CAMPD PROJECT REPORT

DEPARTMENT OF MINING ENGINEERING
IIT(ISM) DHANBAD

Team: Error404

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1. INTRODUCTION

Manual methods of planning and designing require tedious work by the planning team in order to define ore boundaries, defining mine configurations in sections based on available economic and technical information. This method was labour intensive, prone to error and time consuming, moreover it cannot be applied to large open pit mines with millions of blocks. So, with tremendous advancement in the field of computer application and numerical modelling and its increased use in the mining industry. Modern mine planning software plays a crucial role in each and every mining operation and project. Mine planning software provides the mining industry with fast, accurate and cost-effective ways in each and every aspect of the mining industry. From exploration to rehabilitation, the use of the software is becoming more and more widespread.

The software used for this work is **SURPAC** which is one the most sophisticated geology and mine planning software which addresses all the requirements of geologists, surveyors, and mining engineers which is flexible enough to be suitable for every commodity, orebody, and mining method and also uses a relational database model and supports several different types of databases, including Oracle, Paradox and Microsoft Access. Surpac also supports Open Database Connectivity (ODBC) and can connect to databases across networks. The Surpac version used is **Surpac 6.5.1**

2. GEOLOGICAL DATABASE

The geological database is a systematic collection and storing of drill hole data which is the starting point of all mining projects. Geological database is the most valuable assets of a mining company which is used to estimate resource and reserves.
There are two types of tables in the database:

a. Mandatory Tables
b. Optional Tables

1. Mandatory Tables:

This contains different tables like Collar Table, Survey table, Translational table.

a. Collar Table:

Mandatory Table	
	Fields
	hole_id
	y
COLLAR	x
	z
	max_depth
	hole_path
	54 optional fields

b. Survey Table:

The survey table stores the drill hole survey information used to calculate the drill hole trace coordinates.

Mandatory Table	
	Fields
	hole_id
	depth
SURVEY	y (calculated)
	x (calculated)
	z (calculated)
	dip
	azimuth
	53 optional fields

c. Translation Table:

This is the default table created by the surpac to Translate numeric codes.

2. Optional Tables:

Optional tables can be added and used to store information, such as geology and assays. There are three different types of optional tables that can be added to a database:

- Interval (depth from and depth to)
- Point (depth to)
- Discrete (point data)

OPTIONAL TABLE TYPE	
	Fields
INTERVAL ie. down hole samples	hole_id samp_id depth_from y_from (calculated) x_from (calculated) z_from (calculated) depth_to y_to (calculated) x_to (calculated) z_to (calculated) 50 optional fields
POINT ie. piezometer readings	hole_id depth_to y_to (calculated) x_to (calculated) z_to (calculated) 55 optional fields
DISCRETE ie. soil samples	samp_id y x z 56 optional fields

a. Assay Table:

This table contains assay values of minerals and Litho-code of all core lags.

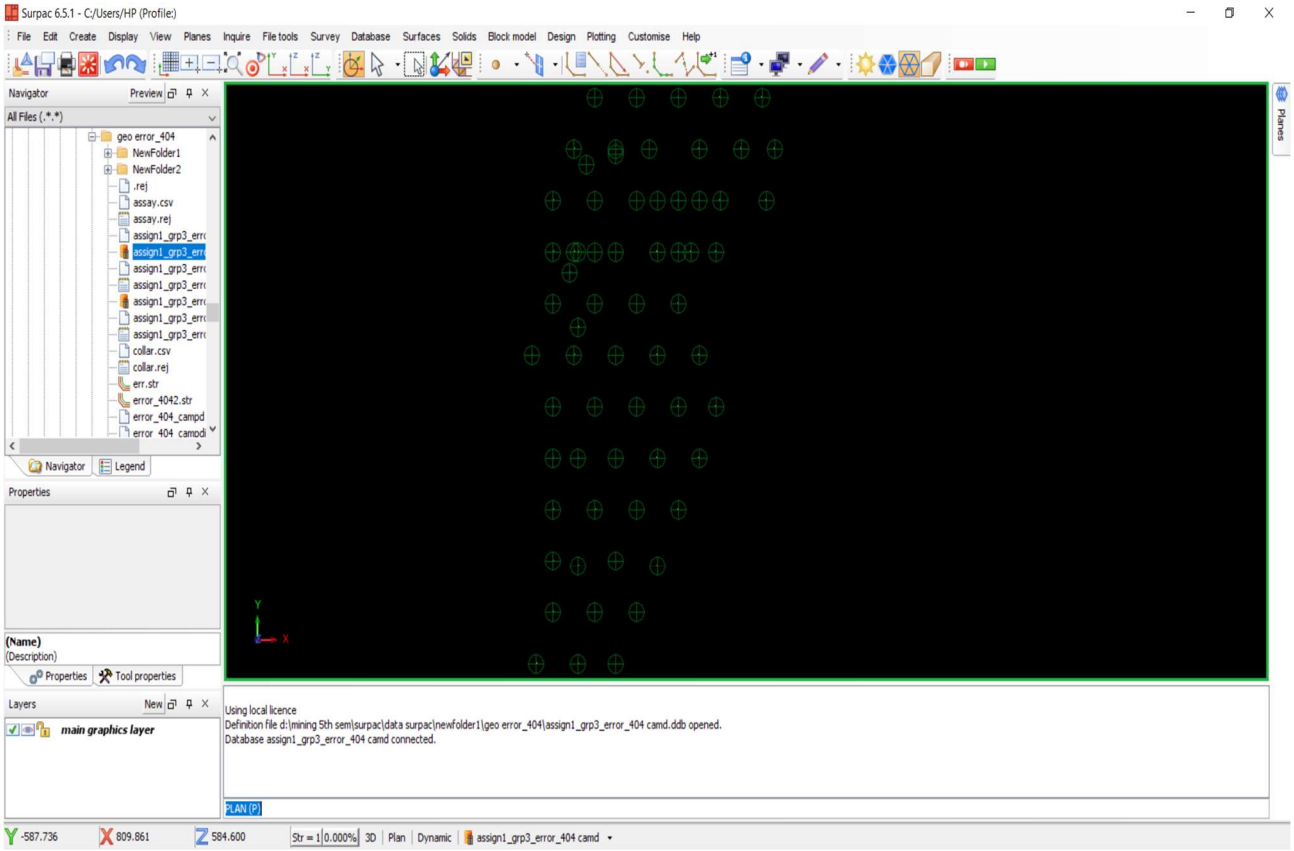
b. Geology Table:

This table contains relevant information of core logs geology i.e Litho-code of samples.

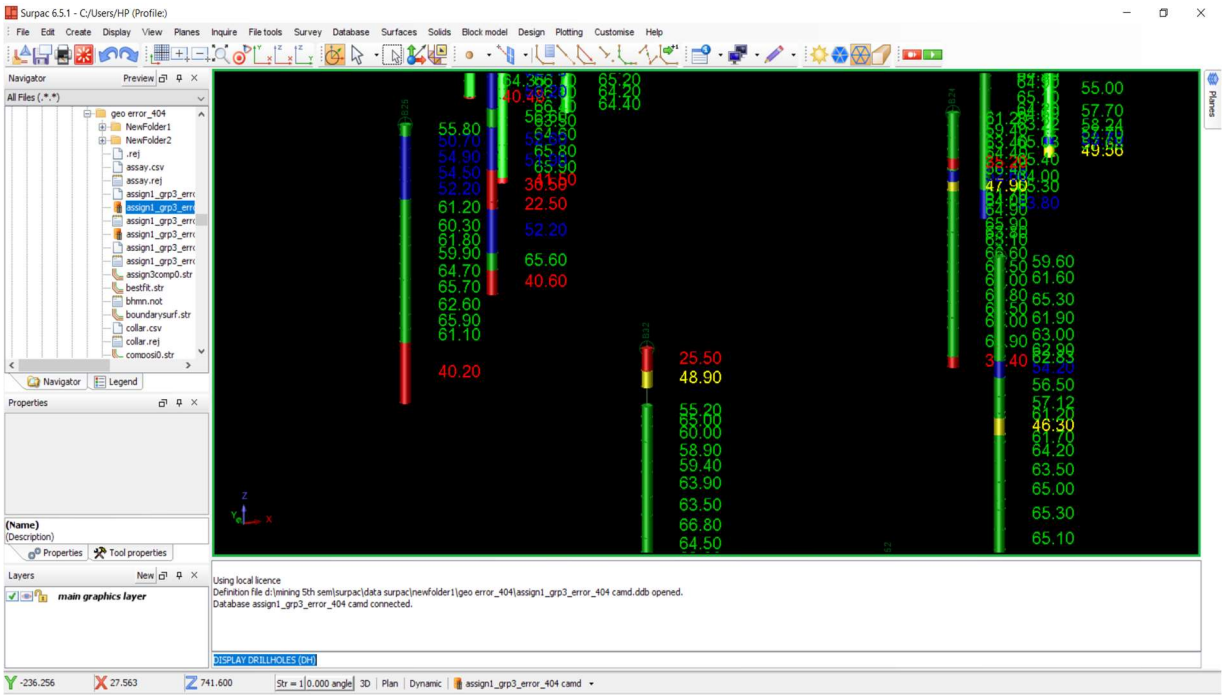
c. Styles Table:

This is the default table created by surpac to store information about styles.

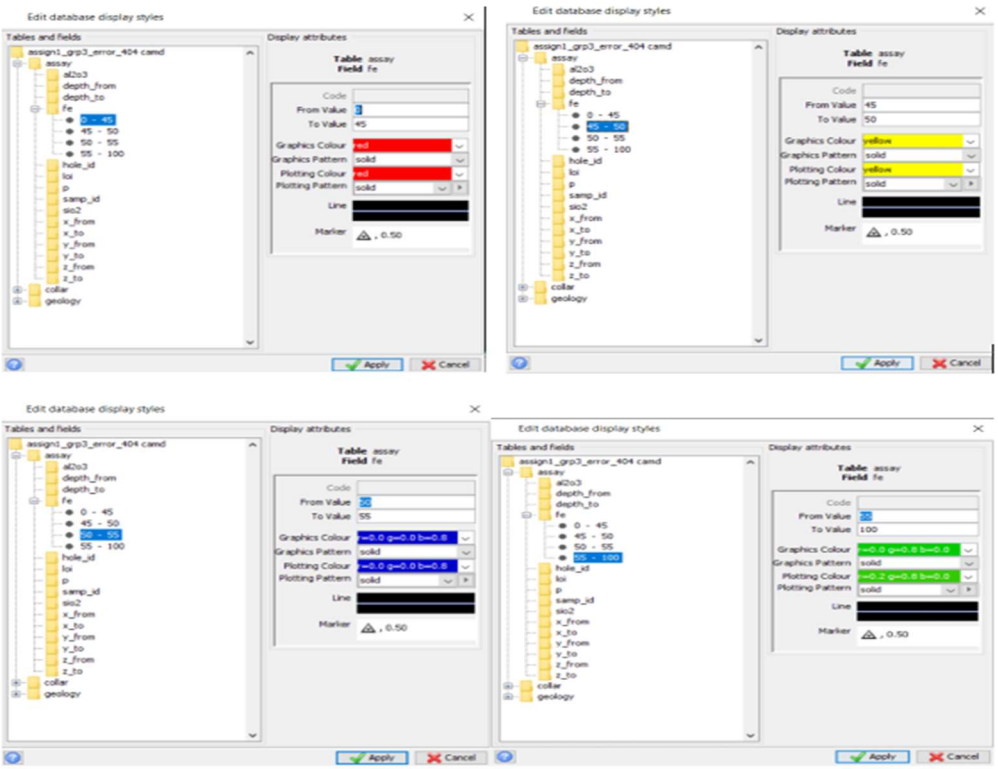
PLAN VIEW OF IMPORED DRILLHOLE



DRILLHOLE DISPLAY WITH RESPECT TO FE GRADE

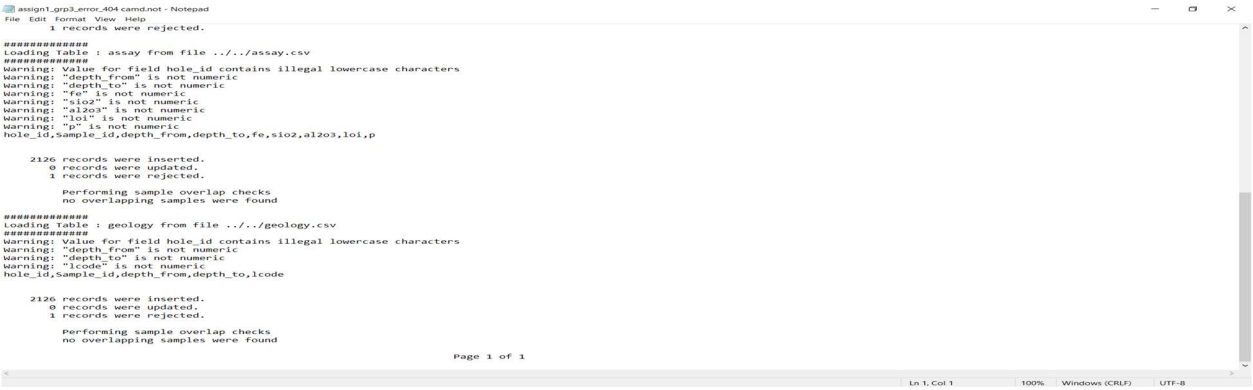


- **LEGENDS USED**



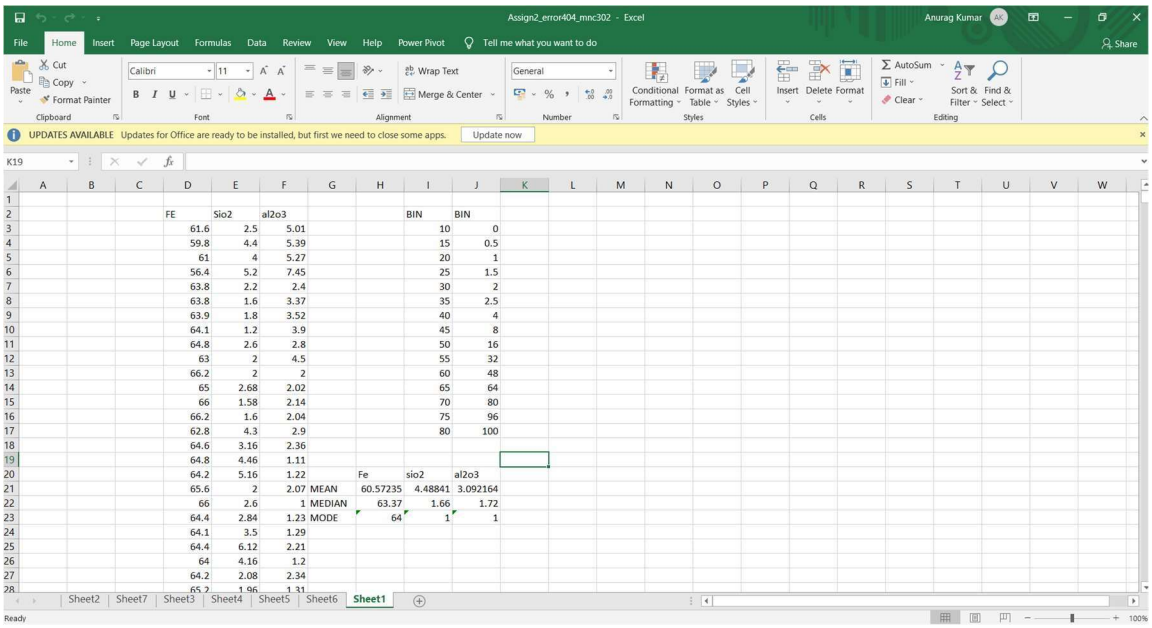
DATABASE REPORT

```
assign1_grp3_error_404 camd.not - Notepad
File  Edit  Format  View  Help
|                Database Management - Database Load Report        Aug 31, 2021


Date         : 31-Aug-21
Database     : assign1_grp3_error_404 camd
Format_file  : error_404_campd.dsc

=================================================================


##############
Loading Table : collar from file ../../collar.csv
##############
Warning: Value for field hole_id contains illegal lowercase characters
Warning: "y" is not numeric
Warning: "x" is not numeric
Warning: "z" is not numeric
Warning: "max_depth" is not numeric
Warning: Value for field hole_path not in allowed set
hole_id,y,x,z,max_depth,hole_path


      71 records were inserted.
       0 records were updated.
       1 records were rejected.
```



```
assign1_grp3_error_404 camd.not - Notepad
File  Edit  Format  View  Help
       1 records were rejected.

##############
Loading Table : assay from file ../../assay.csv
##############
Warning: Value for field hole_id contains illegal lowercase characters
Warning: "depth_from" is not numeric
Warning: "depth_to" is not numeric
Warning: "fe" is not numeric
Warning: "sio2" is not numeric
Warning: "al2o3" is not numeric
Warning: "loi" is not numeric
Warning: "p" is not numeric
hole_id,sample_id,depth_from,depth_to,fe,sio2,al2o3,loi,p

    2126 records were inserted.
       0 records were updated.
       1 records were rejected.

         Performing sample overlap checks
         no overlapping samples were found

##############
Loading Table : geology from file ../../geology.csv
##############
Warning: Value for field hole_id contains illegal lowercase characters
Warning: "depth_from" is not numeric
Warning: "depth_to" is not numeric
Warning: "lcode" is not numeric
hole_id,sample_id,depth_from,depth_to,lcode

    2126 records were inserted.
       0 records were updated.
       1 records were rejected.

         Performing sample overlap checks
         no overlapping samples were found
                                                    Page 1 of 1
Ln 1, Col 1    100%    Windows (CRLF)    UTF-8
```

3. STATISTICAL ANALYSIS OF ORE GRADE



FE	Sio2	al2o3			BIN	BIN
61.6	2.5	5.01			10	0
59.8	4.4	5.39			15	0.5
61	4	5.27			20	1
56.4	5.2	7.45			25	1.5
63.8	2.2	2.4			30	2
63.8	1.6	3.37			35	2.5
63.9	1.8	3.52			40	4
64.1	1.2	3.9			45	8
64.8	2.6	2.8			50	16
63	2	4.5			55	32
66.2	2	2			60	48
65	2.68	2.02			65	64
66	1.58	2.14			70	80
66.2	1.6	2.04			75	96
62.8	4.3	2.9			80	100
64.6	3.16	2.36				
64.8	4.46	1.11				
64.2	5.16	1.22		Fe	sio2	al2o3
65.6	2	2.07	MEAN	60.57235	4.48841	3.092164
66	2.6	1	MEDIAN	63.37	1.66	1.72
64.4	2.84	1.23	MODE	64	1	1
64.1	3.5	1.29				
64.4	6.12	2.21				
64	4.16	1.2				
64.2	2.08	2.34				
65.2	1.96	1.31				

- Data obtained for fe:

  Mean =60.57235
  Median =63.37
  Mode =64

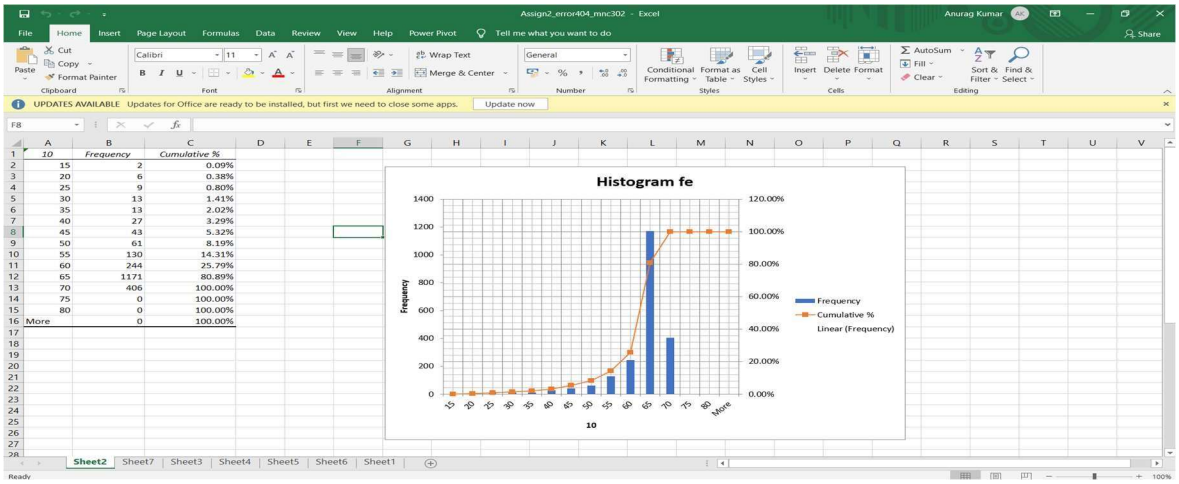
- Data obtained for sio2:

  Mean =4.48841
  Median =1.66
  Mode =1

- Data obtained for al2o3:

  Mean =3.092164
  Median =1.72
  Mode =1

- Histogram and normal distribution curve

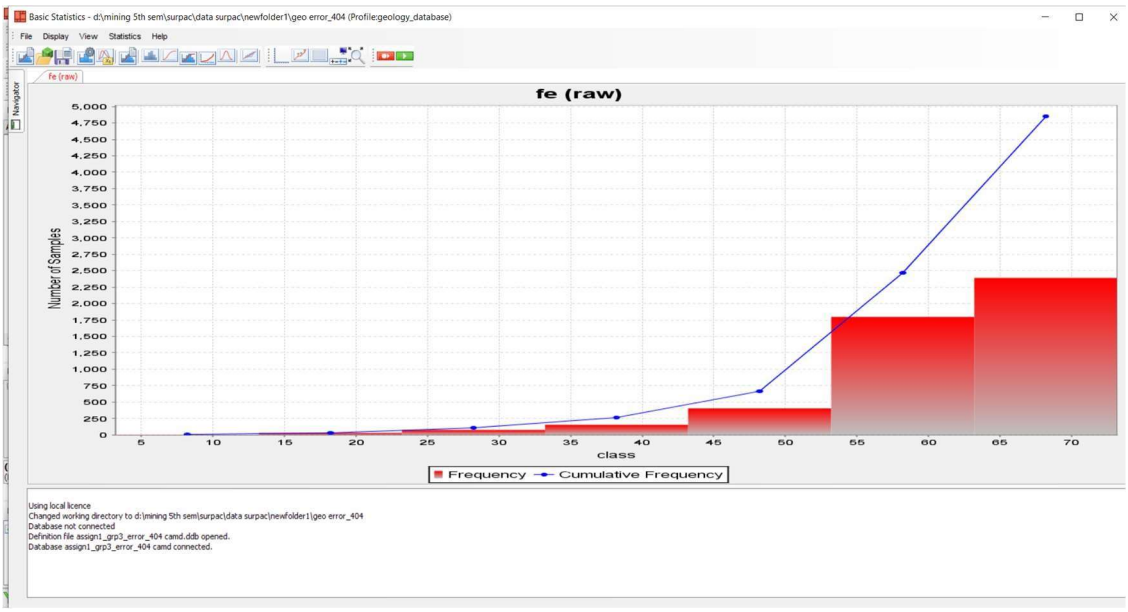


10	Frequency	Cumulative %
15	2	0.09%
20	6	0.38%
25	9	0.80%
30	13	1.41%
35	13	2.02%
40	27	3.29%
45	43	5.32%
50	61	8.19%
55	130	14.31%
60	244	25.79%
65	1171	80.89%
70	406	100.00%
75	0	100.00%
80	0	100.00%
More	0	100.00%

i) From above we can see that bell curve is right skewed.

ii) From above data we can say that cut-off grade should lie between 55-60 i.e. 57.5 as the bell curve is getting flatten after this range.

Cut of grade of 'fe' found according to the drill hole data is 57.5.



4. COMPOSITING OF DRILL HOLES

Compositing is done to bring uniformity in the grade of drillholes within certain interval such as bench height.

Length	Grade	Length × Grade
l_0	g_0	$l_0 g_0$
l_1	g_1	$l_1 g_1$
l_2	g_2	$l_2 g_2$
l_3	g_3	$l_3 g_3$
l_4	g_4	$l_4^* g_4$
$\sum l_i$	$\boxed{\bar{g}}$	$\sum l_i g_i$

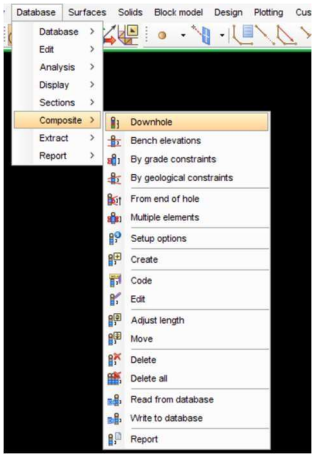
$\sum l_i = H$

where H is bench height. Hence

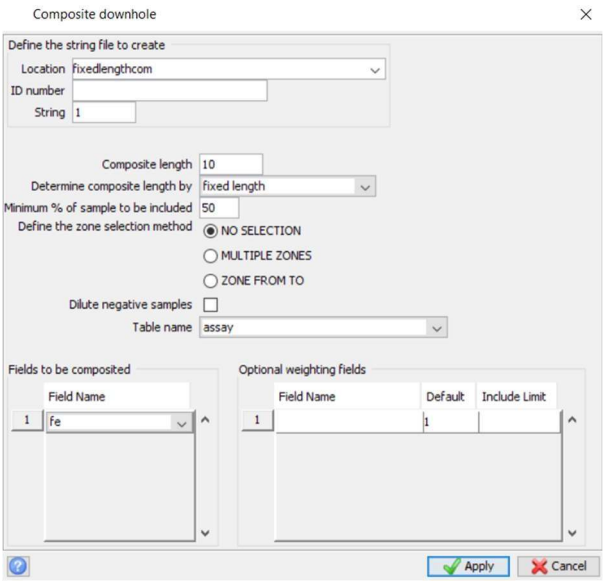
$$\bar{g} = \frac{\sum l_i g_i}{H}$$

- Compositing by fixed length method.

1.first we go to database->composite->by downhole.



2.Now we give the parameters:-



COMPOSITING INTERVAL = 10m.

% MINIMUM COVERAGE AREA= 50%.

MINIMUM COVERAGE DEPTH = 5m.

HOLE NO B1

Length = 82.75m.

N = length/composite interval = 82.75/10 = 8.275

82.75 = 10*8+2.75.

Since 2.75 is less than 5m therefore hole part after 80m will be rejected and no of interval will be equal to 8.

N=8.

HOLE NO B2

Length = 85.53m.

N=85.53/10 = 8.553

85.553= 10*8+5.553.

Since 5.553 is greater than 5m therefore hole part after 80m will be considered for compositing and no of interval will become equal to 9.

N = 9.

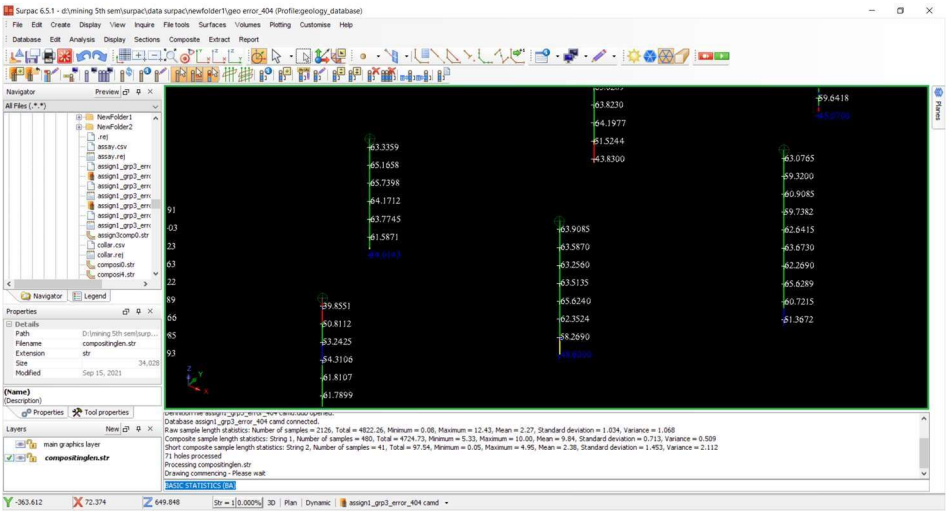


FIG-SHOWING COMPOSITE ALGORITHM RESULT GRADE AT INTERVAL OF 10m.

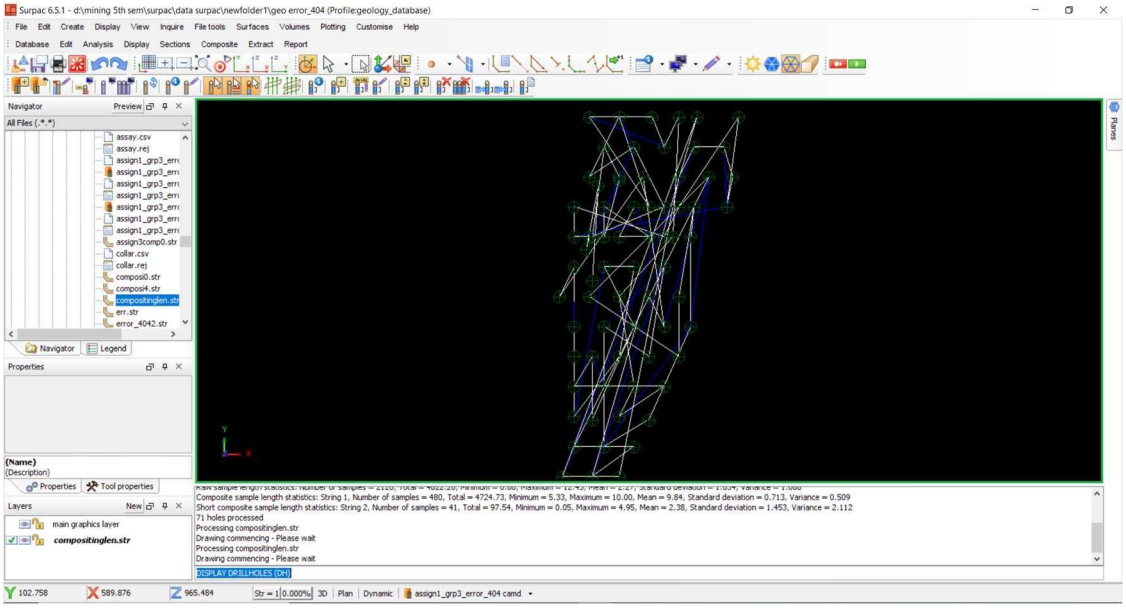


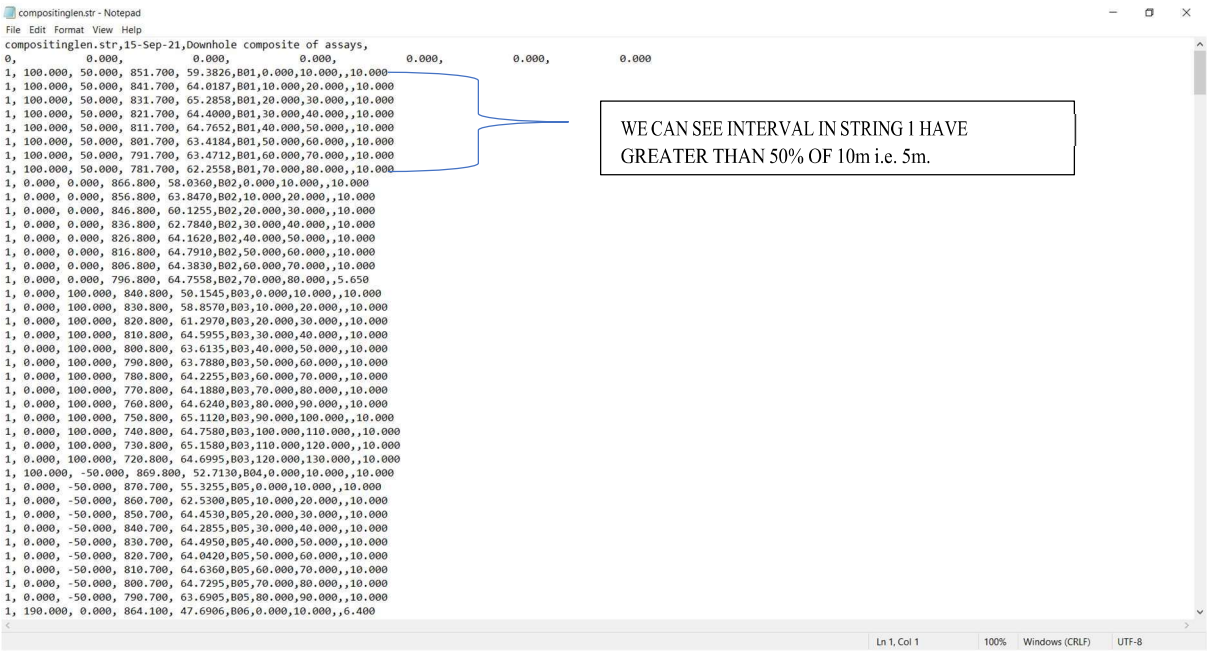
FIG-COMPOSITING RESULT ON DRILLHOLE DATABASE.

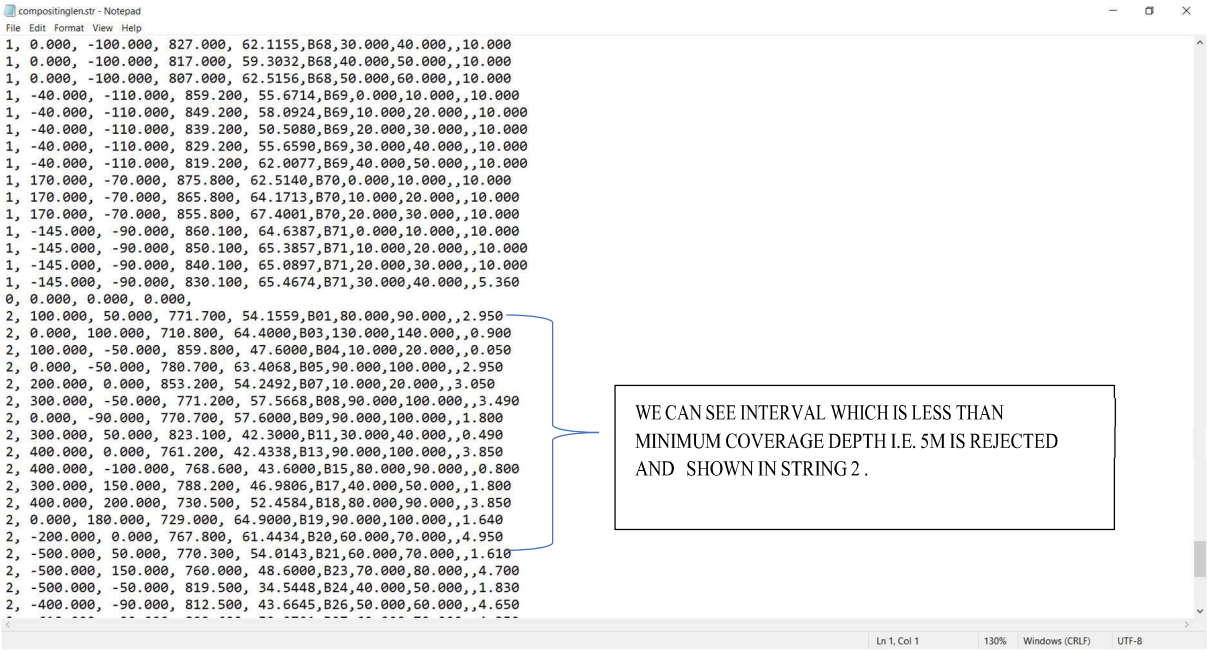
- BLUE STRING

It represents points which has been excluded because that was lying in interval less than 5m interval i.e minimum coverage percentage which is equal to 50% of 10m(drillhole length) i.e. 5m.

- WHITE STRING

White string represents the value having interval greater than minimum coverage depth i.e. 5m.





compositinglen.str - Notepad

File Edit Format View Help

```
1, 0.000, -100.000, 827.000, 62.1155,B68,30.000,40.000,,10.000
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1, -40.000, -110.000, 829.200, 55.6590,B69,30.000,40.000,,10.000
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1, -145.000, -90.000, 840.100, 65.0897,B71,20.000,30.000,,10.000
1, -145.000, -90.000, 830.100, 65.4674,B71,30.000,40.000,,5.360
0, 0.000, 0.000, 0.000,
2, 100.000, 50.000, 771.700, 54.1559,B01,80.000,90.000,,2.950
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2, -500.000, 150.000, 760.000, 48.6000,B23,70.000,80.000,,4.700
2, -500.000, -50.000, 819.500, 34.5448,B24,40.000,50.000,,1.830
2, -400.000, -90.000, 812.500, 43.6645,B26,50.000,60.000,,4.650
```
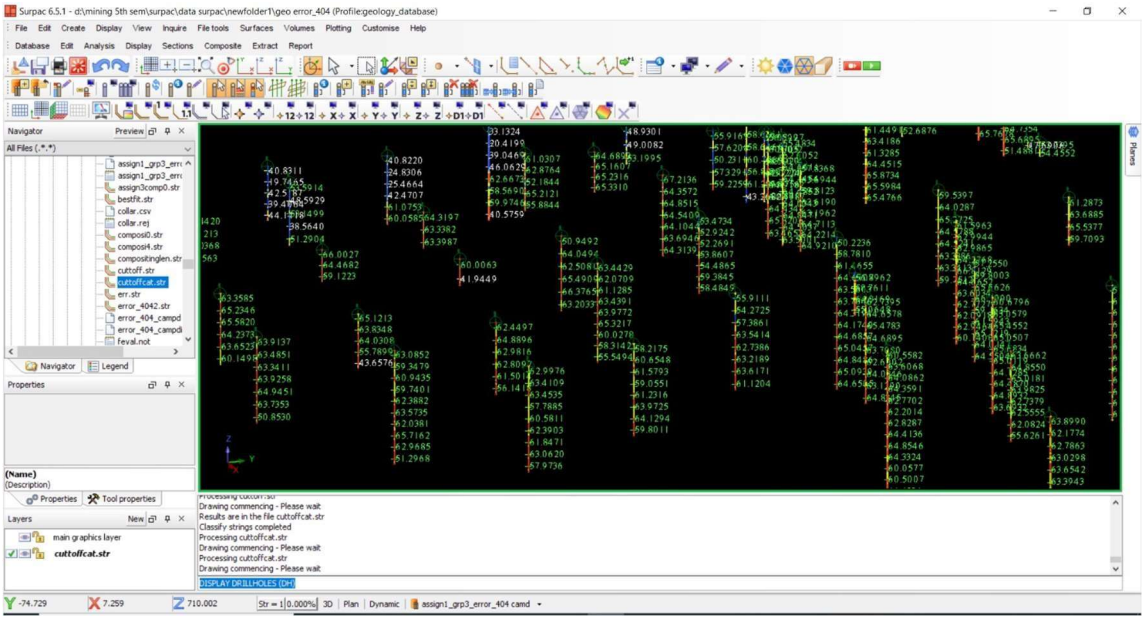

Ln 1, Col 1 | 130% | Windows (CRLF) | UTF-8

WE CAN SEE INTERVAL WHICH IS LESS THAN MINIMUM COVERAGE DEPTH I.E. 5M IS REJECTED AND SHOWN IN STRING 2 .

FIG-NOTEPAD RESULT ANALYSIS



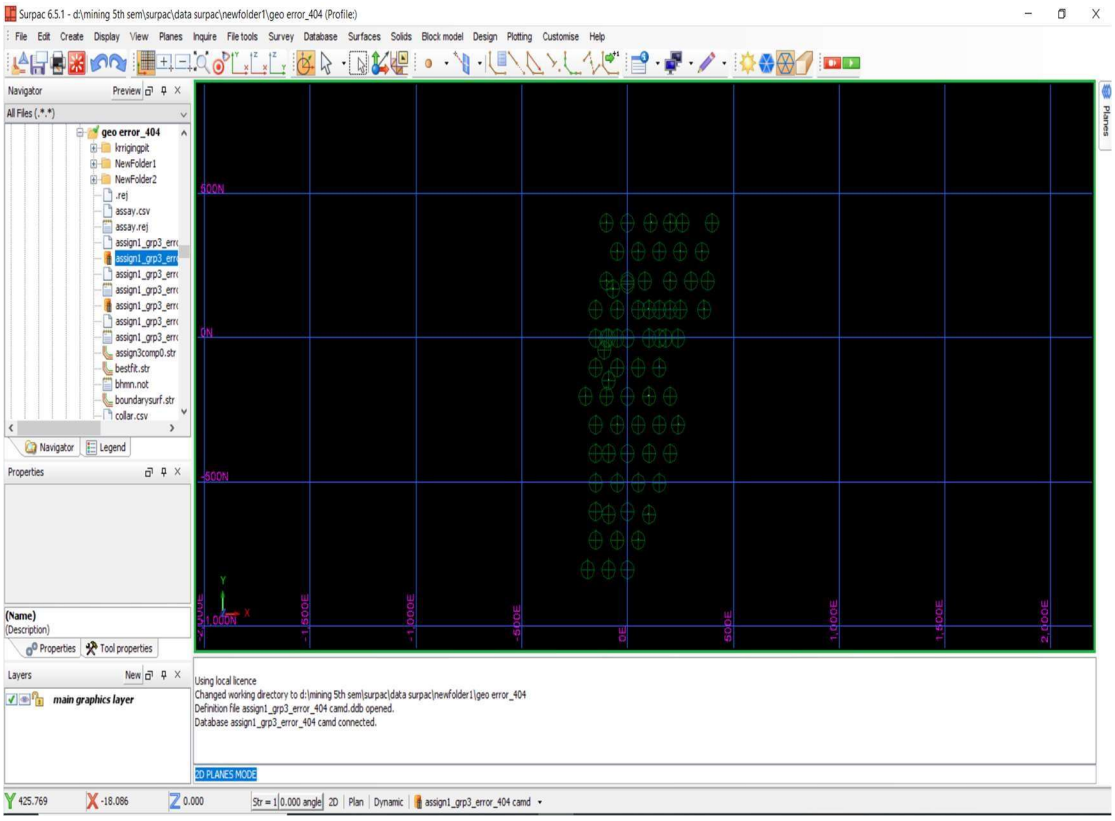
We can see the grade in a hole written with green colour are high grade ore.

5. SECTIONING AND DIGITIZING

sectioning and digitizing is used to make an ore body from a drillholes. We do sectioning and digitizing by dividing drillholes into different sections either by northing, easting or by vertical plane and after that we open each sections one by one and digitize all the sections one by one. We select northing wise if spread of ore is more along northing side similarly easting wise if spread is more along easting side.

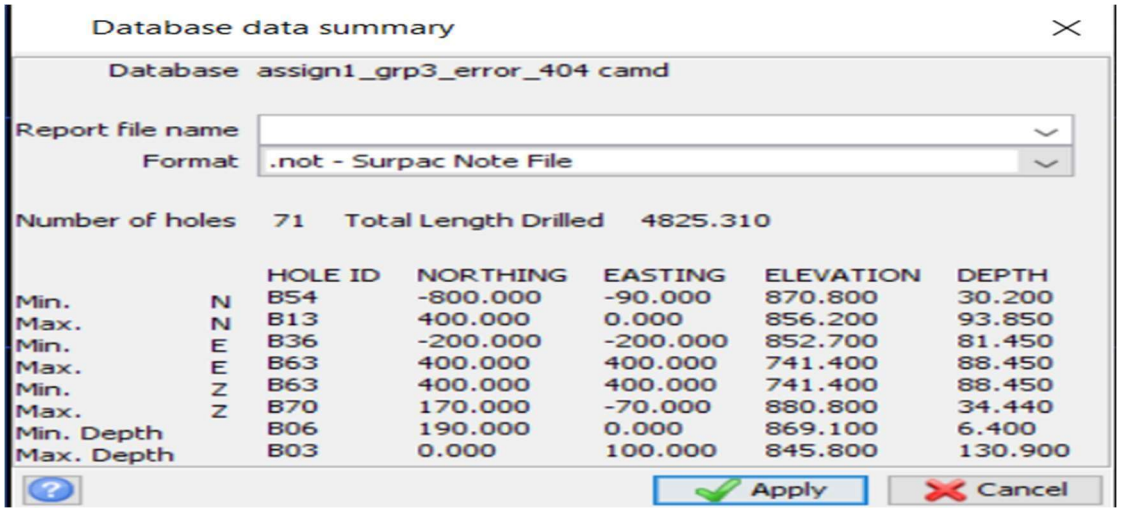
Below we have explained steps for sectioning and digitizing.

1. First we see the drillhole extent for selection of sectioning method.



2.We can observe from the figure that drillholes are spread more along northing side hence we select northing method for sectioning.

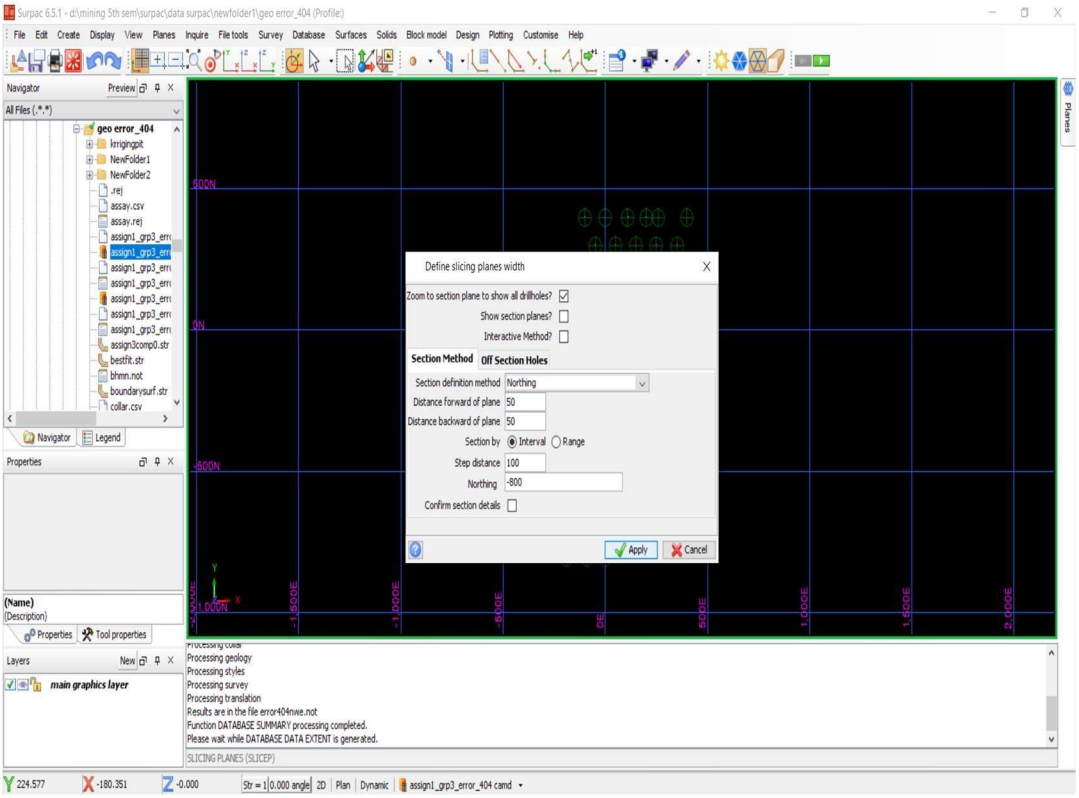
3.By clicking on database->report->database extent we can see the data numerically,



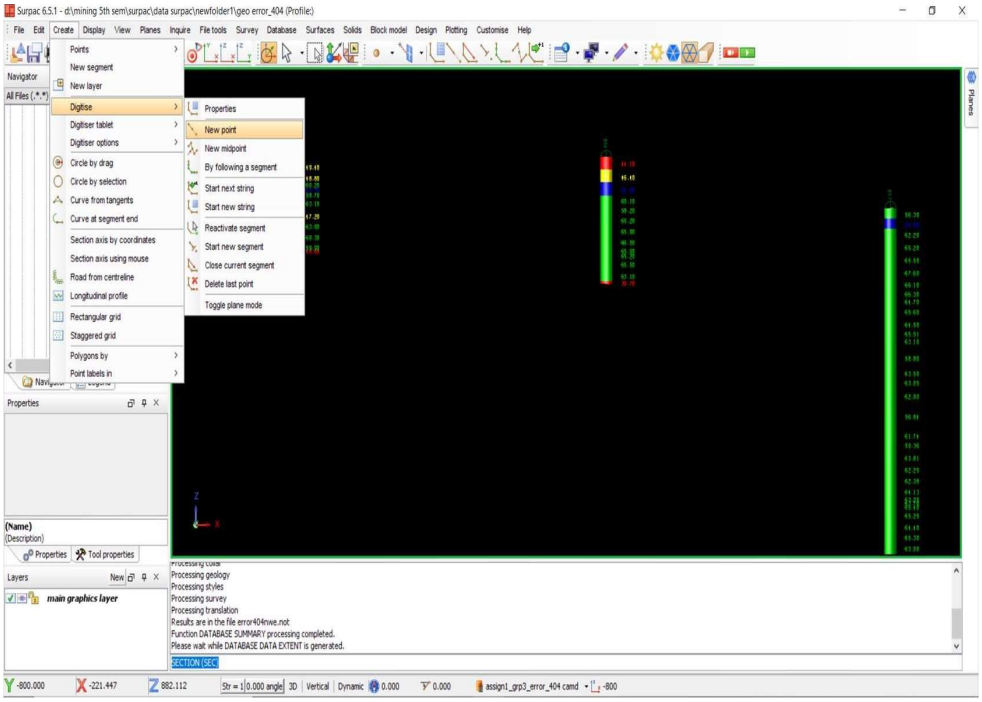
		HOLE ID	NORTHING	EASTING	ELEVATION	DEPTH
Min.	N	B54	-800.000	-90.000	870.800	30.200
Max.	N	B13	400.000	0.000	856.200	93.850
Min.	E	B36	-200.000	-200.000	852.700	81.450
Max.	E	B63	400.000	400.000	741.400	88.450
Min.	Z	B63	400.000	400.000	741.400	88.450
Max.	Z	B70	170.000	-70.000	880.800	34.440
Min. Depth		B06	190.000	0.000	869.100	6.400
Max. Depth		B03	0.000	100.000	845.800	130.900

In northing side it is spread from -800N to 400N. If we will generate sections at a interval of 100N then we will get 12 sections we should select such interval that it should cover all the drill holes.

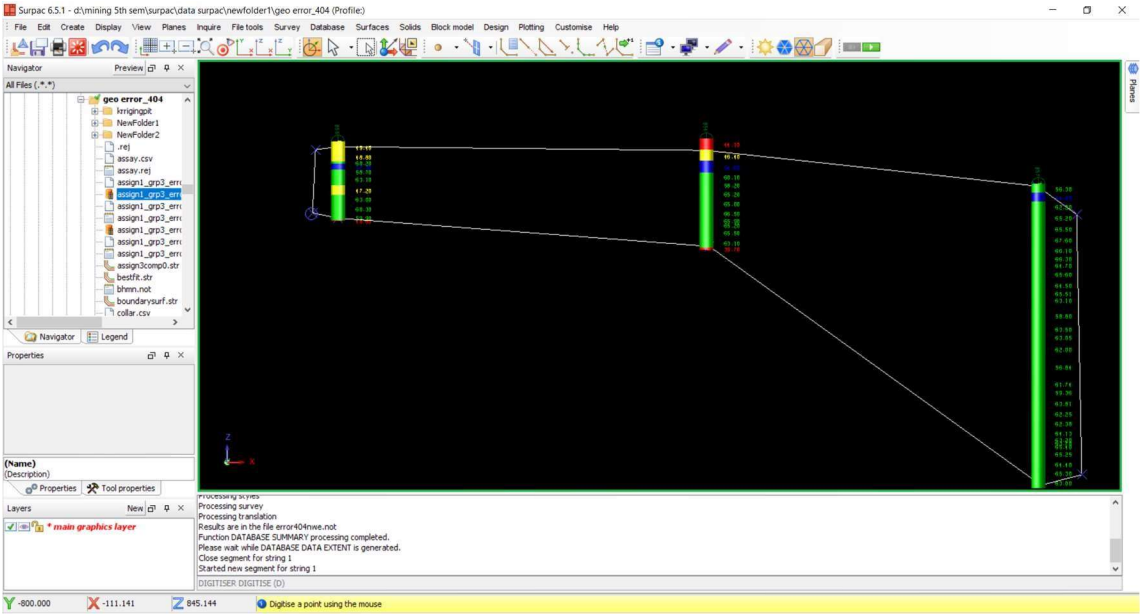
- Steps followed
  1. We go to database->sections->define.



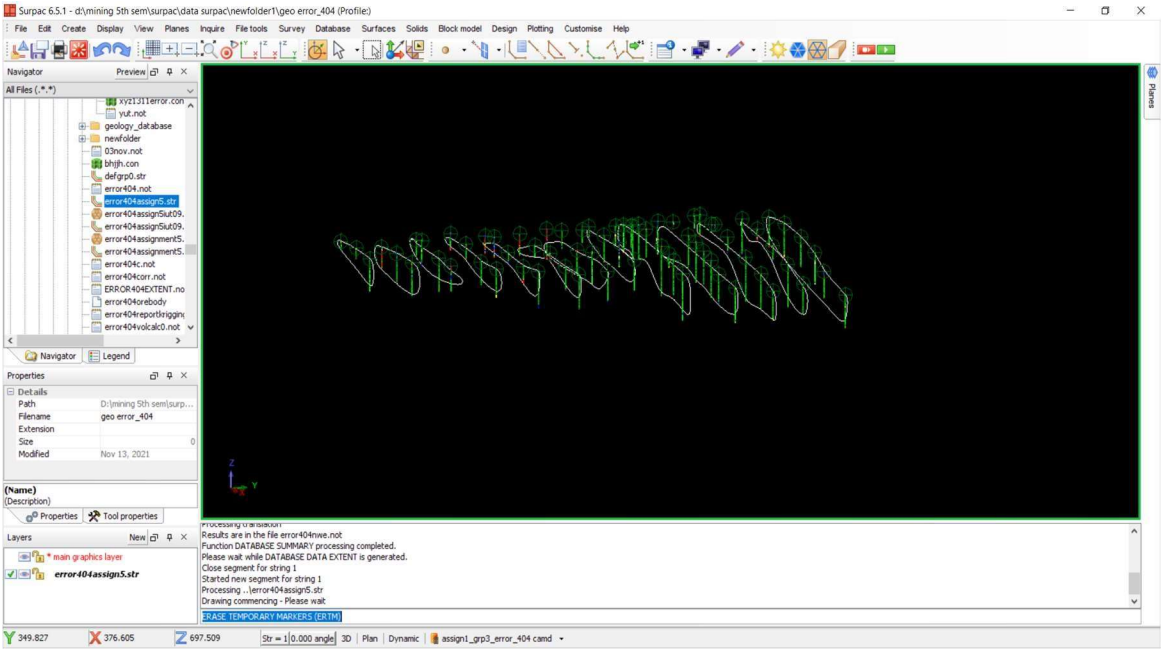
2. Now sections will appear one by one till it covers all the drill holes.



3. We will have to digitize it by create->digitize->new points. We will make a string covering all the drillholes present in that sections. We will exclude the end if low grade is present at end or start of the hole.



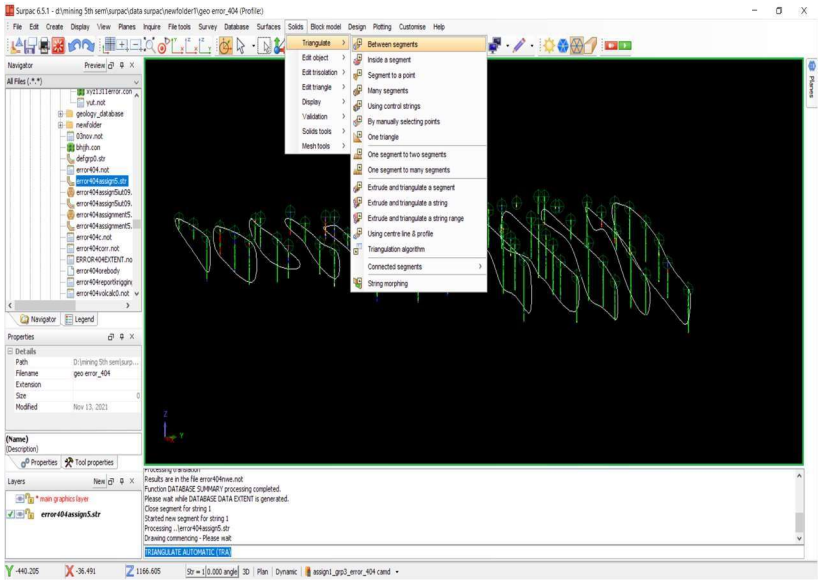
4. After digitizing for all the sections it will look like this.



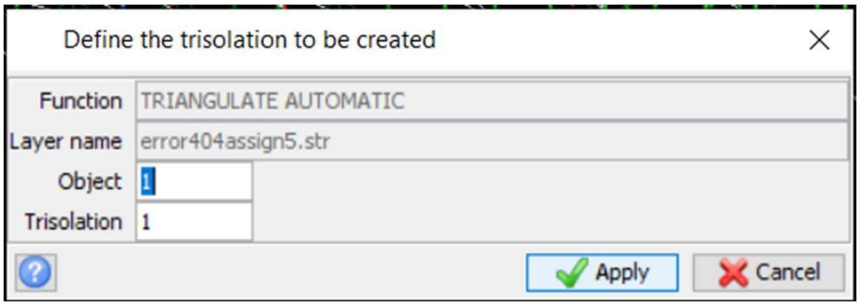
6. SOLID MODELING AND VOLUME OF ORE ESTIMATION

- Steps followed

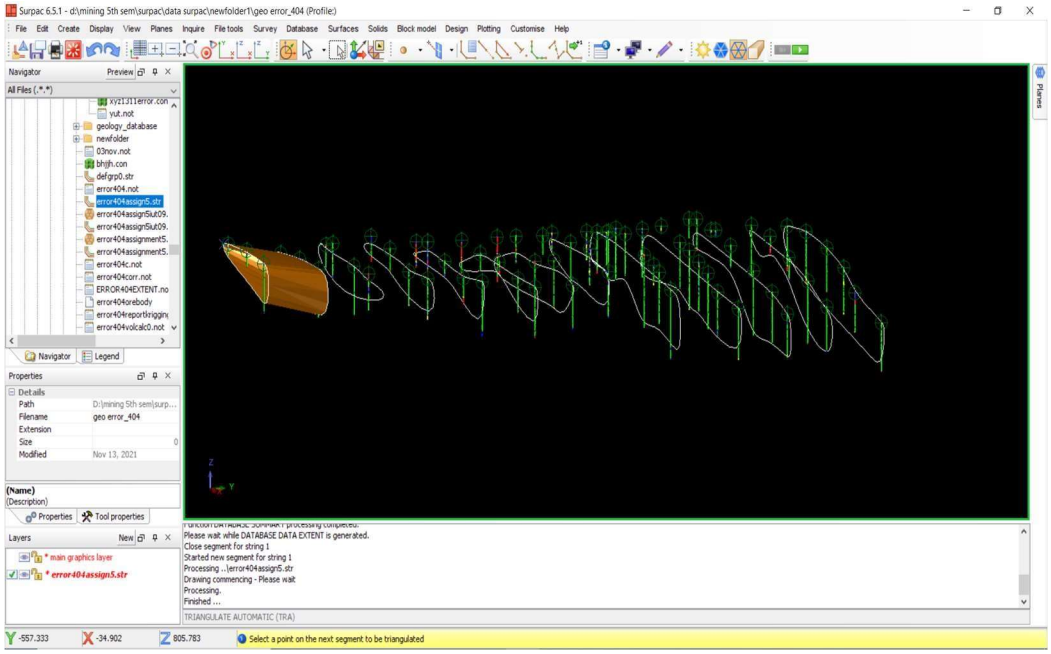
1. We go to solids->triangulate between segments.



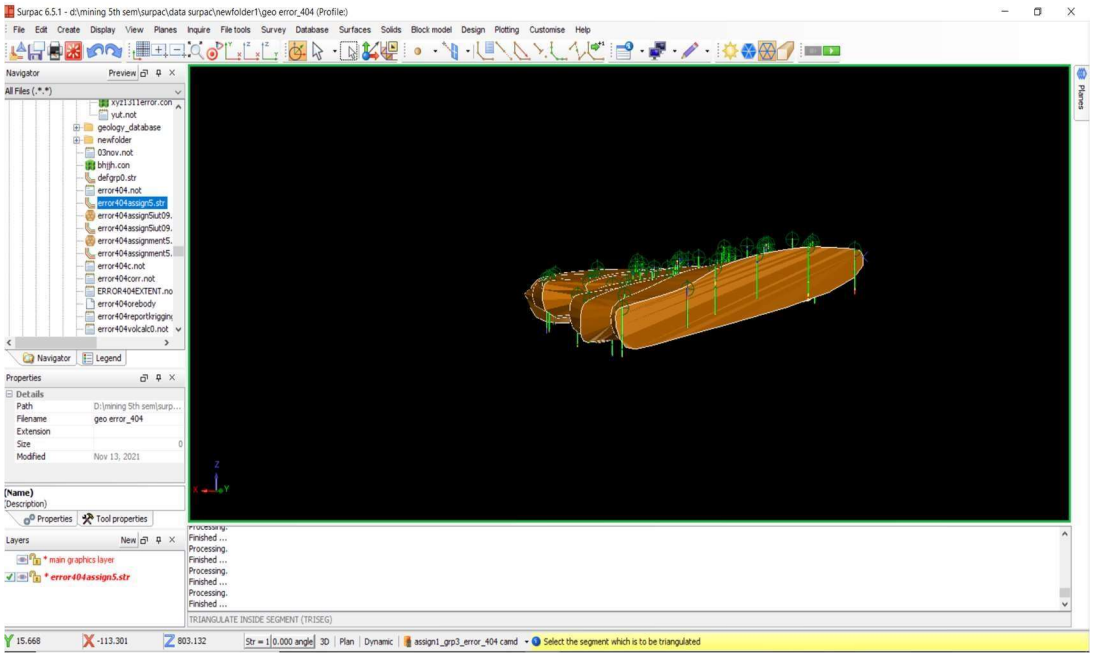
2. Object is left as one and trisolation is also left 1.



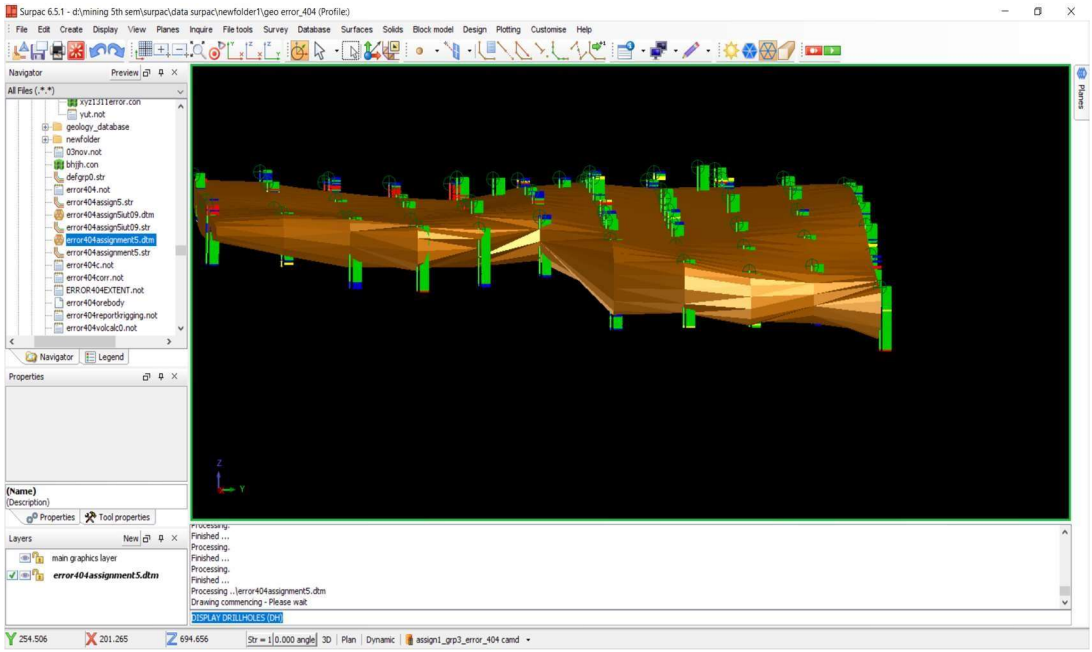
3. By selecting the two consecutive segments we can see 3dtm is created.



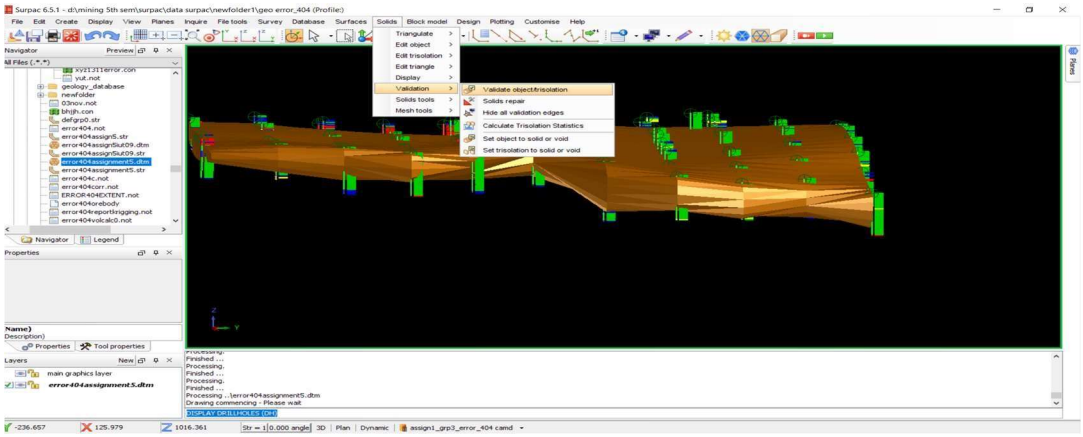
4. At last we have to close the 3dtm from both the opening side. For this we need to select solids->triangulate->inside the segment.



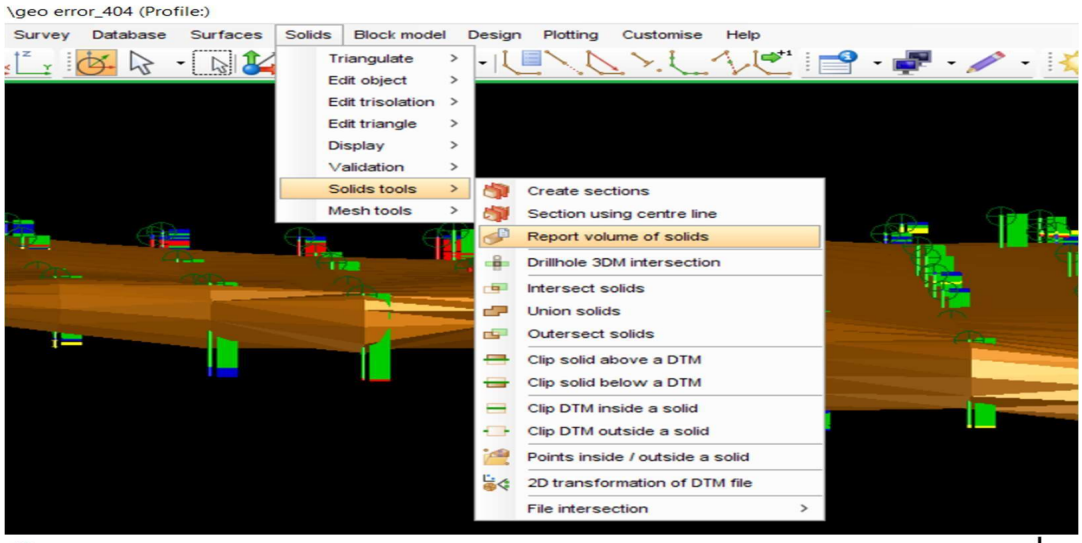
Finally our ore body will look like this.

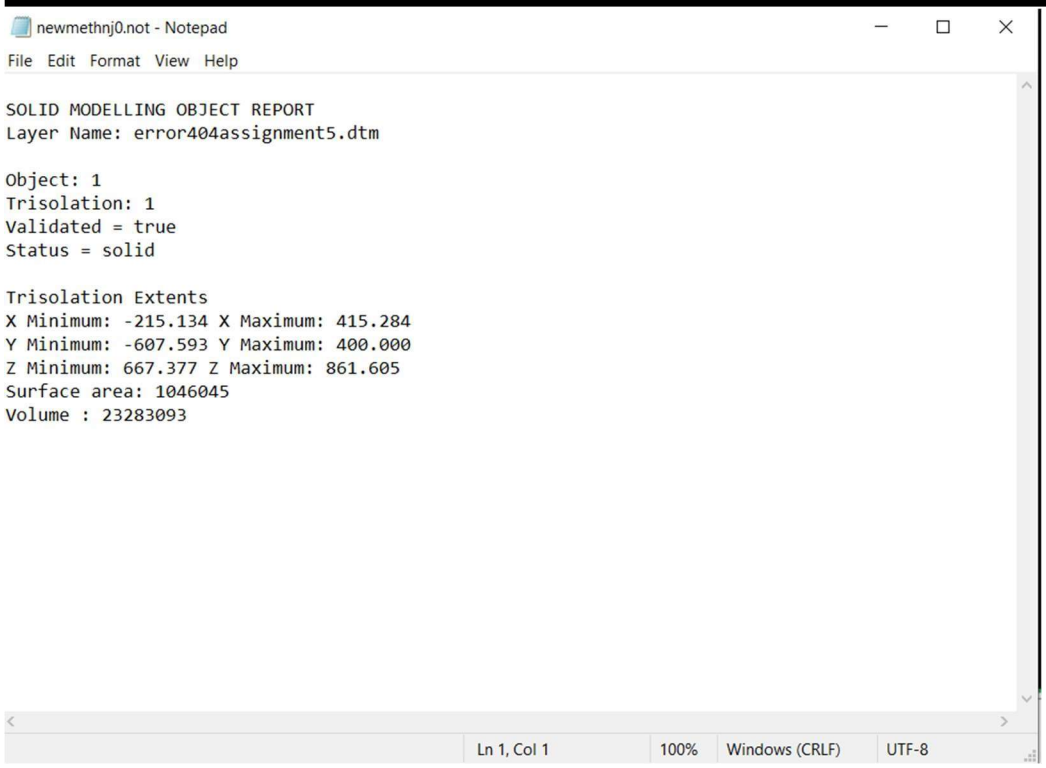


- Now to estimate the volume we first need to validate it for that we go to solids>validation->validate object trisolation.



- After validation and correcting the solids we need to estimate the volume by solids->solid tools->report volume by solids





- After multiplying the volume with density of ore we get the following results.
- VOLUME OF THE SOLID IS EQUAL TO = 23283343m^3

ORE DENSITY = 2.4

- TOATAL TONNAGE = VOLUME*ORE DENSITY

  =23283343*2.4

  =5,58,80,023.2 tonne

  =55.8 million tonne ore body estimated.

- ***TOTAL ORE RESERVE ESTIMATED-55.8 million tonnes.***

7. VARIOGRAM MODELING

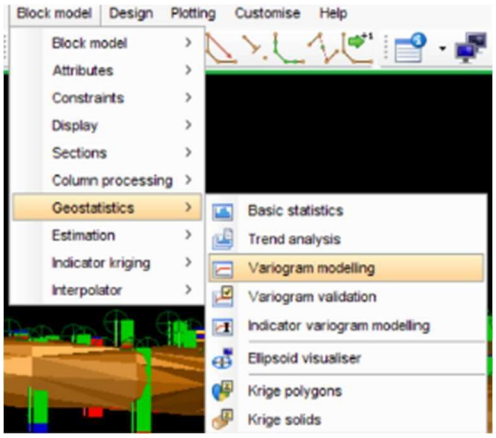
it's a geostatistical method to estimate the grade value of unknown point given some known grade points this method is kriging and making variogram is one of the method involved in kriging. Variogram general depicts dissimilarity on y-axis and lag distance on x-axis , in case of near points grade points difference is less hence dissimilarity is less as distance increases grade point distribution starts becoming unrelated and dissimilarity increase hence value on y-axis gamma(h) increases. By variogram weights are assigned . we get three values out of variogram,

Nugget – it's absurd value we get it's the dissimilarity of grade at distance zero.

Sill – it's the maximum dissimilarity found by a variogram function after achieving this point graph becomes flat.

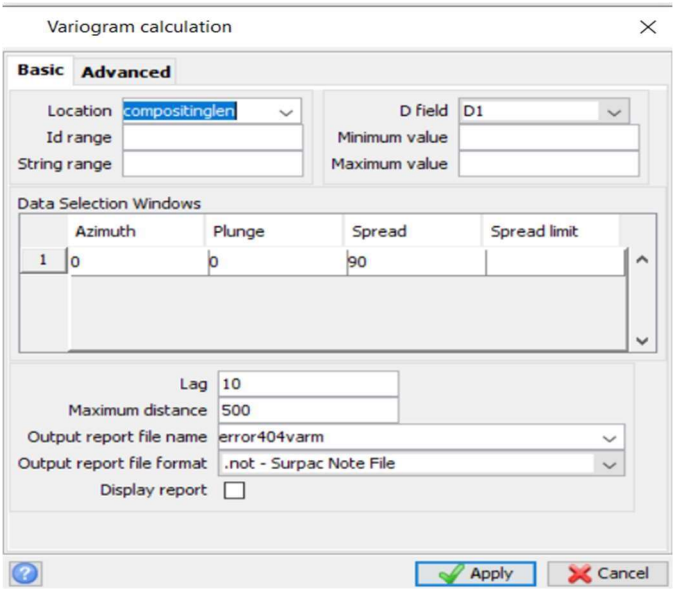
Range – it's the lag distance value at which gamma(h) value attains sill value.

1. We go to block model->geostatistics->variogram modelling.

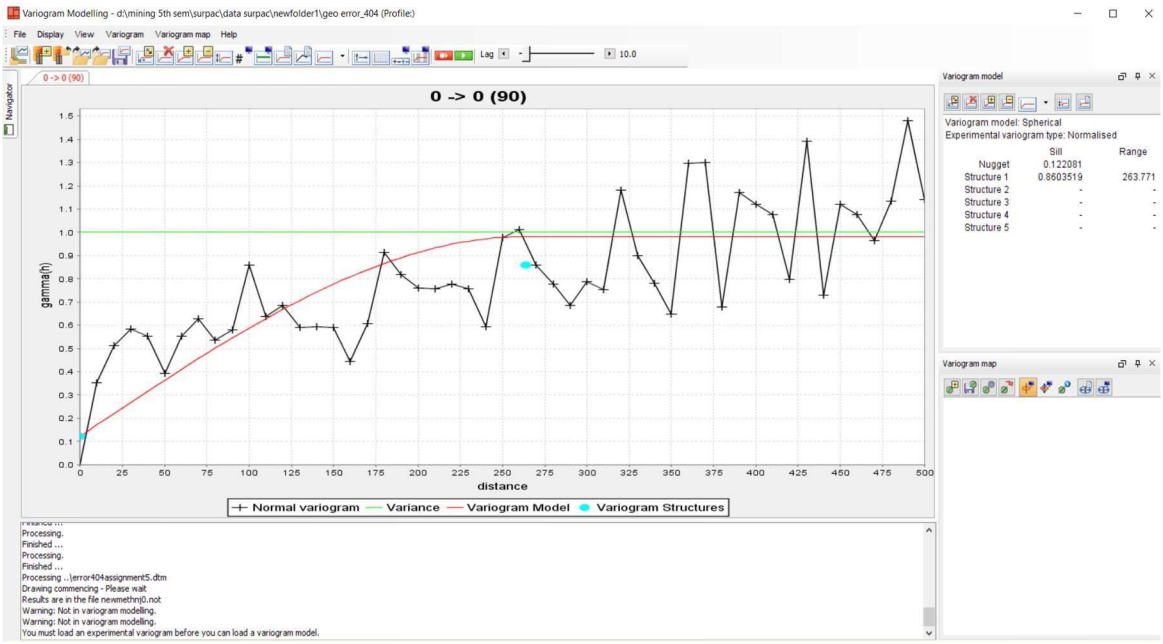


2. Then we import composited string for variogram modeling.
3. We select lag = 10m, Maximum distance = 500m.

Azimuth = 0, plunge = 0, spread = 90 it is for omnidirectional variogram, However we can select different values.



4. We will have to make experimental variogram first and then we have to fit variogram model.
5. After then we will have to adjust variogram model so that we get correct prediction. If our variogram model is correct then only we will get correct kriging result.
6. The variogram which we get is as follows:-



Result

sill = 0.122081.

Nugget = 0.8603519.

Range = 263.271.

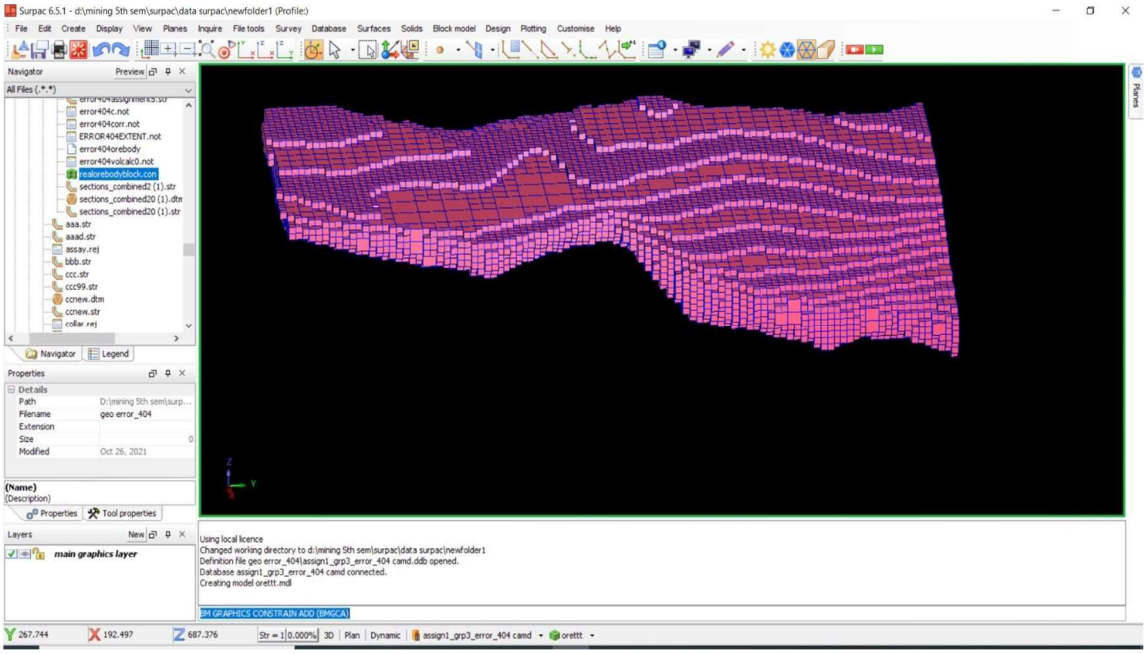
8. BLOCK MODELING

Block modelling is done to divide the ore body in rectangular blocks each blocks will have some value which we get after estimation through kriging or IDW(inverse distance method). This blocks are used to generate pit and give the value of total ore which is above cut-off grade and also by this we can estimate the amount of waste present in our ore body. Block modelling is used to generate ultimate pit. We can create block model by following below defined steps:-

i) Block model is created by first going to block model->new/open give name of the model and click apply.

ii) Extent of ore body is extracted from the string file we upload orebody.str. User block size is given we have given x=10,y=10,z=10.

iii) Constraint is added ore body 3D DTM file is attached to generate blocks in an ore body which was already developed. In this care must be taken that 3D DTM must be properly validated.



iv) Attribute is added ‘fe’,’sio2’,’al2o3’ is selected it’s type is selected as real.

ESTIMATION BY IDW METHOD

i) After adding attributes now we will estimate the value of each blocks in a block model by IDW method.

ii) We go to block model->estimation->inverse distance.

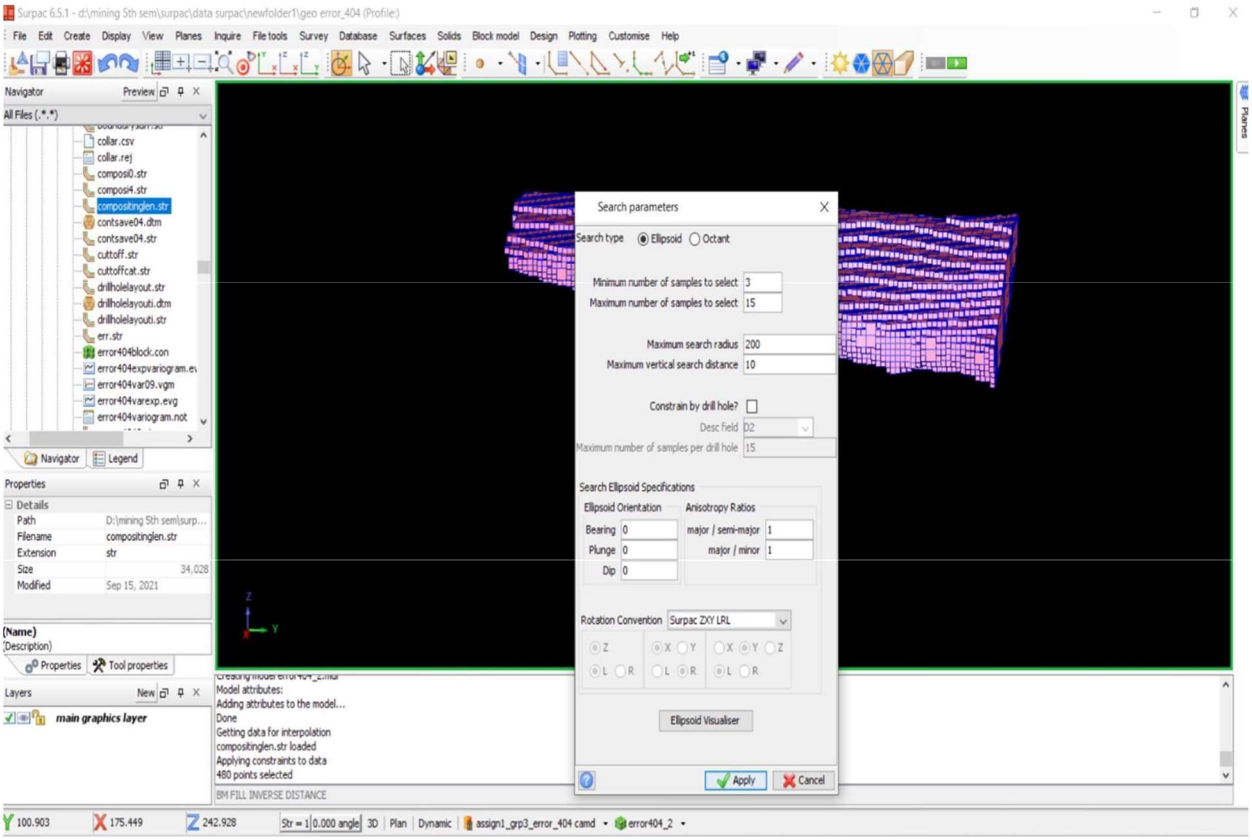
iii) We give the search parameter –

1.minimum no of sample to select – 3.

2.maximum no of sample to select – 15.

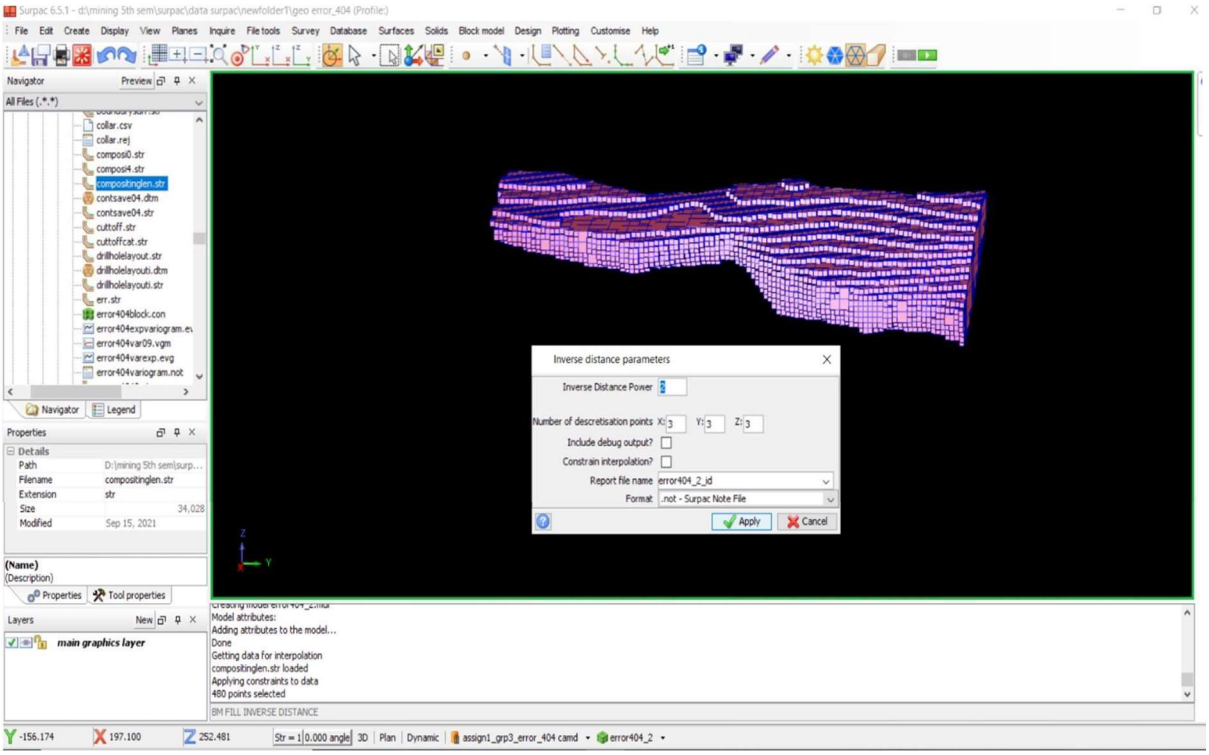
3.maximum search radius – 200.

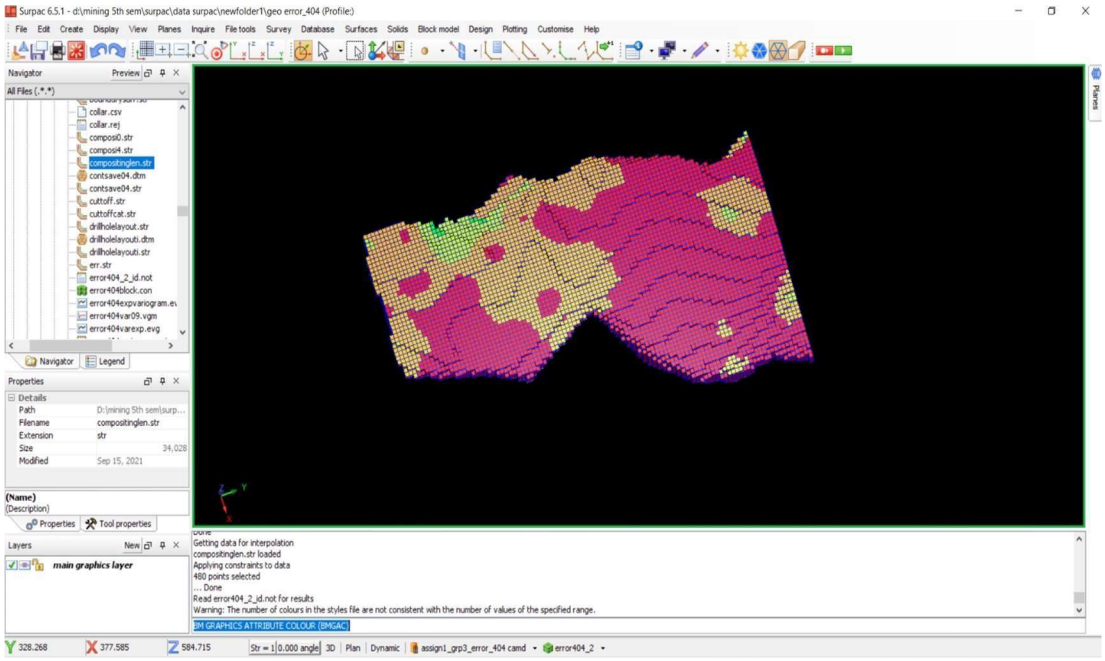
4.maximum vertical search distance – 10.



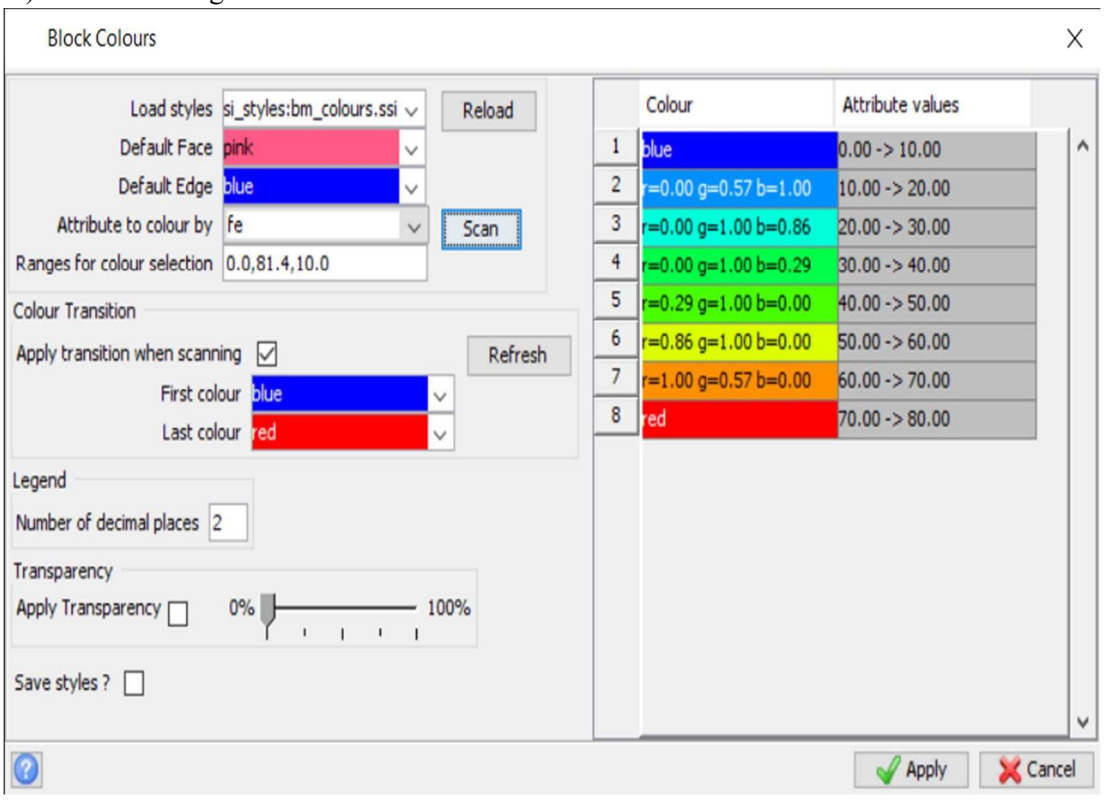
iv) Now we give inverse distance parameter – we select inverse distance power to be 2.

v) We can see the ore body blocks developed after IDW method.

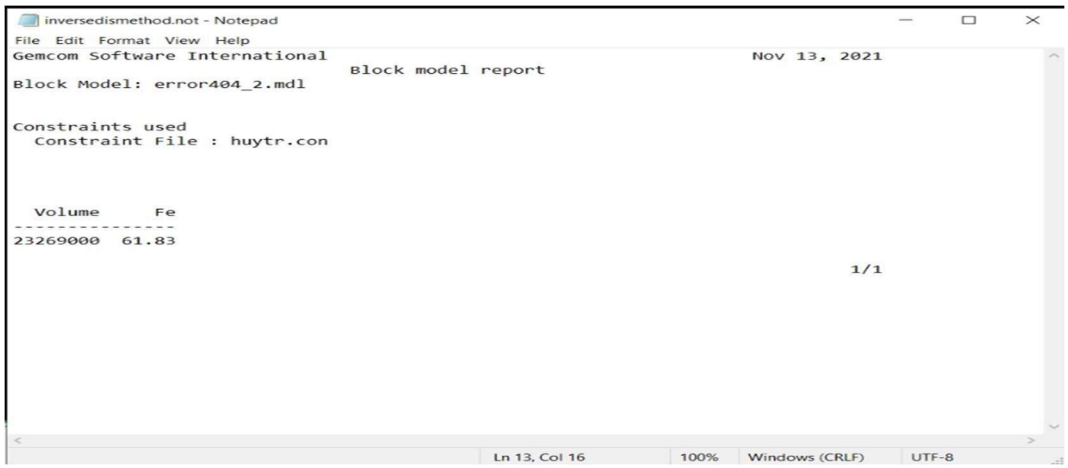




vi) Colour legends are as follows:-



vii) The report which we get from IDW method are as follows:-



inversedismethod.not - Notepad

File Edit Format View Help

```
Gemcom Software International                                    Nov 13, 2021
                                   Block model report
Block Model: error404_2.mdl


Constraints used
  Constraint File : huytr.con



  Volume      Fe
---------------
23269000   61.83
                                                                    1/1
```

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ESTIMATION BY KRIGING METHOD

i) Now same block model value we will calculate by kriging method.

ii) We select block model->estimation->simple kriging

iii) For kriging we need variogram model developed which is used in calculation of individual block grade value.

iv) We give the kriging parameter:-

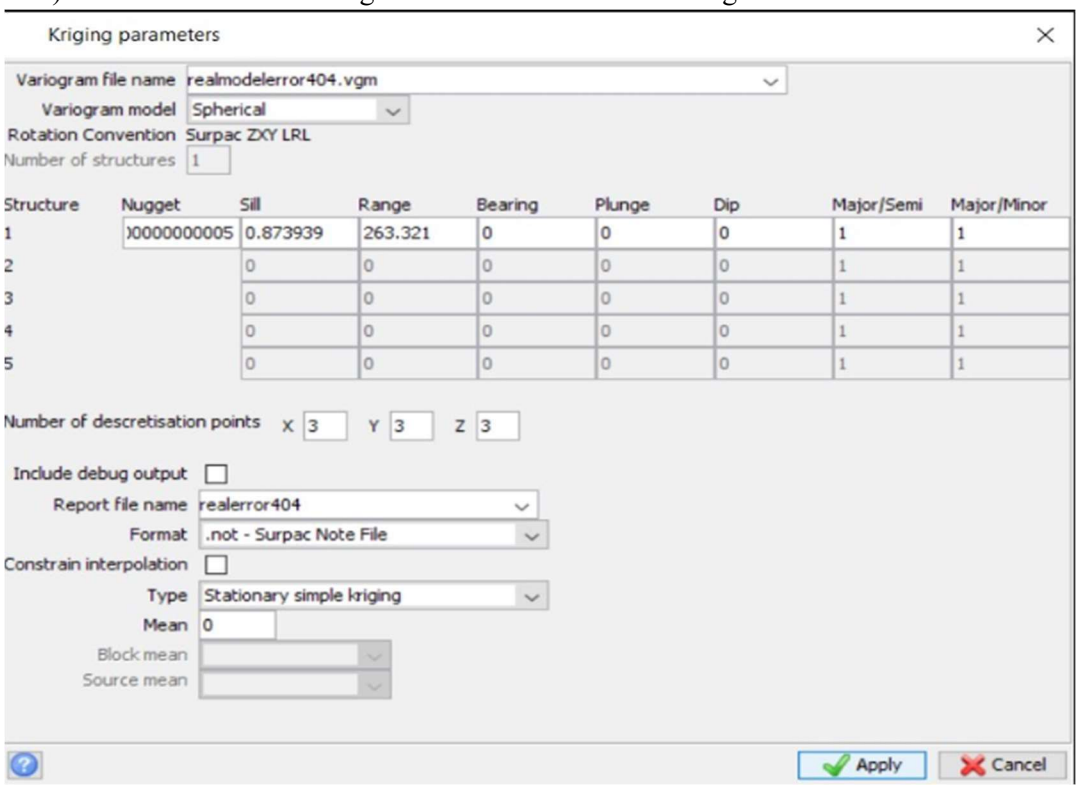
1.minimum no of sample to select – 3.

2.maximum no of sample to select – 15.

3.maximum search radius – 220.

4.maximum vertical search distance – 10.

v) We select the variogram model from our file storage.



Kriging parameters

Variogram file name: realmodelerror404.vgm

Variogram model: Spherical

Rotation Convention: Surpac ZXY LRL

Number of structures: 1

Structure	Nugget	Sill	Range	Bearing	Plunge	Dip	Major/Semi	Major/Minor
1	)0000000005	0.873939	263.321	0	0	0	1	1
2		0	0	0	0	0	1	1
3		0	0	0	0	0	1	1
4		0	0	0	0	0	1	1
5		0	0	0	0	0	1	1

Number of descretisation points X 3 Y 3 Z 3

Include debug output ☐

Report file name: realerror404

Format: .not - Surpac Note File

Constrain interpolation ☐

Type: Stationary simple kriging

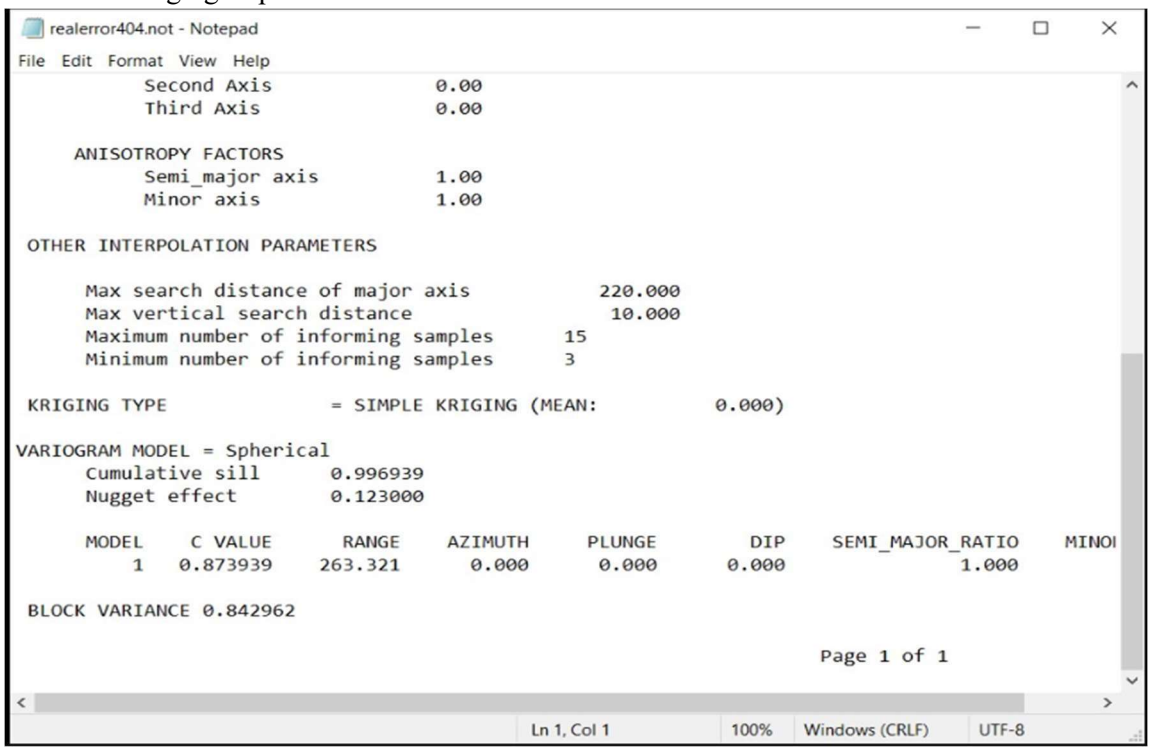
Mean: 0

Block mean

Source mean

Apply | Cancel

vi) After clicking apply we will see our ore block with new values calculated according to the kriging steps.



```
realerror404.not - Notepad
File  Edit  Format  View  Help
          Second Axis              0.00
          Third Axis               0.00

     ANISOTROPY FACTORS
          Semi_major axis          1.00
          Minor axis               1.00

 OTHER INTERPOLATION PARAMETERS

      Max search distance of major axis          220.000
      Max vertical search distance                10.000
      Maximum number of informing samples      15
      Minimum number of informing samples      3

 KRIGING TYPE              = SIMPLE KRIGING (MEAN:          0.000)

VARIOGRAM MODEL = Spherical
      Cumulative sill       0.996939
      Nugget effect         0.123000

      MODEL     C VALUE      RANGE     AZIMUTH      PLUNGE        DIP    SEMI_MAJOR_RATIO    MINOI
          1    0.873939    263.321       0.000       0.000      0.000               1.000

 BLOCK VARIANCE 0.842962

                                                                  Page 1 of 1
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```
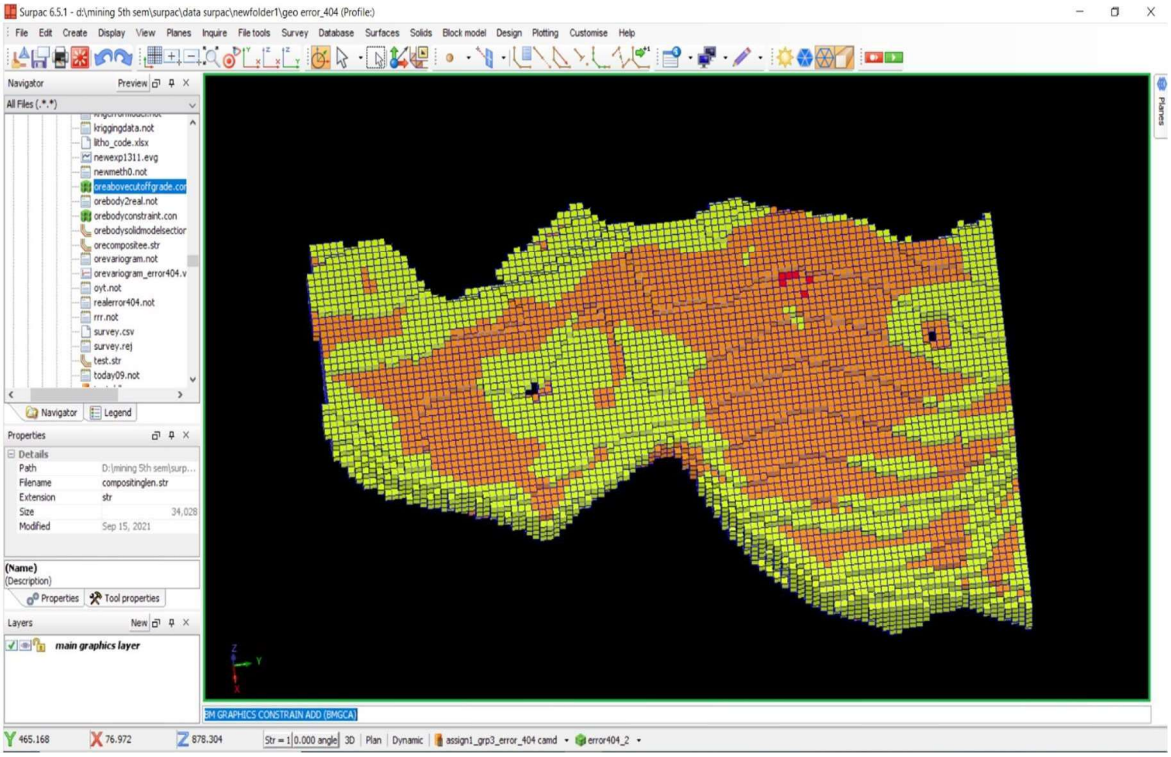
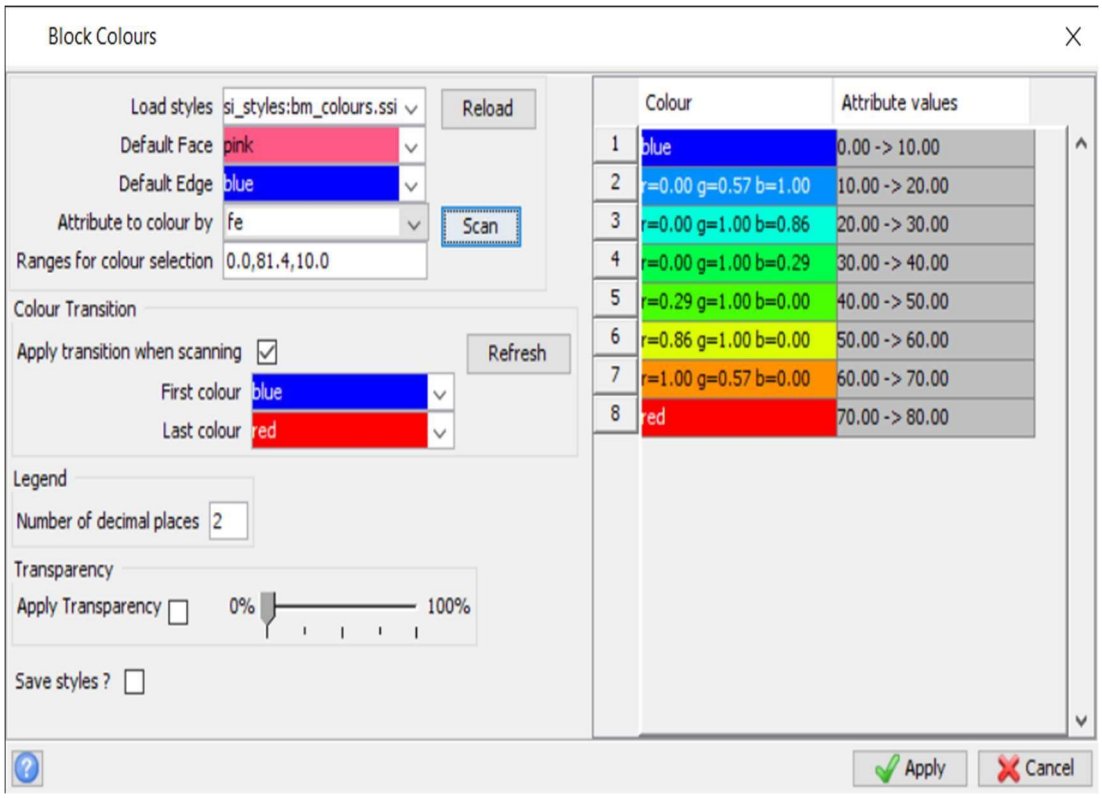
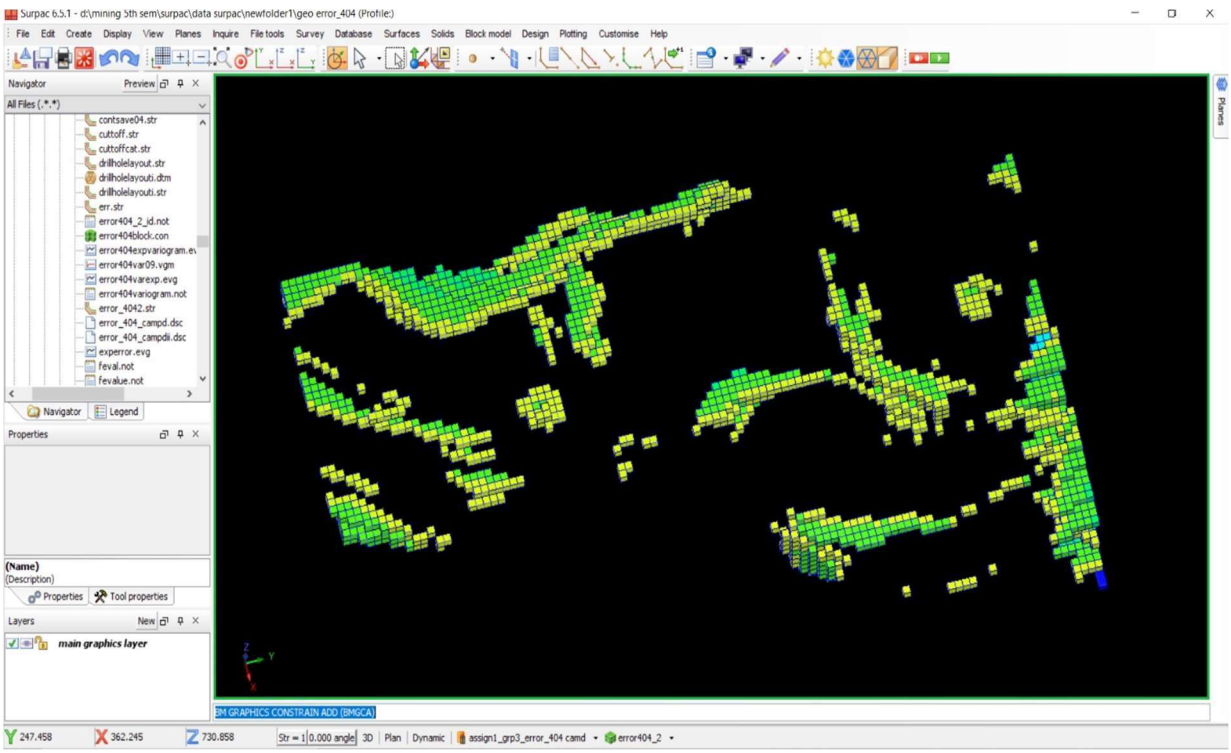

vii) Our ore body after kriging will look as follows:-



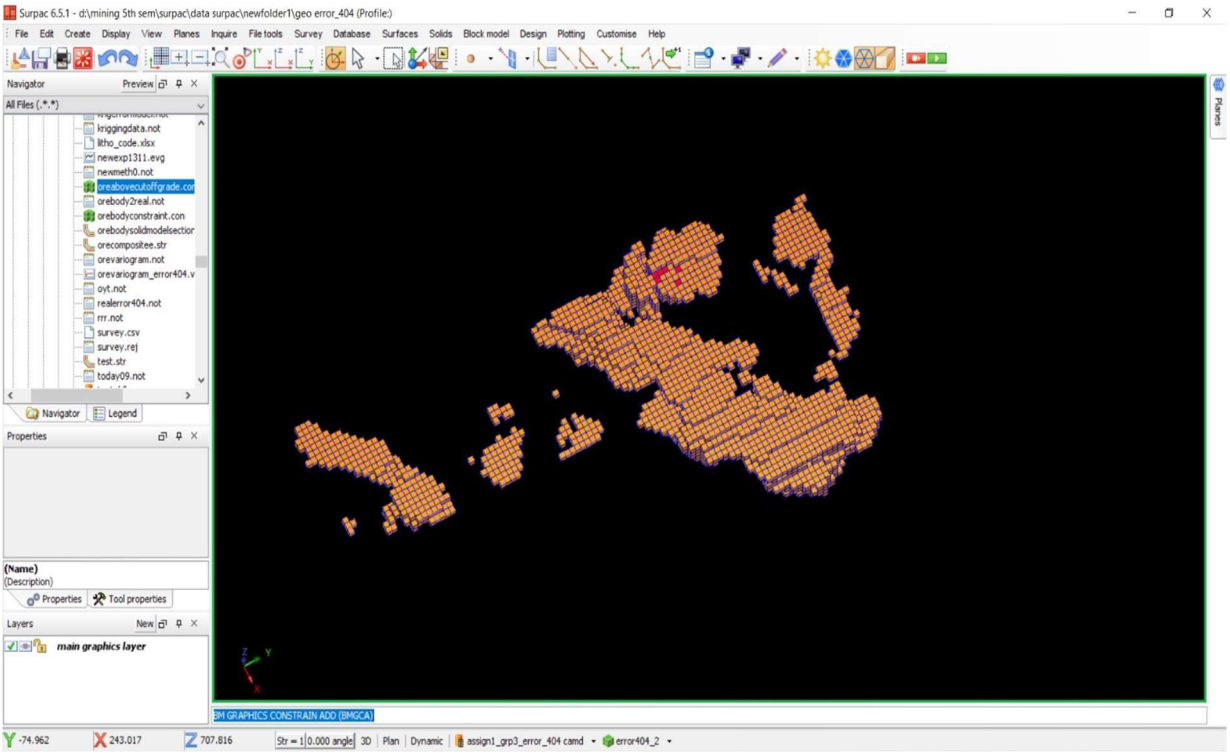
viii) The legend used are:-



ix) By adding constraint to block we can see the waste present in our ore according to kriging model:-



x) By adding constraint we can also see ore of high value present in the ore body in our our case we have applied to display the ore body with value greater than 65% of an attribute fe:-

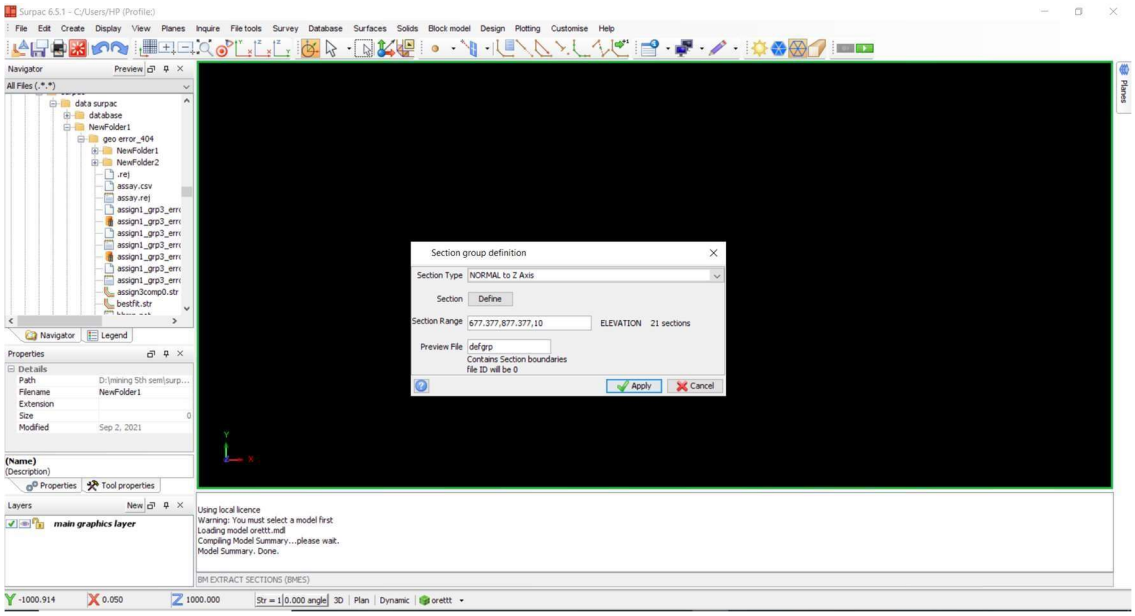


OBSERVATION OF IDW VS KRIGING

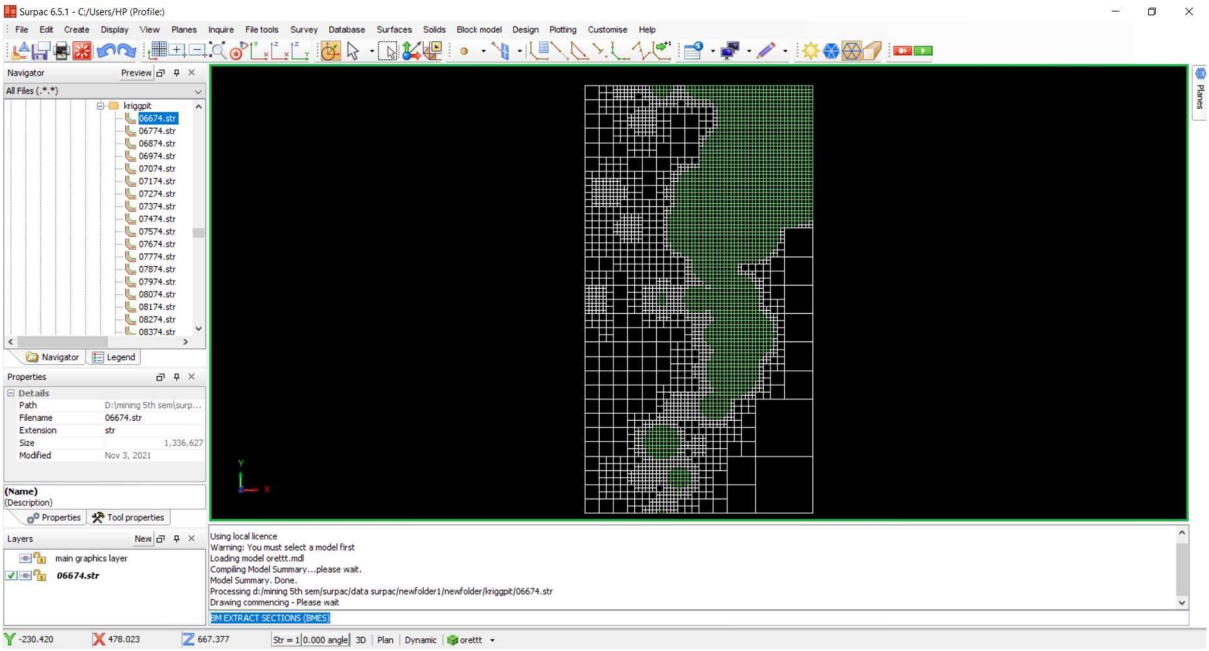
We can clearly observe from the orebody block model that ore body grade decreased drastically when estimation was done by the kriging method.
Kriging is more precise than IDW method since kriging is more advanced geostatistical tool , it considers directional effect of grade. We get good and accurate result when we estimate by kriging method.

9. ULTIMATE PIT DESIGN

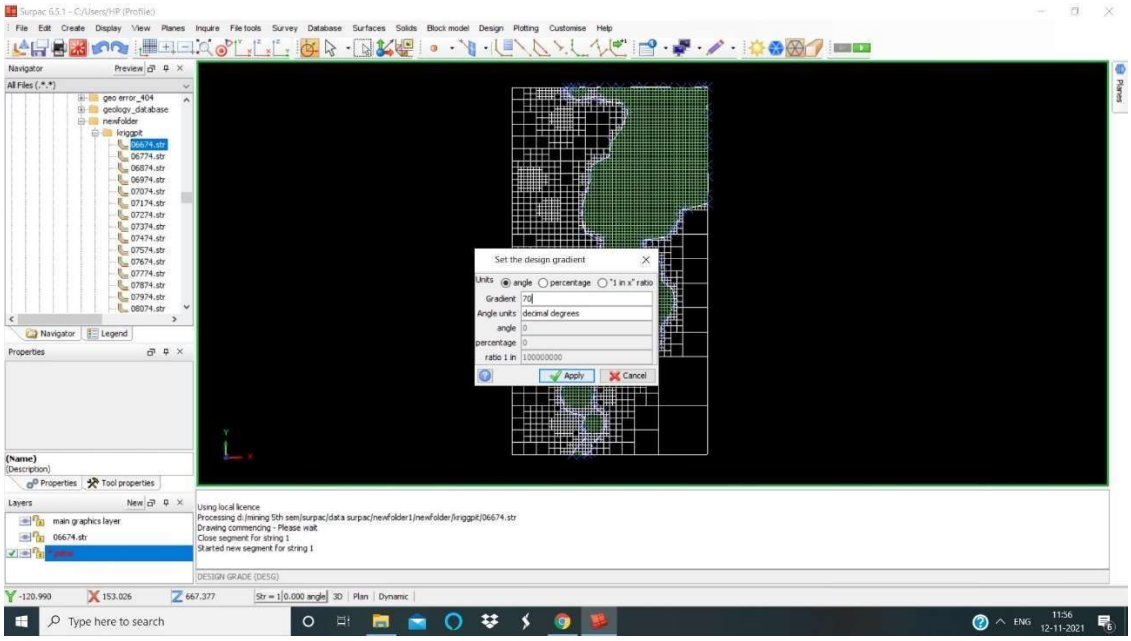
1. After block modelling and estimation our aim is to make the final design/layout of the pit. Pit we generate in same way as we have generated ore body by section and digitizing it instead of drill holes in pit we digitize our block model,
2. Block model sectioning is done.
3. First we go to block model->sections->define , in section type we select ‘Normal to z-axis’ ,then in section range we give value in (lower,upper,range) format by this we will generate sections from block model in z-direction in interval of range.



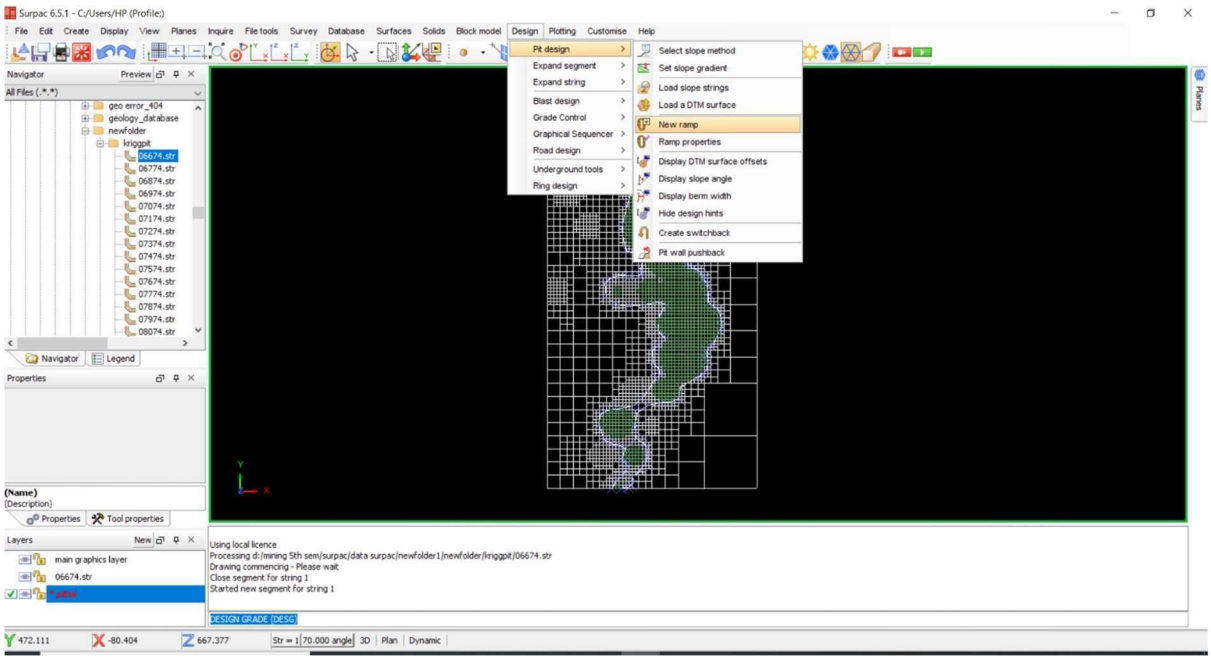
4. Then after clicking on apply 21 sections will be made and now we will have to give pit design parameter at each sections.



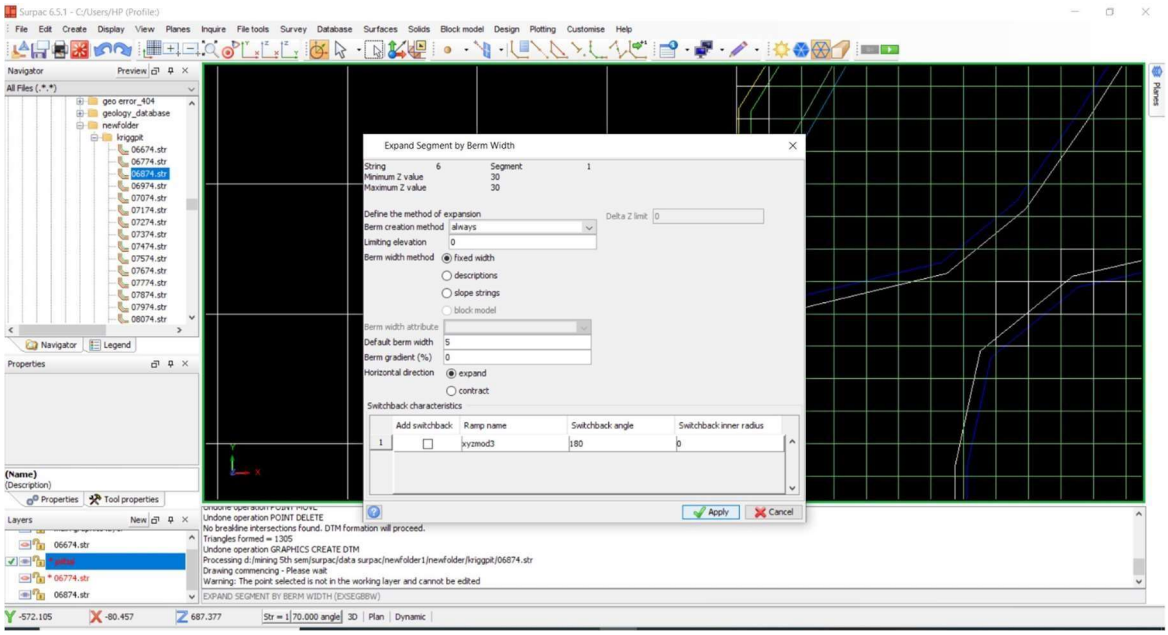
5. Now we will have to digitize it and after digitizing we give pit slope gradient. We can give by design->pit design-> set slope gradient.



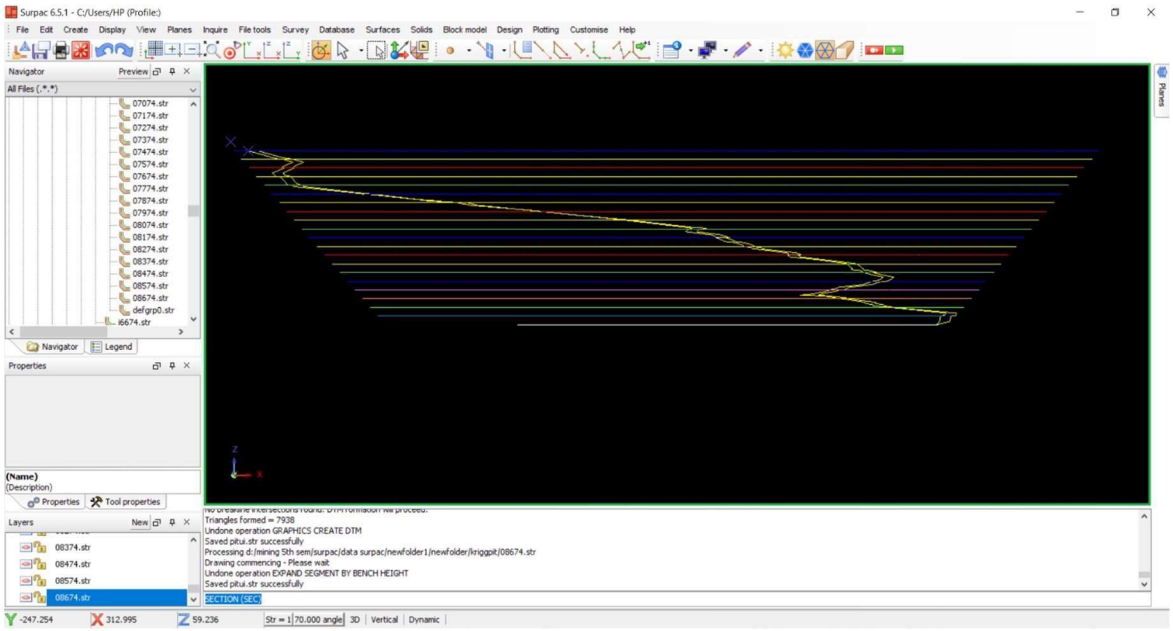
6. Now we will give ramp parameters we will follow this steps, design->pit design ->new ramp then select two points on the segment to locate the place from where our ramp should start.



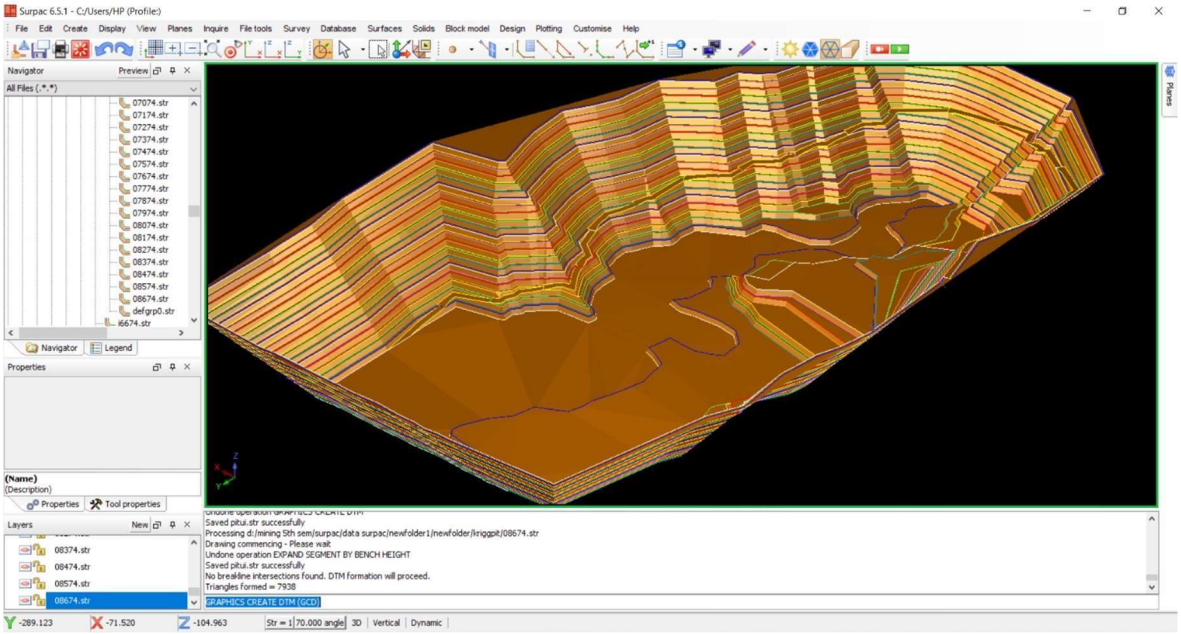
7. Then we give ramp width for our case we have chosen 10 m , however it will depend upon no of lane of haul road , and width of the haulage trucks. Width should be three times the width haulage trucks. We also give gradient of ramp in this case we have given 1in16.
8. Then we expand our pit by clicking to design->expand segment->by bench height , we select bench height of 10m in our case.
9. Then we give berm width to our bench developed by clicking to design->expand segment>by berm width. We selected berm width of 5m in our case.



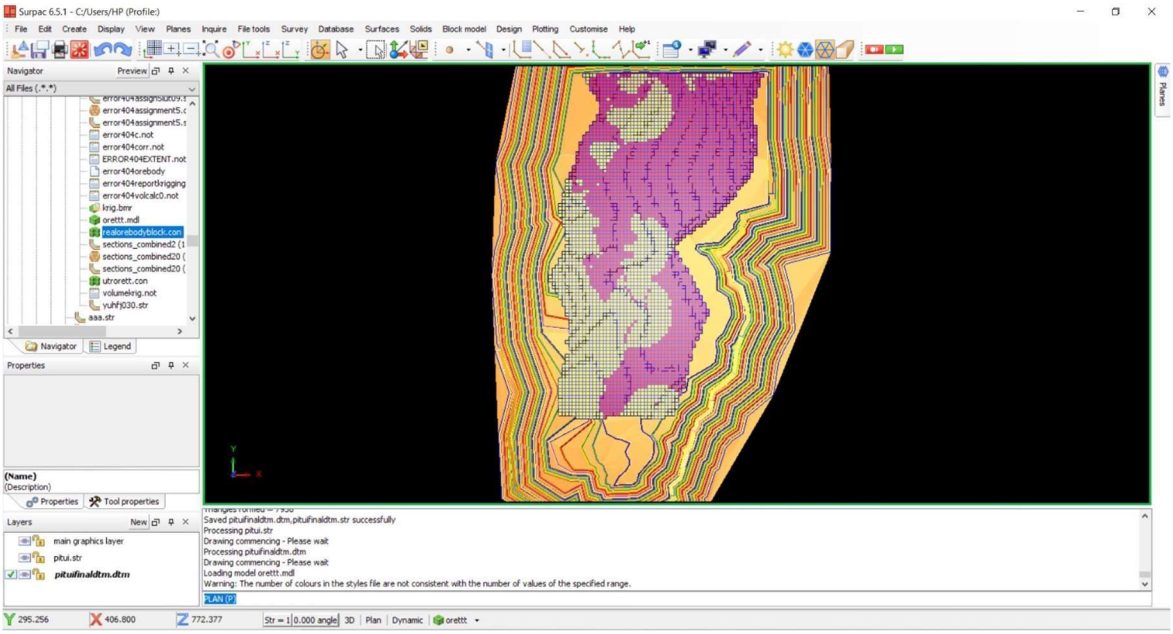
10. Then we will observe that our ramp will automatically connect to the upper bench from lower bench.
11. Then we will save our string and once again open new section we are developing our pit from bottom.
12. Now we expand our second bench string such as it should cover the new section exposed ore.
13. Then we again expand our segment by giving bench height and appropriate berm width ramp will be generated automatically and it will connect to consecutive upper bench.
14. By following this step for all 21 sections we get our ultimate pit as shown below.



15. After this we save the string and generate the .DTM of this string file we would require to do some corrections if intersection of string takes place.



16. We can see our pit by overlapping block model on our final pit.



10. APPENDIX:

* Common data types in surpac:

1. String(.str) :

A string is a sequence of three-dimensional coordinates representing some physical feature.

2. DTM(.dtm) :

Digital Terrain Model (DTM) files are generated from string(.str) files and can represent surfaces or solids.

3. Geological database(.ddb) :

Drillhole database (.ddb) files are used to connect to relational drillhole databases.

4. Microsoft access database(.mdb) :

Microsoft access database (.mdb) are files which contain the data we store.

5. Block mode(.mdl) :

A block model is a form of spatially-referenced database that provides a means for modelling a 3D body from point and interval data such as drillhole sample data. It provides a method for estimating volume, tonnage, and average grade of a 3D body from sparse drillhole data.

* Basic Terminology in variograms:

1. Azimuth:

It's the bearing of the search line (i.e., Axis of Cone/Cylinder)

2. Plunge:

It's the angle made by search line with horizontal (lies between -90 to 90 degrees)

3. Spread:

It's the angle made by a curved edge of the cone with search line (lies between 0 to 90 degrees)

THANK YOU