KRIG2D

V0.1

1.0 INTRODUCTION

KRIG2D is a simple quick estimation application for mineral, namely Gold (Au), Copper (Cu), and Silver (Ag) concentrations. It utilizes Ordinary Kriging (OK) in 2D and variogram modeling with option for isotropic and anisotropic (directional) cases. Good estimations can be obtained by following proper estimation practice in addition to the following:

- appropriate sampling undertaken in the project (preferably 100 to 700 samples)
- proper understanding of the deposit size/shape (3D model may be required),
- spatial continuity of mineralization is preferable; however, isolated ore bodies/deposits can be estimated separately. In the same manner, large deposits may be sliced and estimated on a layer-by-layer basis considering kriging in 2D.
- careful and proper preparation and formatting of the input data (excel or csv files).

2.0 INPUT DATA

Understanding of the mineral concentration area (deposit) and proper sampling is key to getting the best results. The following schematic (Figure 1) illustrates an example of a sampled deposit which can be estimated for contained minerals using KRIG2D.

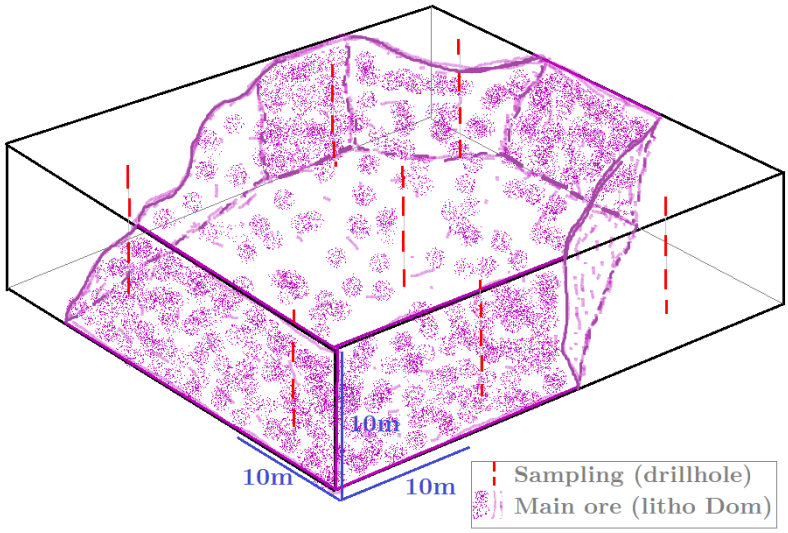

Figure 1. A schematic slice of a deposit prepared for estimation using KRIG2D. Note that ideally there should be 100 to 700 samples for use in estimation.

The minimum data required are as follows:

- x, y and z coordinates (in easting, northing and RL). If RL is not given, you can put in some synthetic values as long as you know the correct location.
- at least one mineral of interest; either Gold (Au), Copper (Cu) or Silver (Ag) with its grade on **gram/ton (for Au or Ag)** or **percentage (for Cu).**
- density of the ore, that is the host-rock (litho_dom). Density should be in **gram/cm^3**.
- Ore or lithology type (litho_dom). Allocate a number to each of the lithology or ore type that hosts your mineral. For example, if your deposit is in mudstone and basalt, you can allocate two numbers (e.g. 8 and 5) to each of these rock units.
- Thickness of the deposit layer (in meters). Note that in the sample data in Figure 2, the thickness is labeled as '**depth**', so you should label it in the same way.

The data should be prepared in an excel or csv file in one sheet (without any other sheets or data), strictly in the format as shown in Figure 2. Note that the column headings should be labeled as shown in Figure 2.

	A	B	C	D	E	F	G	H
1	**x**	**y**	**z**	**au**	**cu**	**density**	**litho_dom**	**depth**
2	615513.1	724003.15	1595.74	0.62	0.81	2.8	8	17
3	615506.46	724006.21	1596.05	0.54	0.53	2.8	8	17
4	615500.08	724002.79	1596.2	0.68	0.77	2.8	8	17
5	615499.3	724008.99	1596.09	0.59	0.8	2.8	8	17

Figure 2. Sample prepared data in excel file for importing in KRIG2D. Note that the column naming conventions should be as shown here.

3.0 WORKING WITH THE USER INTERFACE

KRIG2D has a FILE menu for importing excel or csv data and 5 tabs: (1) MAIN INPUT, (2) PREPROCESS, (3) KRIGING, (4) ESTIMATION, and (5) REPORT.

3.1 Main Input

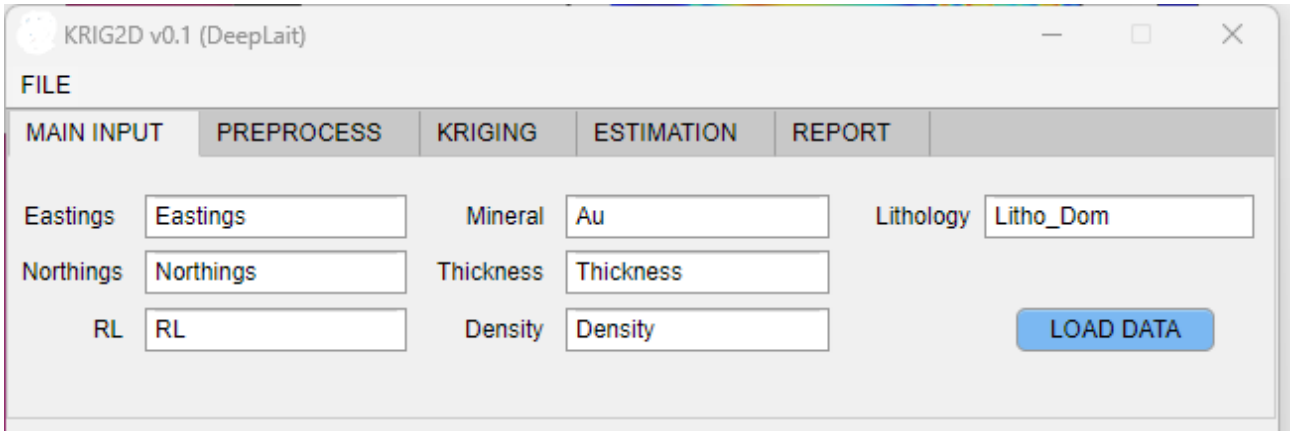

Figure 3. The MAIN INPUT tab.

Input data can be imported using the “FILE” menu. Note that you will rename the input parameters strictly as shown MAIN INPUT in Figure 3, i.e.

- enter **Eastings** in Eastings entry space,
- enter **Northings** in Northings entry space,
- enter **RL** in RL entry space,
- enter **Au** (Cu, or Ag) in Mineral entry space,
- enter **Thickness** in Thickness entry space,
- enter **Density** in Density entry space,
- enter **Litho_Dom** in Lithology entry space.

Check to ensure that there is no spelling error or no unnecessary characters like space-bar are included in the naming. Once satisfied, click LOAD DATA and a figure will be generated. The figure will be a plot of your data on the x-y coordinate.

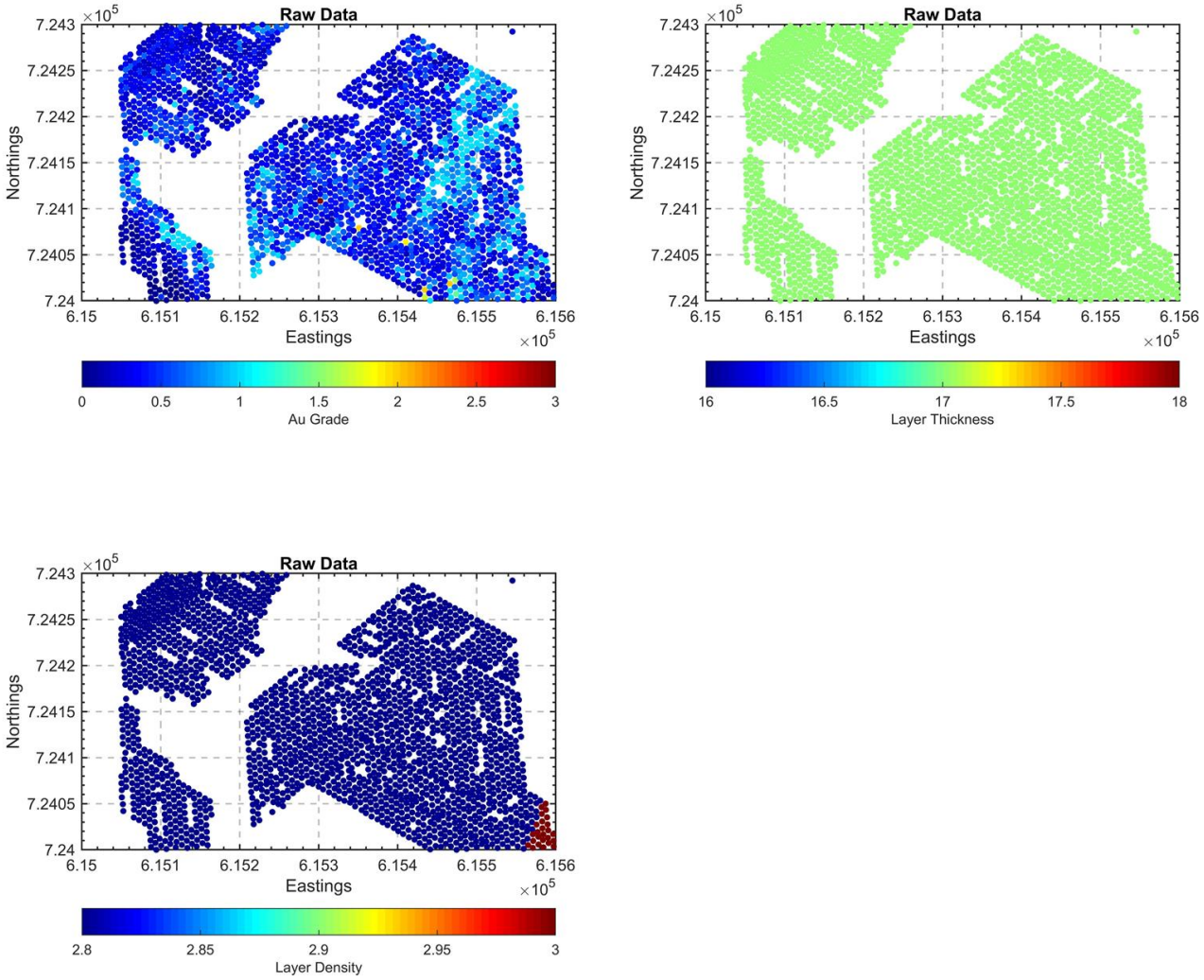

Figure 4. A sample of the plot that will be generate once you click LOAD DATA. Note that you can figure out any outlier values here and consider setting cut-offs in the next step.

3.2 Preprocess

Move to PREPROCESS tab once you have loaded the data in MAIN INPUT tab. PREPROCESS tab is mainly for entering cut-off values and setting the grid resolution.

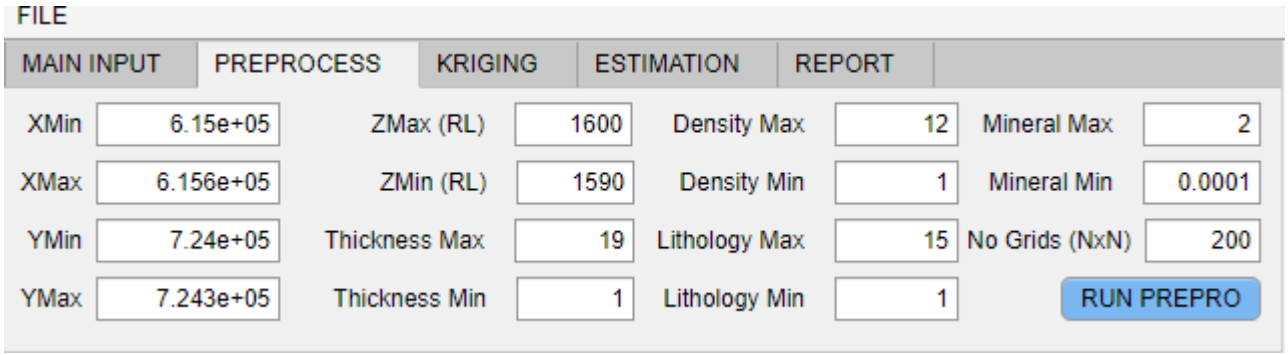

Figure 5. The PREPROCESS tab with sample cut-off (limit) values and a grid resolution.

- **XMin** & **XMax:** enter desired project limit (minimum and maximum Easting values)
- **YMin** & **XMax:** enter desired project limit (minimum and maximum Northing values)

- **Zmax** & **Zmin**: enter desired project limit (minimum and maximum RL values)
- **Thickness Max** & **Thickness Min:** Set minimum and maximum values for your thickness layer (meters).
- **Density Max** & **Density Min:** Set minimum and maximum values for the Density values (in grams per cubic centimeter).
- **Mineral Max** & **Mineral Min:** Set minimum and maximum values for the mineral grades (gram per tonne for Au or Ag and percent (%) for Cu).
- **No Grids (NxN)**: set grid resolution. If you want your estimation area (domain) to be divided into 10-by-10 (total of 100 blocks), then you can enter just 10.

Check to ensure that there is no spelling error or no unnecessary characters like space-bar are included in the naming. Once satisfied, click RUN PREPRO and a figure similar to the previous one (Figure 4) will be generated, but now with the cut-offs applied.

3.3 Kriging

Move to KRIGING tab once done with PREPROCESS. Here, variogram and kriging parameters need to be put in.

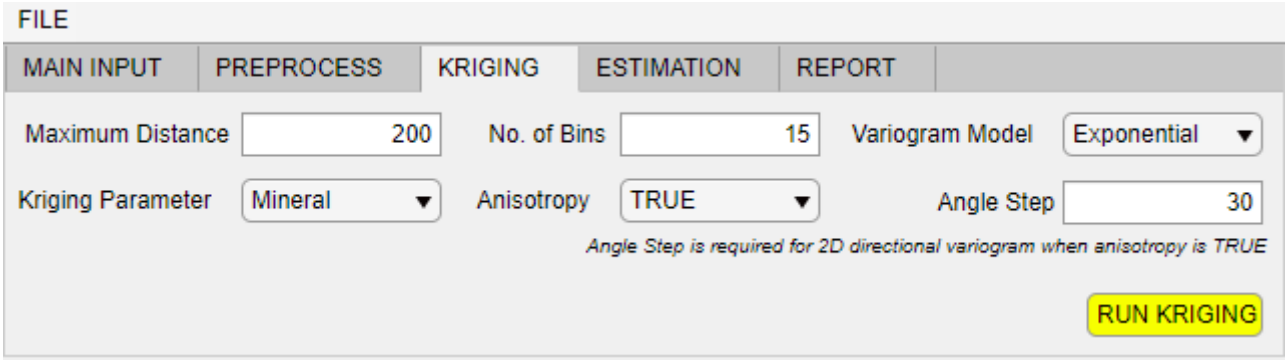

Figure 6. The KRIGING tab.

- enter maximum distance for variogram calculation in the **Maximum Distance** space
- enter number of bins the distance should be grouped into in **No. of Bins** space
- select a theoretical variogram model in the **Variogram Model** drop-down list. The list includes spherical, exponential, gaussian, circular, stable and bi-linear. You can check which model works depending on your dataset.
- Select the **Kriging Parameter** in the drop down list. These include mineral, thickness, density, etc.
- Select TRUE in **Anisotropy** if you want your variogram model to calculate different variograms in different directions in 2D, and FALSE if direction doesn't matter. This can be useful if spatial distribution of mineralisation favor certain directions.
- If you select TRUE in the Anisotropy list, then you need to set the **Angle Step** (in degrees)**.** For instance, if you enter 30, directional variograms will be calculated every 30 degrees from the west to east.

Once satisfied, click RUN KRIGING. Experimental (semi-) variograms will be constructed and fitted to the selected theoretical variogram model. *Note that you will repeat the kriging process for each and all of the kriging parameters in the Kriging Parameter drop down list.*

Figures (variogram plots) will be generated once kriging is complete. If a parameter has one (same) value for all the samples (e.g. one thickness value for all samples), then that same value will be allocated for all grid blocks (no kriging) when you click RUN KRIGING; and no figures will be generated. You need to wait a few seconds before kriging the next parameter.

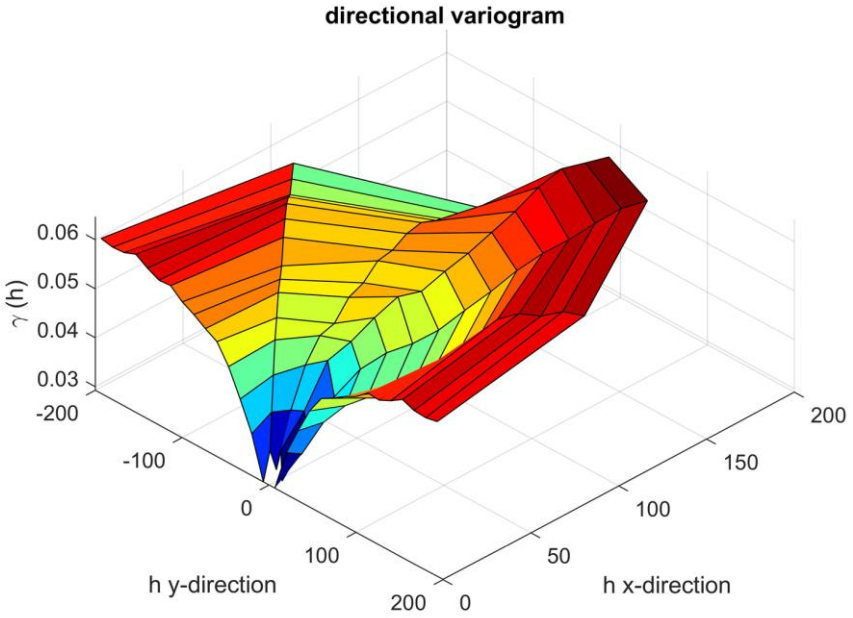

Figure 7. Sample plot of directional variograms calculated when Anisotropy is TRUE (Angle Step 30 and No. of Bins 15).

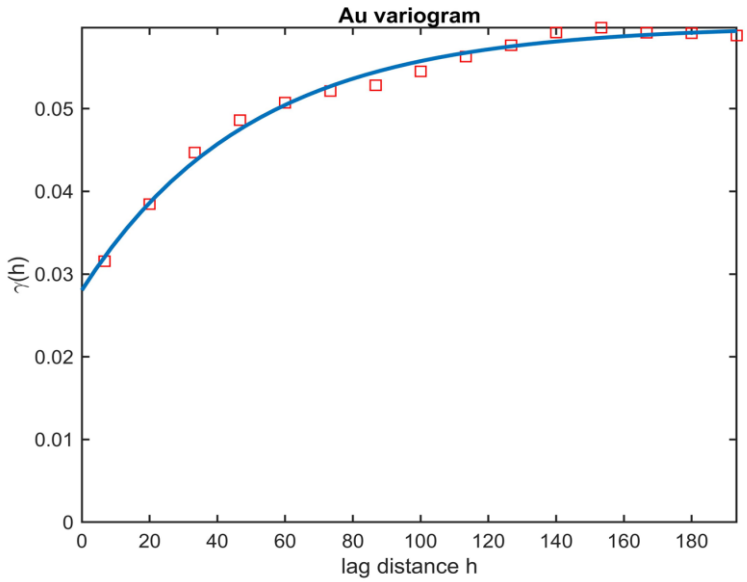

Figure 8. Sample of fitted Exponential variogram model.

3.4 Estimation

After kriging each and all parameters, move to ESTIMATION tab.

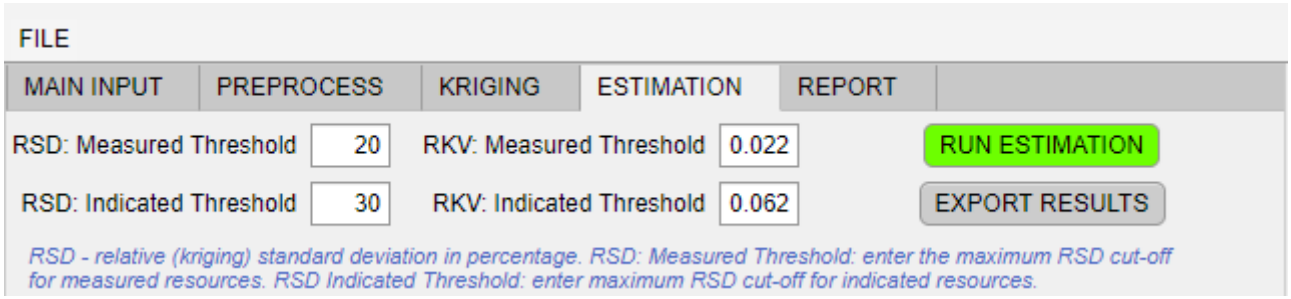

Figure 9. Estimation tab with cut-off input spaces for relative (kriging) standard deviation (RSD) and relative kriging variance (RKV).

Once the RUN ESTIMATION button is clicked, a quick estimation is performed for all blocks and a crude classification based on RSD (percent) is made. The RKV values are also computed and all these values are exported in excel to guide interpretation.

- enter top RSD percantage cut-off for “measured” category in **RSD: Measured Threshold** space
- enter top RSD percantage cut-off for “indicated” category in **RSD: Indicated Threshold** space.
- You can also enter RKV thresholds in the same manner; but note that classification is based on RSD. RKV values are in decimals.

Once threshold values are set, RUN ESTIMATION. Several figures will be generated including the following.

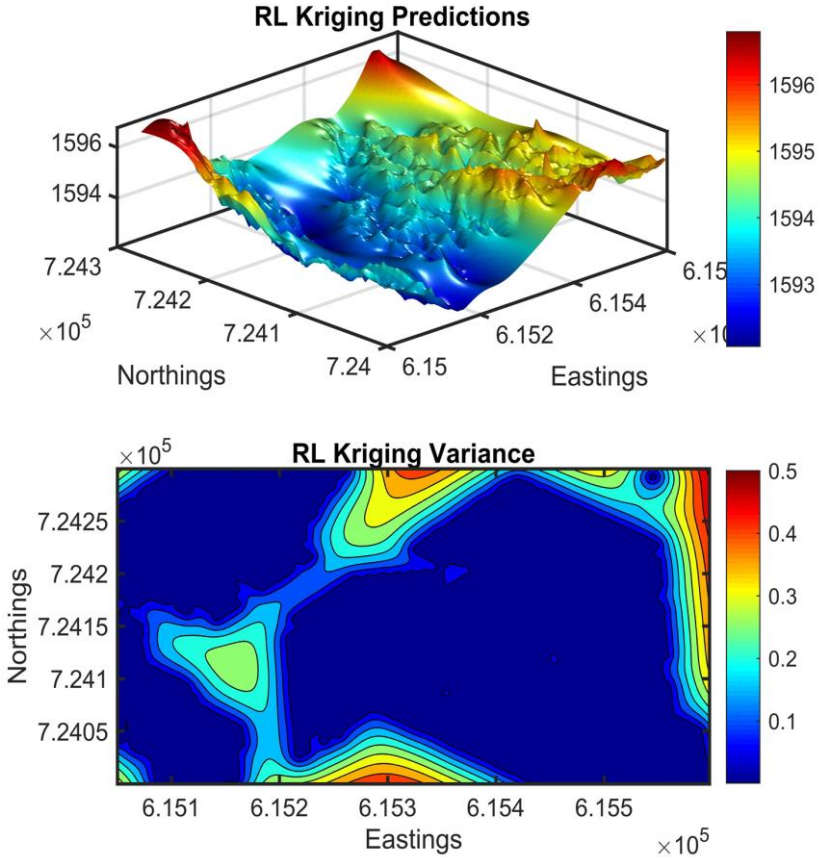

Figure 10. Sample kriged parameter (RL) along with kriging variance (KV).

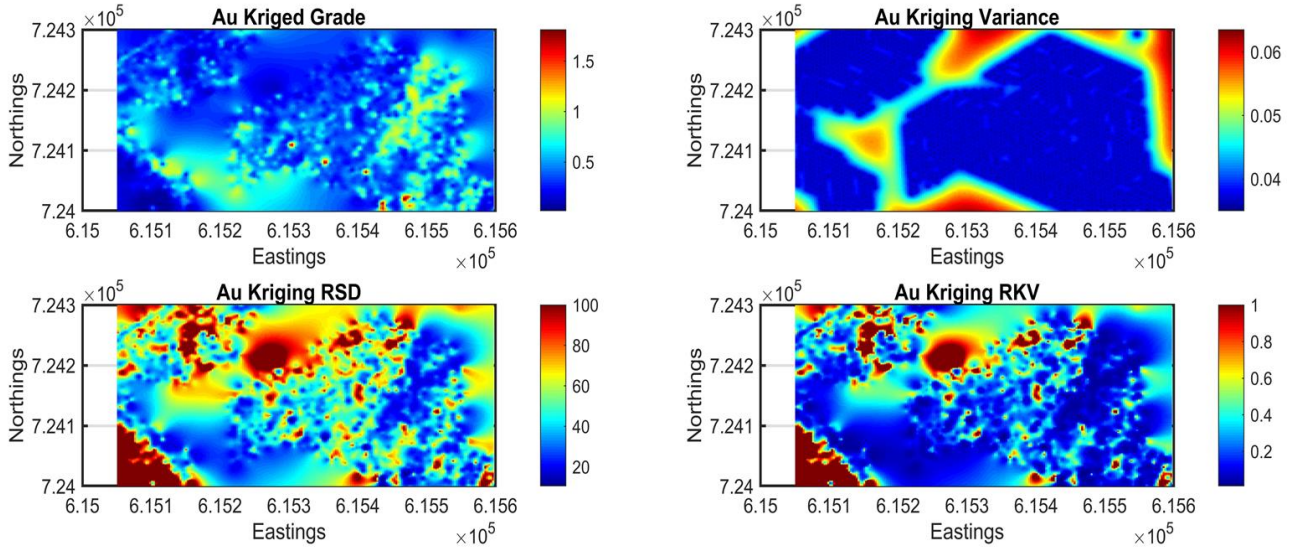

Figure 11. Sample Au kriged grades, kriging variance, RSD and RKV plots. Note that the grid resolution (200-by-200) was high so individual blocks are not clear here.

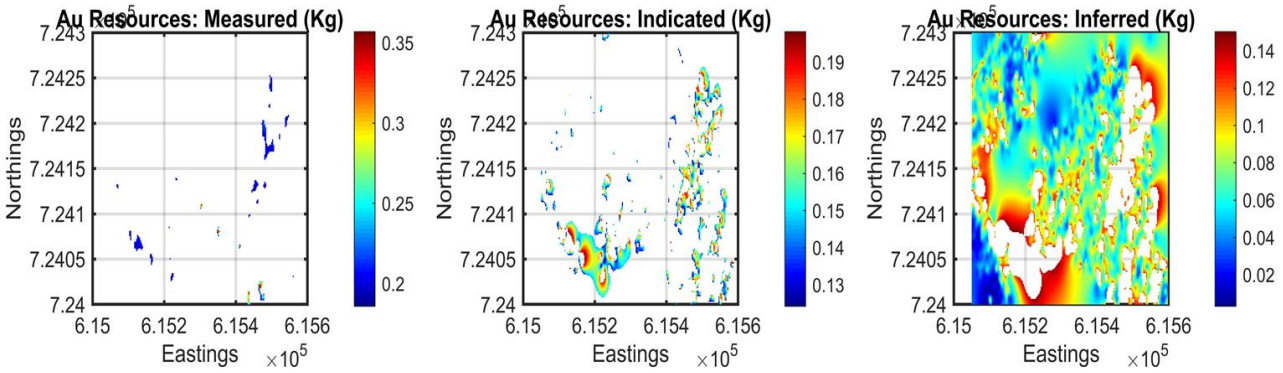

Figure 12. Sample plot of classified resource based on RSD with RSD cut-off 20% for measured and 30% for indicated.

After running estimation, you can click EXPORT RESULTS button to export the results in excel file. This excel file will be as shown in Figure 13 below:

	A	B	C	D	E	F	G	H	I	J	K
1	Block_No	X	Y	Z	Mass_Tonnes	Au_Grade	Contained_Au_Kg	KV	RSD	RKV	Category
2	1	615050.12	724000.01	1593.8	197.365427	0.184163	0.036347497337	0.0567	129.28	1.671	Inferred
3	2	615050.12	724001.516	1593.8	197.3580482	0.182315	0.035981263372	0.0563	130.18	1.695	Inferred
4	3	615050.12	724003.022	1593.8	197.3507789	0.180594	0.035640333529	0.056	130.99	1.716	Inferred
5	4	615050.12	724004.527	1593.8	197.3436172	0.179	0.035324423354	0.0556	131.71	1.735	Inferred
6	5	615050.12	724006.033	1593.8	197.3365604	0.177529	0.035033016787	0.0552	132.33	1.751	Inferred
7	6	615050.12	724007.539	1593.8	197.3296052	0.176179	0.034765368041	0.0548	132.85	1.765	Inferred
8	7	615050.12	724009.045	1593.8	197.3227478	0.174944	0.034520509681	0.0544	133.26	1.776	Inferred
9	8	615050.12	724010.551	1593.8	197.3159836	0.173819	0.034297269412	0.0539	133.58	1.784	Inferred

Figure 13. Sample spreadsheet of exported results, which includes Block No, block coordinates, resource (tonnes), grade, contained kilograms, KV, RSD, RKV and resource category..

3.5 Report

This tab is for generating a summary report. Here you can enter your's and project's details and click generate report.

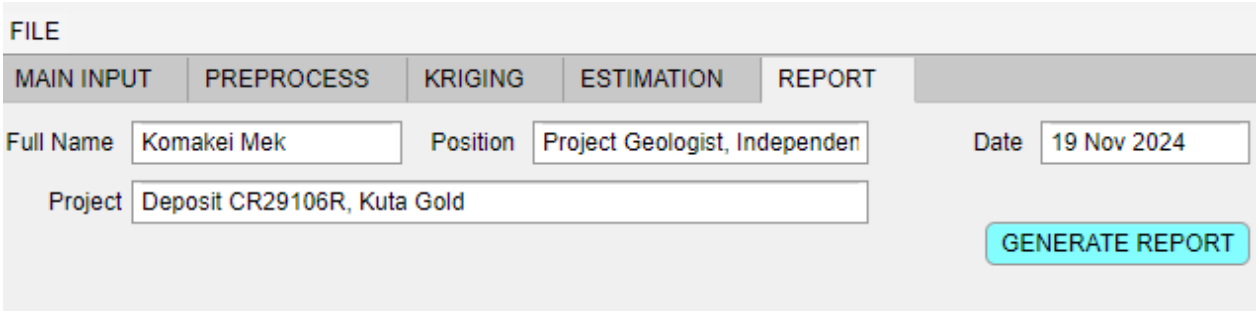

Figure 14. REPORT tab for generating summary report.

A PDF report will be generated as shown in Figure 15.

Report: Deposit CR29106R, Kuta Gold

Reported By: Komakei Mek
Position: Project Geologist, Independent Consultant

Date: 19-Nov-2024

Based on the provided inputs, computed block parameters used in the estimation include a total of blocks: 40000 blocks, length per block: 1.51 meters, width per block: 2.75 meters, and average thickness per block: 17 meters. Grids are uniform throughout.

The quick estimation indicates that Deposit CR29106R, Kuta Gold has a total of 125122.26 ounces (Oz) of Au, hosted in 7894557.58 tonnes of material, ~2816569.42 cubic meters in volume. Resource classification is based on relative kriging standard deviation (RSD) along with relative kriging variance (RKV), which are summarised below:

Resource	KiloTons	AuGrade	ContainedAuOz	RSDpct	RKV
Measured	312	0.95	10470.204	18.293	0.034
Indicated	1302.735	0.717	32926.952	25.382	0.065
Inferred	6279.51	0.369	81725.099	58.994	0.479

Exported Results:
The exported excel file has collumns that include Block Number (1 to 40000) and respective Coordinates, Au Grade, and tonnage, KV, RSD, RKV, and resource category details.

This report should only be used as supplementary results to expert interpretation.

Signed:

Figure 15. Sample summary report generated in PDF.

Summary of overall steps

- *Step 1: Prepare data and import (FILE menu),*
- *Step 2: Enter parameter names correctly (MAIN INPUT tab)*
- *Step 3. Click LOAD DATA (MAIN INPUT tab)*
- *Step 4. Enter project limits, cut-offs and grid resolution (PREPROCESS tab)*
- *Step 5. Click RUN PREPRO (PREPROCESS tab)*
- *Step 6. Enter Kriging and Variogram parameters (KRIGING Tab)*
- *Step 7. Click RUN KRIGING. (KRIGING Tab)*
- *Step 8. Enter classification cut-offs (RSD and RKV) (ESTIMATION Tab)*
- *Step 9. Click RUN ESTIMATION (ESTIMATION tab)*
- *Step 10. Click EXPORT RESULTS to export results file (Estimation Tab)*
- *Step 11. Enter yours and projects details (REPORT tab)*
- *Step 12. Click GENERATE REPORT to generate pdf report (REPORT Tab)*
- *Step 13. Evaluate results, adjust model parameters and repeat everything where necessary.*

4.0 CLOSING

This app provides insights for spatial (geological) data and it should be used as a supplementary tool to expert interpretation. Results are dependent on input quality, and users are responsible for validating all outputs in their specific contexts. Further information on statistical methods used in the app can be sourced from the references provided below. The is a trial app version and any issues or assistance can be directed to optimsuservices22@gmail.com or WhatsApp 71087533.

REFERENCE

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Emery, X., Ortiz, J.M., & Ridriguez, J.J., Quantifying Uncertainty in Mineral Resources with Classification Schemes and Conditional Simulations.

Krige, D.G., 1951. A statistical approach to some basic mine problems on the Witwatersrand. J. Chem. Metall. Min. Soc. S. Afr. 52, 119-139.