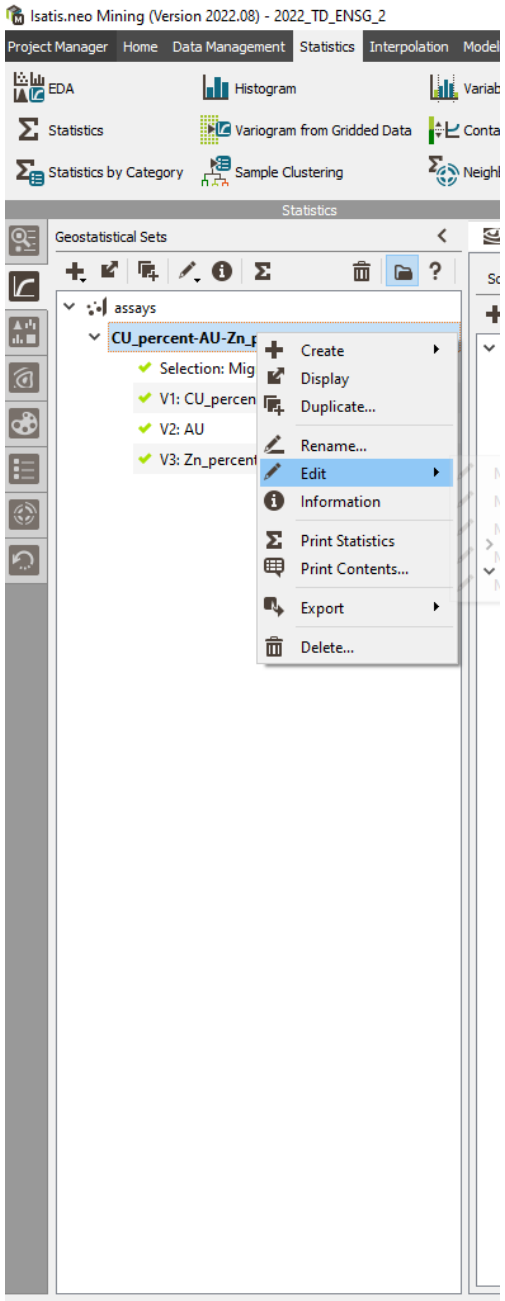


Geostatistical set

The geostatistical set is saved and

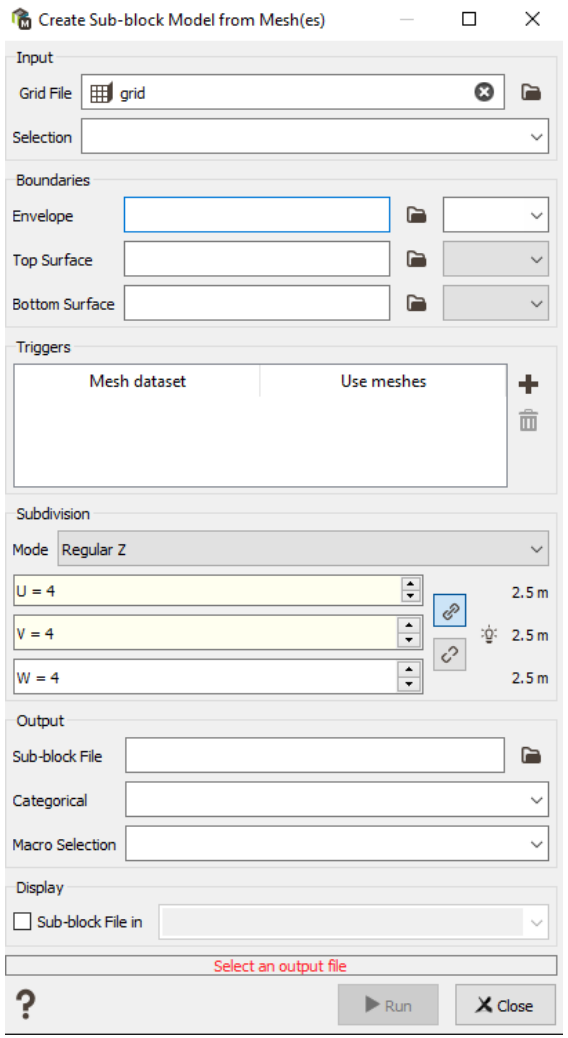
can be reviewed any time (right click)

It will be used for the co kriging



Another way

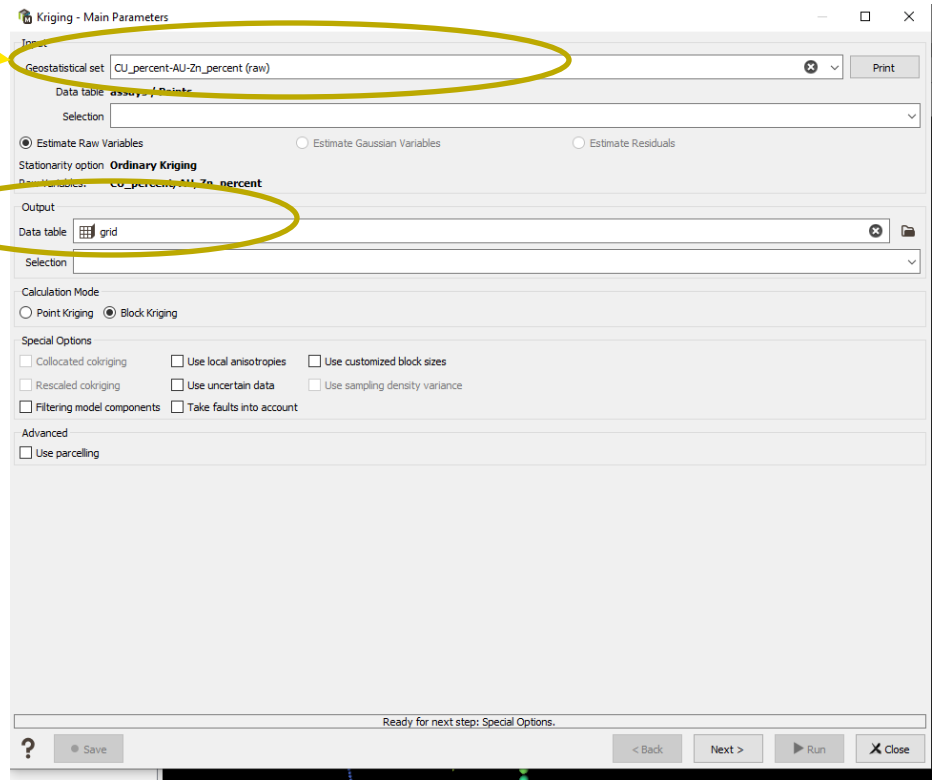
Create a sub block model



Kriging

In interpolation → kriging

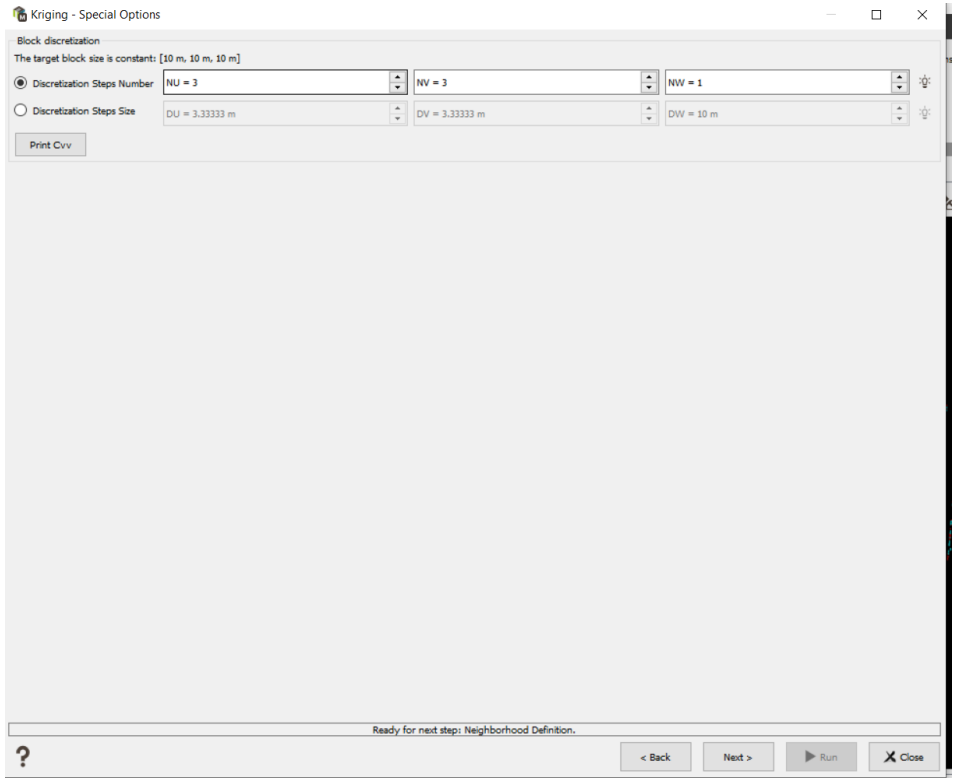
Choose your geoset and your grid. Make sure the selections are coherent. We will do a block kriging



Kriging

Use several discretisation points = block kriging

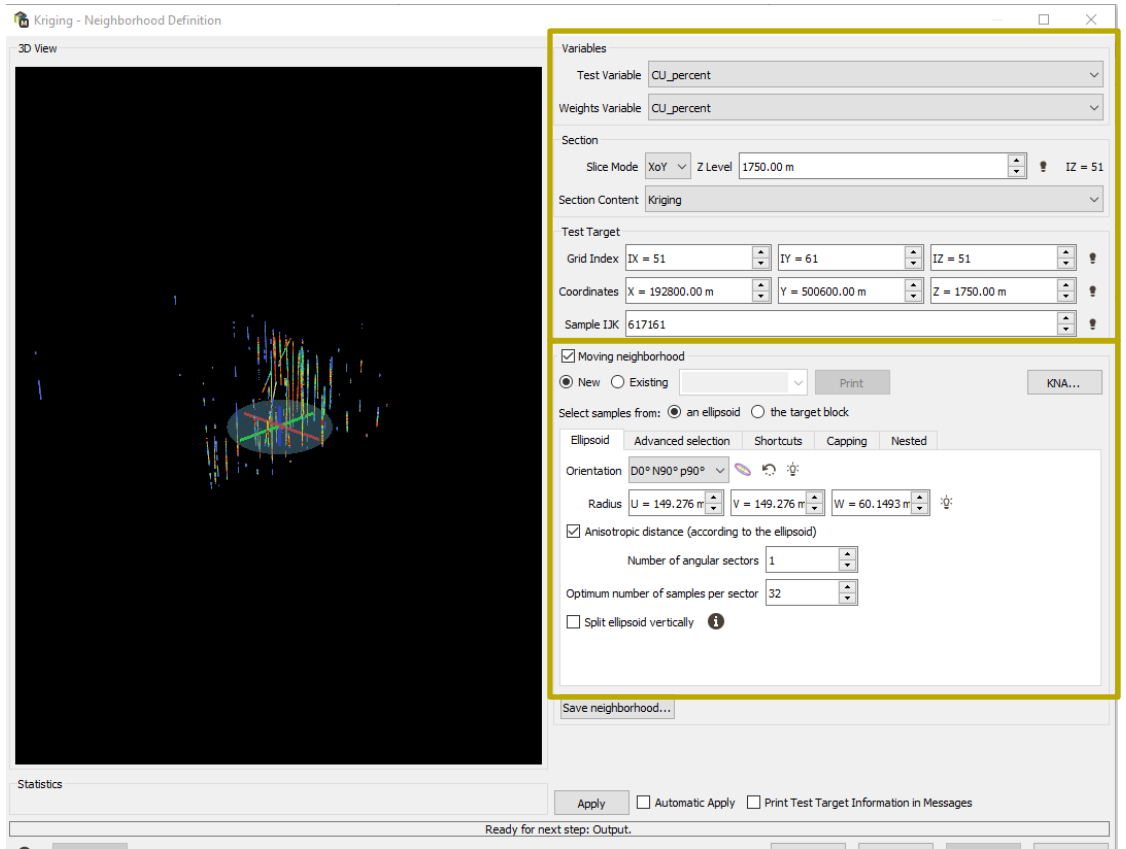
Can be justified by the Cvv



Kriging

Check the discretization (equal or more points than 3 over X, Y and Z, can be verified via the CVV)

Neighborhood definition: check all the sheets. *Quick justification of your choices*

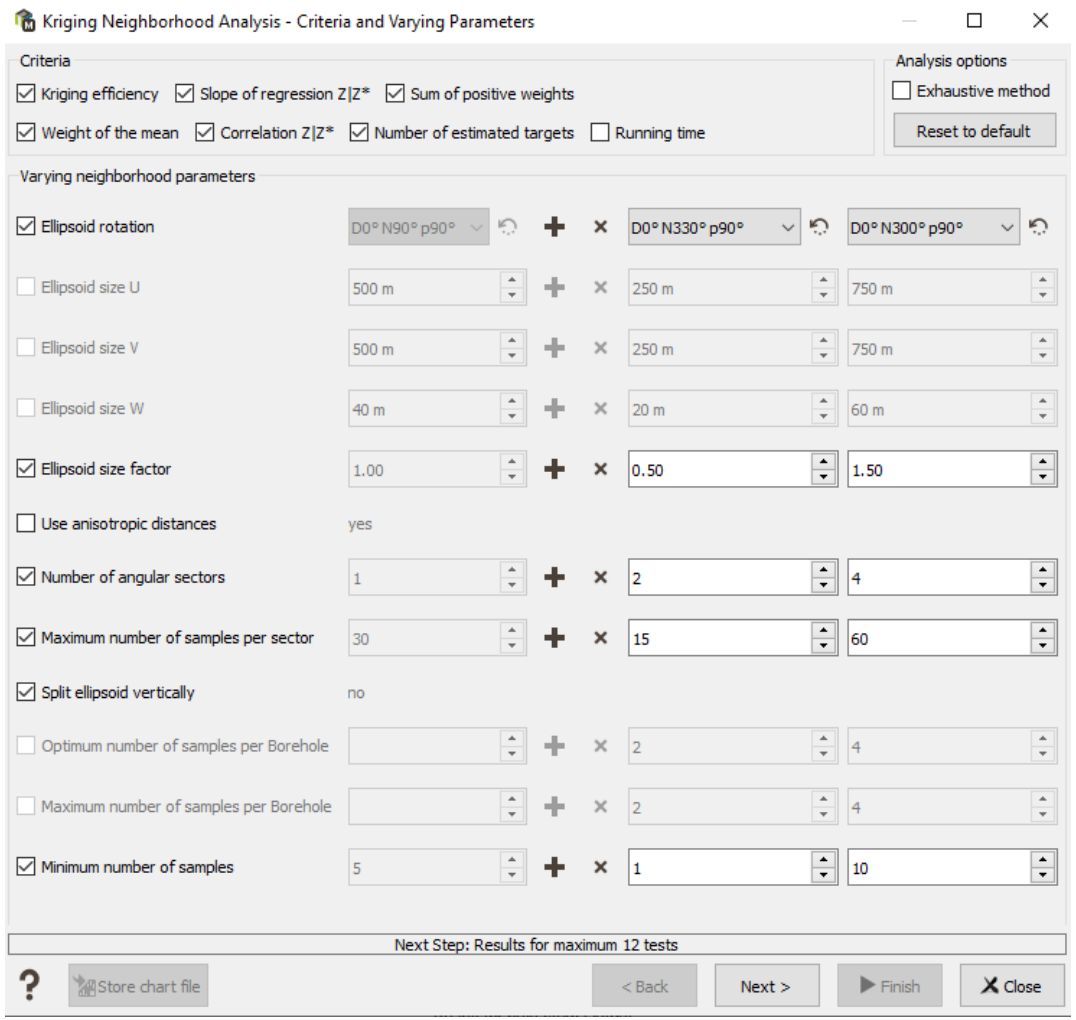


Test target parameters: for the the 3D view display

Neighborhood parameters

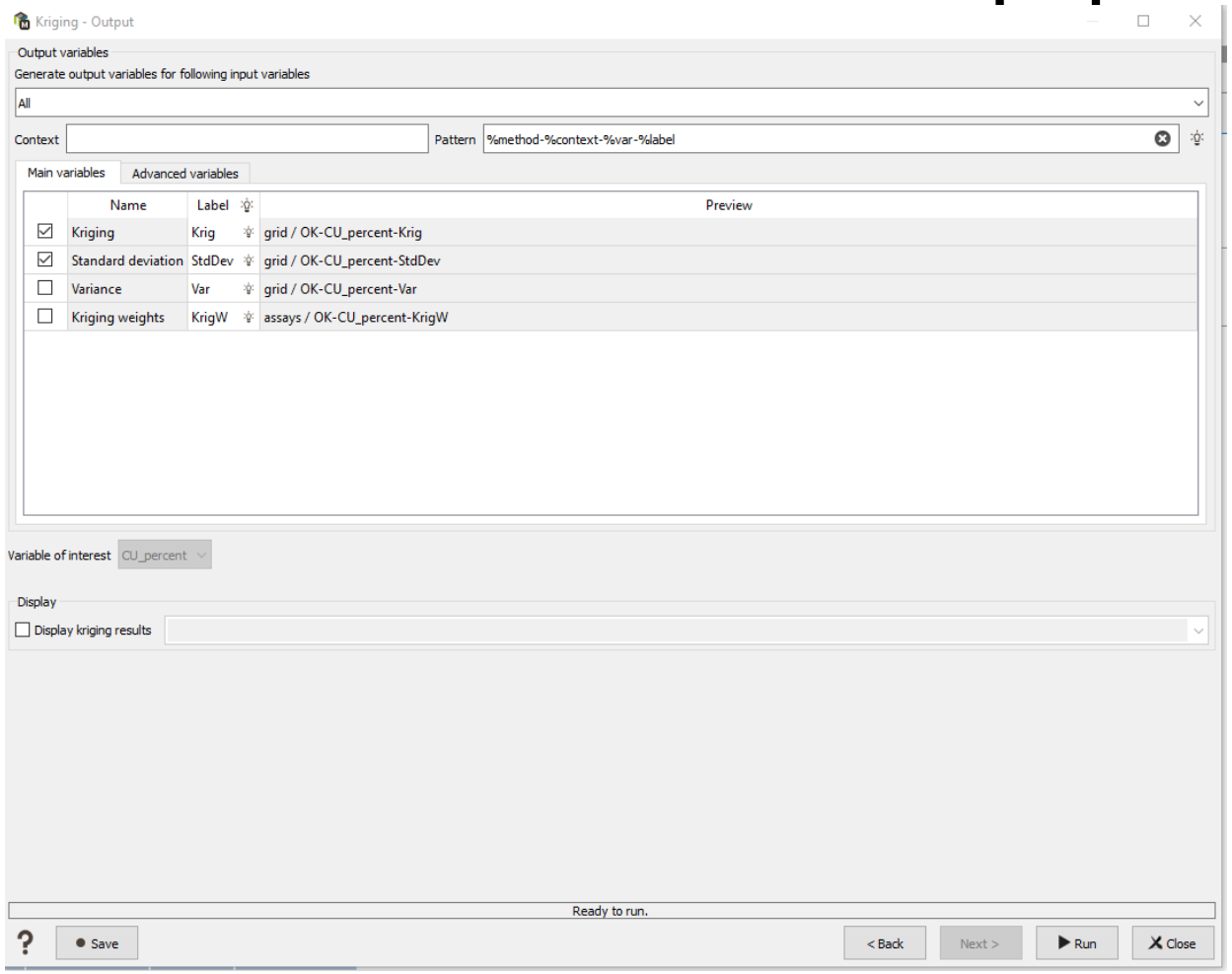
Kriging

Neighborhood parameters



Kriging

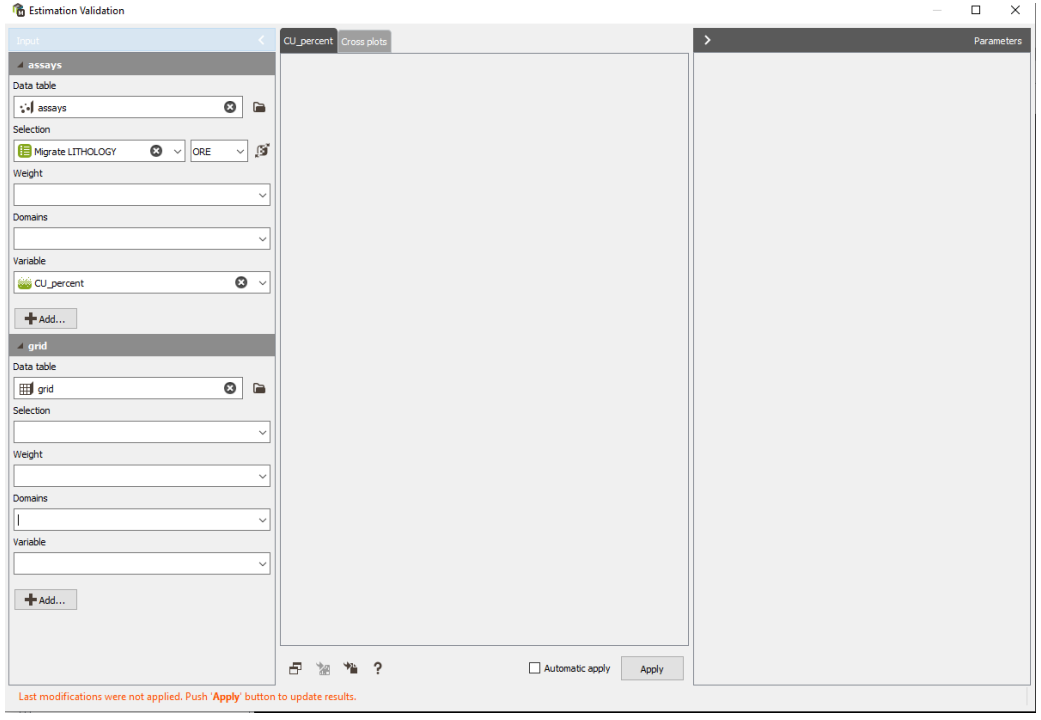
Save at least the standard variables for the kriging. You can look at some additionnal variables for validation purpose (advanced variables)



Kriging validation

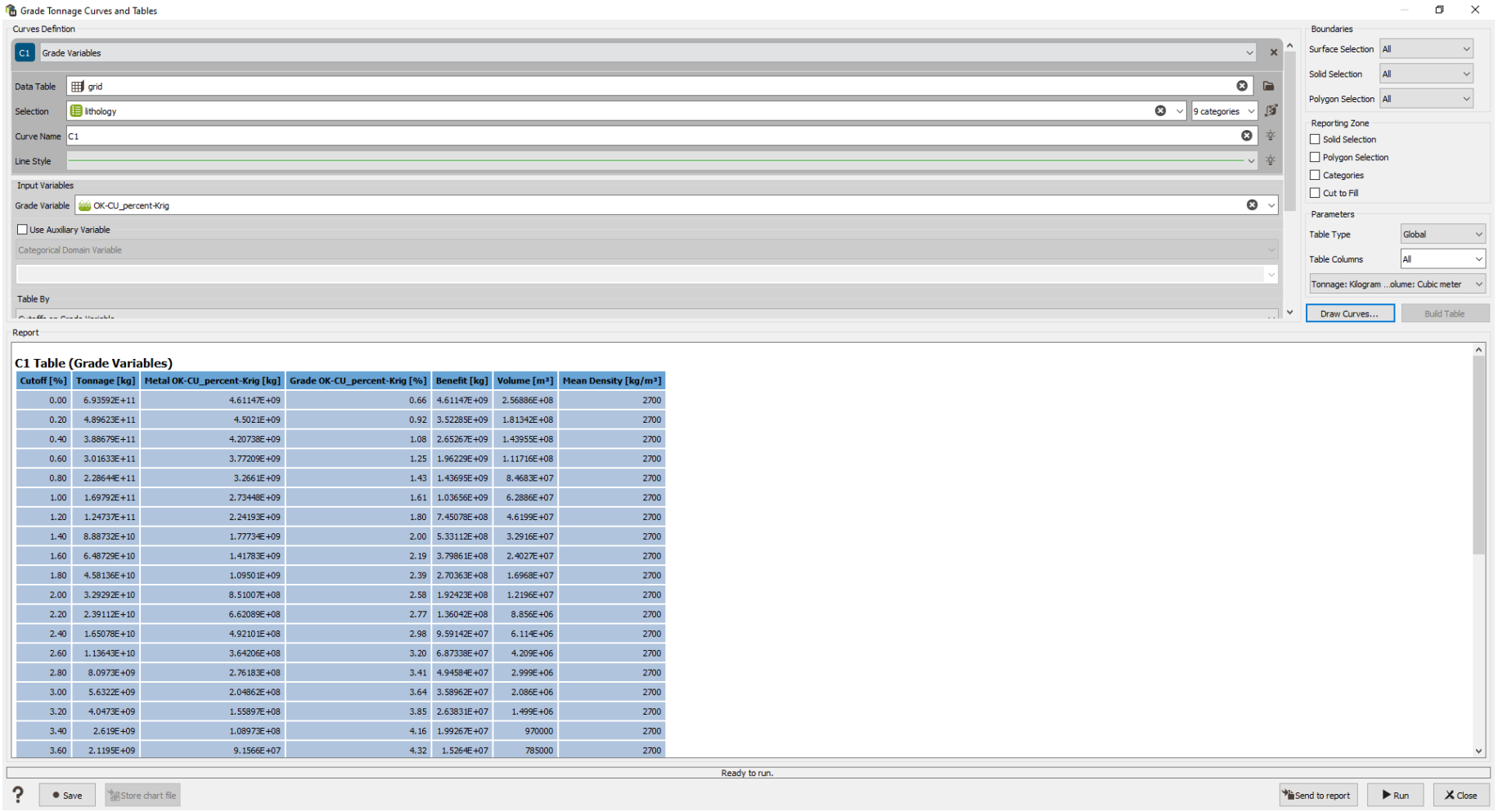
In Interpolation → estimation validation

Look at the statistics and the swath plots to see if the estimation seems OK. You can also do cross sections in the 3D view. It's also possible to run a quick inverse distance and nearest Neighbors estimation as a validation.



Grade tonnage curve

In interpolation → Grade tonnage curve and table



Cutoff [%]	Tonnage [kg]	Metal OK-CU_percent-Krig [kg]	Grade OK-CU_percent-Krig [%]	Benefit [kg]	Volume [m³]	Mean Density [kg/m³]
0.00	6.93592E+11	4.61147E+09	0.66	4.61147E+09	2.56886E+08	2700
0.20	4.89623E+11	4.5021E+09	0.92	3.52285E+09	1.81342E+08	2700
0.40	3.88679E+11	4.20738E+09	1.08	2.65267E+09	1.43955E+08	2700
0.60	3.01633E+11	3.77209E+09	1.25	1.96229E+09	1.11716E+08	2700
0.80	2.28644E+11	3.2661E+09	1.43	1.43695E+09	8.4683E+07	2700
1.00	1.69792E+11	2.73448E+09	1.61	1.03656E+09	6.2886E+07	2700
1.20	1.24737E+11	2.24193E+09	1.80	7.45078E+08	4.6199E+07	2700
1.40	8.88732E+10	1.77734E+09	2.00	5.33112E+08	3.2916E+07	2700
1.60	6.48729E+10	1.41783E+09	2.19	3.79861E+08	2.4027E+07	2700
1.80	4.58136E+10	1.09501E+09	2.39	2.70363E+08	1.6968E+07	2700
2.00	3.29292E+10	8.51007E+08	2.58	1.92423E+08	1.2196E+07	2700
2.20	2.39112E+10	6.62089E+08	2.77	1.36042E+08	8.856E+06	2700
2.40	1.65078E+10	4.92101E+08	2.98	9.59142E+07	6.114E+06	2700
2.60	1.13643E+10	3.64206E+08	3.20	6.87338E+07	4.209E+06	2700
2.80	8.0973E+09	2.76183E+08	3.41	4.94584E+07	2.999E+06	2700
3.00	5.6322E+09	2.04862E+08	3.64	3.58962E+07	2.086E+06	2700
3.20	4.0473E+09	1.55897E+08	3.85	2.63831E+07	1.499E+06	2700
3.40	2.619E+09	1.08973E+08	4.16	1.99267E+07	970000	2700
3.60	2.1195E+09	9.1566E+07	4.32	1.5264E+07	785000	2700

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Giving nuclear energy its full value