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OREBODY MODELLING AND RESERVE ESTIMATION BY USING SURPAC

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ABSTRACT

Generally, the size of the database is just too bulky to manage studies with hand effort. Thus, numerical algorithms and mathematical approaches necessitate computer applications to beat huge computational time and process. Currently, many computers aided systems and software deliver for geological modelling. The accuracy and speed of computers enable the evaluation of varied scenarios within reasonably short times. Computer systems have been demonstrated very essentially for mining and geological studies.

SURPAC is a computer-aided valuation system capable of generation of the survey, stratigraphy, assay databases, drill hole, and bench compositing, 2D and 3D log sectioning, contouring, 3D surface generation, cross-sectioning, 3D orebody modelling, designing of the open pit, volume, and reserve estimation andeconomical valuation.

With the help of a mine planning and design software SURPAC, a geological database was created into whichthe coordinates and alignment of the borehole points and their constituents along with their grades were fed.

The deposit which has been studied is Gold. From this database, the boreholes were displayed graphically in the software GUI (Graphical User Interface). Further, surface generation using the points was done that facilitated the manual task of sectioning individual borehole row sets. After sectioning all the hole sets, a solid model representation of the ore deposit was generated and validated and its volume and tonnage were determined with the input of its specific gravity which is known as reserve estimation. Moreover, the borehole data was composited using the downhole compositing method, and statistical trends of individual constituents of Gold were studied. Block modelling was done with the help of a downhole composite and the volume of the total block modelwas also calculated.

A resource is the tonnage and grade of the subsurface material of interest. The resource is in-situand may not be economic to extract. A reserve is that fraction of a resource that is demonstrated to be technically and economically recoverable. Estimation of resources and reserves requires the construction of long-term models (life of the asset) for the entire deposit, which is updated every 1– 3 years of operation. Medium-term models may be built for planning one to 6 months into the future. Short-term models are built for weekly or day-to-day decisions related to grade control or detailed planning.
Constructing numerical models for long, medium or short-term resource assessment includes four major areas of work:

1. Data collection and management;
2. Geologic interpretation and modelling;
3. Grades assignment; and,
4. Assessing and managing geologic and grade uncertainty.

Data collection and management involve a large number of steps and issues.

Key words: SURPAC, DTM, Database, Orebody, Reserve Estimation, Block modelling.

I.INTRODUCTION

1.1 Introduction

The advancement in computer technology has started the development of software applications. SURPAC is one of the software applications that was developed to be used in the mining industry. This SURPAC software should be addressed by a specialized staff composed of mining engineers, surveyors,and geologists. Each of them has a separate module dedicated. The surveyors create DigitalTerrain Model (DTM), geologists create a digital model of the deposit, and mining engineers use it toestimate the production of useful minerals. Underground minerals, metals, and non-metals are invisible whose shapes, quality compositions, and quantities are not known. Geological explorations and investigations aimed at determining the unknown minerals and metals.

At the start of the process, topographical and lithology data are gathered and a database is generated by using SURPAC. Depth, thickness and grade changes, ore volume, shape and extensions, and properties are determined by mathematical and algorithm approaches using this database. All numerical estimationsare used to get out visuals to bring out ore body model. The concrete data to define the shape, location, quality, and quantity of an ore body is by bore cores. GPS data is usually taken to draw topographical maps and surfaces. Underground maps like thickness and grade contours are drawn also. Topographical coordinates are combined with stratigraphical information, a 3- dimensional data set is handled. After following several mathematical techniques, 3- a dimensional model of the ore body is often obtained. Besides the physical ore model, the quality composition should even be known.

This is often crucial because further engineering activities have a cheap aspect to perform. With the known volume of block properties like thickness and grade of ore at each particular block, it becomespossible to convert this information to an economical aspect. (Volume × tonnage factor × grade = block reserve.) Surveying includes 3-dimensional components x, y, and z (easting, northing, elevation) which are used for surface modelling. Drill hole data depth and layer information contribute to explaining how the geological structure is in the three dimensions. Drill holes also carrythe knowledge about ore grade. Geological interpretation of stratigraphical layers provides a 3- dimensional ore body model.

1.2 Particular features of SURPAC software

- Covers all disciplines, Geology, Resource Modelling, Mine Engineering, Survey,Production,Surface, and Underground.
- Multi-language including the ability to add and customize.
- Flexible scripting tools to allow automation of processes and development of productextensions.
- Reads and writes native file formats of other mine planning products, including some CAD andGIS formats.
- Widely used and supported by consulting industry.

1.3 Objectives

- To create a geological database through the borehole log data.
- To create a BLOCK MODEL of the ore body.
- To predict with the greatest accuracy possible the shape, distribution, and concentration ofthe ore before mining.
- To find out the most appropriate method for reserve estimation by block modelling usingSURPAC.
- Calculation of correct volume of material removed from an area between certain periods asrequired.
- Reserve estimation to optimize and conserve the mineral resource.
- Multi-elemental grade calculation, grade control, and prediction.

II.LITERATURE REVIEW

Erarslan *et al.* (2001)

Geological Block Models are used to generate economical block models by using unit costs and income. As the volume of a block, thickness, and grade of ore at each particular block is understood, then it becomes possible to convert this information to an economical aspect. Multiplication of volume, tonnage factor, and grade give block reserve. Economical block models have visual and numerical results.

Indranil *et al.* (2005)

They concluded that ore body modelling on geological of an ore deposit. Geologists and mining engineers can enjoy such an integrated modelling approach by honouring deposit geology, understanding distribution, and emphasizing spatial continuity studies. The model can act as a principal guide for the development of the mineral inventory model and grade-tonnage curves which ultimately can cause a worth model in terms of economic extraction of the ore body.

Michel *et al.* (1966)

Having conducted ore reserve estimation on four deposits (A, B, C, D) they felt it's more complicated with a large number of fractures in the ore deposit. When the ore body 5problems are there the geologist's advice is essential. Geologists had proposed he work with the automatic kriging method.

MS Khakestar *et al.* (2013)

Determined the Best Search Neighbourhood in Reserve Estimation Ordinary kriging and non-linear geostatistical estimation methods are accepted in mining methods are used for reserves estimation. To evaluate a specific kriging neighbourhood truth and estimated block grades, the amount of kriging negative weights and therefore the kriging variance. Radius is one of the foremost important parameters of search volume which frequently is decided on the idea of the influence of the variogram.

Ping Huang *et al.* (2011)

The three-dimensional geological model of a mine including the geological database, ore body model, and block model, was established by mining software SURPAC. The calculation results are accurate,which may be utilized in the resource estimation, reserve calculation, and mine design of the mine production stage. The three-dimensional model of the ore body was established by using SURPAC software.

III.METHODOLOGY

3.1 Introduction of resource modelling

3.1.1 Approach

Geologic interpretation and modelling require that site-specific geologic concepts and models are integrated with actual data to construct a three-dimensional model of geological domains. This geologic model is a representation of those variables that control the mineralization the most and formsthe basis for all subsequent estimations. Often, the geological model is the most important factor in the estimation of mineralized tonnage. The concentrations of different elements or minerals (grades) are assigned within geological domains. The grades within the different domains may be reasonably homogeneous; however, there is always some variability within the domains. The grades are predicted at a scale relevant to the anticipated mining method. The recoverable resources are calculated considering a set of economic and technical criteria. There are a wide variety of methods available and many implementation aspects must be considered. The chosen method will depend on the study objectives, the available data, and the professional time available to complete the study. Resource estimates should be complemented with a measure of uncertainty. All numerical models have multiple significant sources of uncertainty including the data, the geologic interpretation, and the grade modelling. A statement quantifying the uncertainty in the predicted variables is required for good and best practices.

3.1.2 Scope of Resource Modelling

The collection, gathering, and initial analysis of data are the first steps in mineral resource modelling. Sufficient quality controls and safeguards are required to achieve an adequate degree of confidence in the data. The overall process of Quality Assurance and Quality Control (QA/QC) should encompass field practices, sampling, assaying, and data management. This is necessary to ensure confidence in theresource model. The data are subsets within different geological domains.

These domains may be based on a variety of geological controls such as structure, mineralogy, alteration, and lithology. Categorical variable models are constructed to subdivide the data and focus the analysis on different regions of the subsurface. Domains are commonly assigned to a gridded block model. The block model must have sufficient resolution to represent the geological variations and provide the required resolution for engineering design. Of course, the number of blocks must not betoo large. At the time of writing this book, it is common to use 1 to 30 million blocks. Larger models are possible, but they require more computer resources, and managing multiple realizations of many variables becomes time-consuming.

Statistical analyses of the available data are required before decisions can be made about geological domains. Mineralization controls interact to control the spatial distribution of grades. Compositing the original data values is common practice. This is done partly to homogenize the support of the data used in estimation, but also to reduce the variability of the dataset. Further statistical analyses are performedto understand and visualize the data distributions and to define the most appropriate form of estimation. After defining the block model geometry and geological domains, it is necessary to assign grades. The choice of an estimation method and the formulation of plans for grade interpolation are described in later chapters.

Special considerations required for simulation are also discussed. Each step in mineral resource estimation requires assumptions and decisions that should be explicitly stated. Perceived limitations and risk areas should be documented. The process of model validation and reconciliation is iterative. The calibration of a recoverable resource model against the production, if available, is particularly important to ensure future predictions are as accurate as possible. Proper and detailed documentation isrequired for each step. An audit trail must be created during the entire resource estimation process to allow a third party to review the modelling work. Transparency and the ability to allow for peer reviews are essential components of the work.

3.1.3 Critical Aspects

The estimation of resources and reserves requires detailed consideration of several critical issues. Like a chain, they are linked such that the quality of the overall resource estimate will be equal to the quality of the weakest link; any one of them failing will result in an unacceptable resource estimate.

Resource estimators must deal with these issues daily. The quality of the mineral resource estimate depends firstly on the available data and the geological complexity of the deposit; however, the resource estimate is also strongly dependent on the overall technical skills and experience of the mine staff, how the problems encountered are solved, the level of attention to detail at every stage, the open disclosure of basic assumptions along with their justifications, and the quality of the documentation foreach step.

The emphasis on documenting every aspect of the work is stressed throughout this book because it is the final and, possibly, the most important link in the chain. Justification and documentation of every important decision serve as quality control of the work because it forces detailed internal reviews. In addition, it also facilitates third-party reviews and audits, which are a common requirement in the industry.

3.1.4 Data Assembly and Data Quality

The quality of the resource estimate is directly dependent on the quality of the data gathering and handling procedures. Many different technical issues affect the overall quality of the data. Some important ones are mentioned here. The concept of data quality is used pragmatically. The concept is that data (samples) from a certain volume will be collected and used to predict tonnages and grades of the elements of interest. Decisions are made based on geological knowledge and statistical analyses applied in conjunction with other technical information. Therefore, the numerical basis for the analyseshas to be of good quality to provide for sound decision-making.

3.1.5 Geologic Model and Definition of Estimation Domains

Much geologic information is gathered during the investigations performed at different stages of a mining project. The information is used to understand the genesis of the mineral deposit, the distribution of mineralized rock, and to develop exploration criteria for increasing resources. The level of detail in the geologic description of a deposit steadily increases as the project advances through its different stages. Economic factors are the most important ones affecting the decision of whether or not to proceed with further geologic investigations; therefore, most geologic work is orientated toward finding more mineral resources and to some extent to more detailed general exploration. Not all geologic information is relevant to resource estimation.

Geologic investigations for resource development should concentrate on defining mineralization controls. Certain geologic details and descriptions are more useful for exploration in that they do not describe a specific mineralization control, but rather provide guidelines for mineral occurrences. The process of defining estimation domains amounts to modelling the geological variables that represent mineralization controls. The estimation domains are sometimes based on combinations of two or more geologic variables, for which a relationship with grade can be demonstrated. For example, in the case of an epithermal gold deposit, an estimation domain can be defined as a combination of structural, oxidation, and alteration controls.

The frequency and volume of these within the pipe may condition the definition of estimation domains. The determination of the estimation domains to use is based on geologic knowledge and should be supported by extensive statistical analysis (exploratory data analysis, or EDA), including variography.

Quantifying Spatial Variability

The grade values observed within a mineral deposit are not independent of each other. Spatial dependency is a consequence of the genesis of the deposit, that is, all of the geological processes that contributed to its formation. A clear description of the spatial variability (or continuity) of the variables being modelled is desirable. Knowledge of the spatial correlation between different points in the deposit will lead to a better estimation of the mineral grade at an unknown location. The spatial variability is modelled using the variogram and related measures of spatial variability/correlation. A spatial variability model improves the estimation of each point or block in the deposit. Parameters of the model are important. Attention should be paid to the definition of the nugget effect (the amount of randomness); the number of structures; the

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behaviour of the variogram model near the origin; and the specification of anisotropic features.

3.1.6 Location of Drill Holes, Trenches, and Pits

The geostatistical tools used to predict the tonnages and grade of ore material are based on knowledge of the location of the samples. The location of each sample is expressed as two- or three-dimensional coordinates (X, Y, and Z) and is obtained by surveying its position in space. Several surveying methods can be used. The location of the drill hole collar as well as the deviations down the hole are surveyed. The location information can be handled using different coordinate systems, but one system should be used for the project to avoid errors.

The location of the drill hole collars is typically surveyed with total stations tied to a local triangulation point. High-precision GPS systems are increasingly common. It is also common to develop a local topographic map from a topographic satellite or fly-over (aerial) image. All surveys should be checked against other information such as the general topography map of the area. The elevation of the drill holes should coincide with the available topographic surface within an acceptable tolerance. A discrepancy of more than half a bench or stope height is considered a problem. Two meters of maximum error in elevation is generally acceptable. Down-the-hole surveys measure drill hole deviations after the drill hole is completed. Commonly used measuring devices are based on photographs of a bubble ring and related to an original orientation, such as single or multi-shot photos, a magnetic compass, or small gyroscopes, from which azimuth and dip measurements are taken. For additional details on measuring devices. The device is lowered into the hole, taking azimuth and dip measurements at pre-specified intervals, typically every 20 to 50 m down the hole. The measurements are later used to determine the X, Y, and Z location of each sample. The measured azimuths and dips are particularly important for long, inclined holes. The deviation of a drill hole is a function of the rockit traverses, the drilling technique used, and the depth and initial inclination of the hole. If the hole is drilled close to the schistosity of the natural fabric of the rock, it will tend to follow the weaker planes in the rock. If the drill hole is drilled at a higher angle, it will tend to deviate normally to planes of weakness. If the hole is expected to deviate significantly, then more frequent measurements should be taken. The composition of the rock being drilled through is another consideration since some of the instruments used are affected by natural magnetism, such as the reflex system and single-shot devices. The presence of magnetic iron ore minerals, such as magnetite, pyrrhotite, and quartz-magnetitealterations may affect the readings. Other factors that increase the likelihood of down-the-hole deviations are sudden and periodic changes in rock hardness. Finally, the measured azimuths should becorrected for magnetic declination, particularly in high latitudes.

Figure: Boart Longyear's LF-140–2 Core Drill Rig (diamond drilling)

3.1.7 Sampling Methods and Drilling Equipment Used

In addition to drilling, samples can be obtained directly on the surface or from underground workings through trenching, channel samples, or chip samples. Samples chipped from a rock exposure are generally not used in resource estimation. Although a properly done channel sample provides good information, in practice, it is very difficult to obtain consistently representative samples.Representative channel samples will correspond to limited spatial coverage along exploration adits or underground workings.In underground mines, where channel samples are routinely gathered for grade control, the spatial coverage is more significant, but the sample quality tends to be poorer, because of the shorter times allowed for the sampling and assaying cycle. Most channel samples in this case become chip samples, where only a small amount of rock is taken from the face, with a high probability of being biased. Drilling is the most common and important method for obtaining representative samples. Drilling allows sampling an unexposed orebody.
The most common types of drill holes include conventional rotary (percussion), reverse circulation,and diamond drill holes. Each drilling method has its characteristics and variants that affect the quality of the samples collected. Although other methods exist, they are either for special applications or have been replaced because they are slower and more expensive. W.C. Peters provides a clear discussion on different drilling and sampling methods.

3.1.8 Relative Quality of Each Drill Hole or Sample Type

It may not be appropriate to use samples from a percussion rig and a diamond drill hole simultaneously to obtain a resource estimate. One set of samples may be biased concerning the other. When more than one sample type is available, it is necessary to make comparisons of each set of samples and their statistical properties. Ideally, it is better to compare sets of twins or duplicate samples, but they are not always available. Commonly, channel or chip samples will also show significant differences with nearby drill hole data.

Data from biased drill hole or channel samples should be discarded or used cautiously solely for the construction of a geological model. In some cases, secondary poorer quality data could be used in some form of cokriging (Journel and Huijbregts 1978). Samples from percussion drilling commonly suffer from significant loss of material and little control during the drilling operation; high or low grades may be preferentially lost. Also, significant mixing of material occurs as the samples come up the hole; thus, the exact location of the sample is uncertain. In most cases, data from percussion drilling is not acceptable for resource estimation. Reverse circulation drilling is cheaper than diamond drilling, and so, for a given budget, may provide more information. If done carefully and under good sampling conditions, it can provide good samples.
Often, reverse circulation drill holes are of larger diameter than common diamond drill holes. It may be difficult to obtain good geological descriptions since the material is recovered as broken rock chips. Diamond drilling is more expensive, although if core recovery is good, it has the advantage of bringing intact rock to the surface. This allows for better geologic mapping, and, after splitting the core in half, provides a representative sample for preparation and assaying. The down-the-hole location is better known than other types of drilling. Diamond drilling is generally considered to provide the best samplequality.

Figure: Partial view of the core farm for Olympic Dam's mine and expansion project

3.2 Sampling Conditions

The quality of samples also depends on the material being sampled and the conditions under which the samples are taken. For example, the presence of underground water or very fractured rock requires careful and sometimes much slower and expensive sampling methods to minimize possible biases.
Reverse circulation drilling and sampling could be particularly difficult below the water table or in the presence of significant amounts of water. Down-the-hole contamination, washing, and cave-ins are concerns, as well as loss of mineralization in the slimes produced. In these situations, and to avoid losing fines, the output water from the hole can be redirected to a large decantation barrel before final discharge. The fine material that decants in the barrel can be collected and analyzed, indicating whether the loss of fines results in a mineral grade bias.

In practice, the amount of material that can be decanted is limited and it is difficult to assign an exact down-the-hole location to the analyzed fines. Diamond drill holes can also have problems with excess water during drilling. For example, when the mineral is lodged in veinlets that can be washed away before the core is recovered. A multiple-tubing system is sometimes used to achieve better core recoveries in weak, fractured rock. Core cutting is sometimes a source of concern, particularly when a diamond-blade saw cutter is used in the presence of schistose or friable material; a hydraulic press may be preferable in these cases.

Collar table

The information stored in the collar table describes the location of the drill hole collar, the maximum depth of the hole, and whether a linear or curved hole trace will be calculated when retrieving the hole.Optional collar data can also be stored for each drill hole. For example, date drilled type of drill hole,or project name.

The mandatory fields in a collar table are shown as follows:

Mandatory Table	
	Fields
COLLAR	hole_id y x z max_depth hole_path

Table3. 1 Collar table

Survey table

The survey table stores the drill hole survey information used to calculate the drill hole trace coordinates. Mandatory fields include downhole survey depth, dip, and the azimuth of the hole.

For a vertical hole that has not been surveyed, the depth would be the same as the max_depth field in the collar table, the dip would be -90, and the azimuth would be zero. The y, x, and z fields are used to store the calculated coordinates of each survey.

Optional fields for this table can include other information taken at the survey point. For example, coreorientation.

The mandatory fields in a survey table are:

Table: Survey Table

Mandatory Table	
	Fields
SURVEY	hole_id y x z max_depth dip azimuth

Geology table

Geology table or Lithology table must be able to save information about the stratigraphic compositionof a real geology from core leading of the sample.

Table3. 3 Geology table

	Fields
GEOLOGY	depth_from depth_to hole_id rock

Sample table

Sample tables are used for storing data for a point, which has a unique sample_id. All that isrequired for this table is the sample_id and its position in space i.e., its X, Y and Z coordinates. Thesample table is ideally suited for storing and later processing geochemical soil samples. Here, the sample we focused on is gold ore.

Table3. 4 Sample table

	Fields
SAMPLE	depth_from depth_to hole_id sample_id gold

Study the drill holes

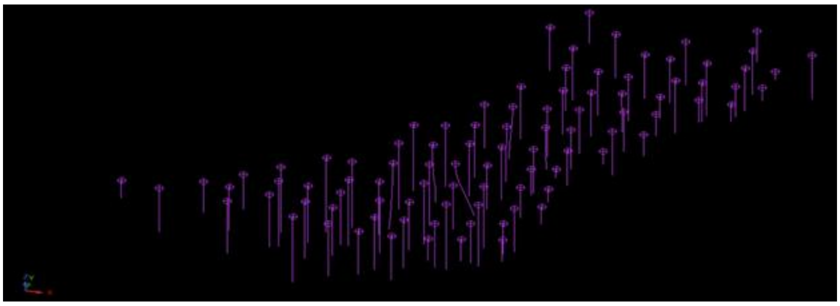

Figure: Displaying the Drillholes

Once the whole data has been processed in the software, the drill holes can be a prospect as shown in the figure. Once the drill holes have been displayed, the geology orientation and the lithology are distinguished by using colour variants. The mineral concentrations down the borehole aredifferentiated with different colours. These particular values have come from the sample and geology tables. As the gold ore body has the major mineral is gold. Once the borehole has been exhibited, the surface condition has to be known, and the ore body has to be generated to know the volume of ore which is also known as reserve estimation after compositing has been done. The surface conditions cannot be predicted from the known boreholes.

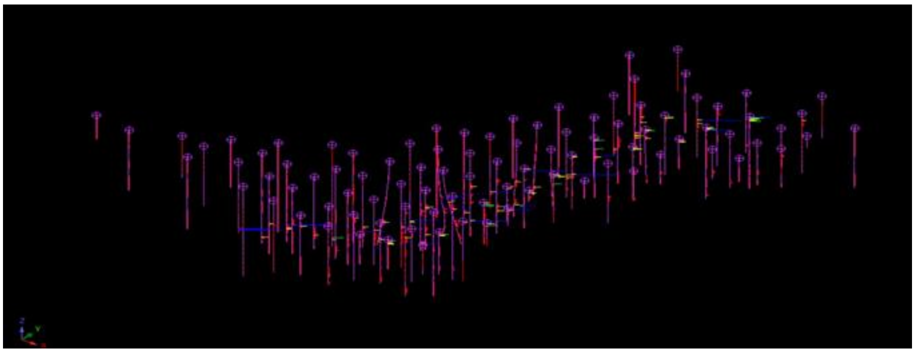

Figure: Displaying the drill holes of the geological database

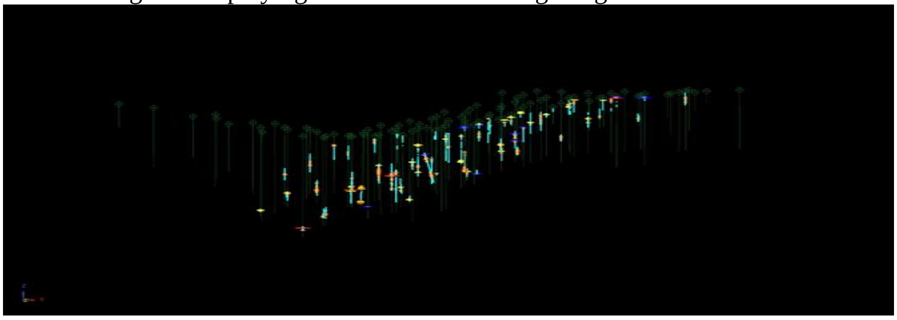

Figure: Gold grade

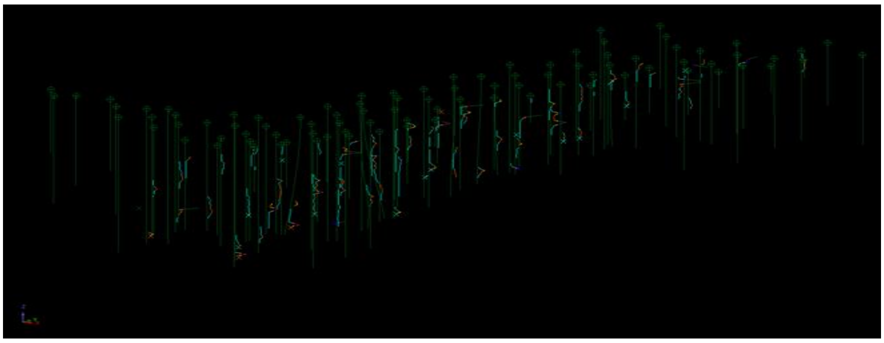

Figure: Rock material

Analysis of drill holes by creating strings and intersecting them to form an orebody

In SURPAC, string data are always raw point and line data. All data are stored as strings. A string isan order of three-dimensional coordinates representing some physical feature. As drawn lines in a sketch define vital features, so too do strings. Related strings are stored together in ASCII files called string files, recognized by a .str extension. A string file can include up to 32000 different strings. Each file is recognized by a two-part name - the two parts are nominated separately in practice, but they are combined to form a filename acquired to the computer on which the software is being run. Here the first part is called the Location code. This is an alphanumeric character identifier usually chosen to specify what the strings in the file represent, e.g., contour, borehole, etc. A second part is an ID number defining the file as a member of a set of files. This is a numeric character identifier.

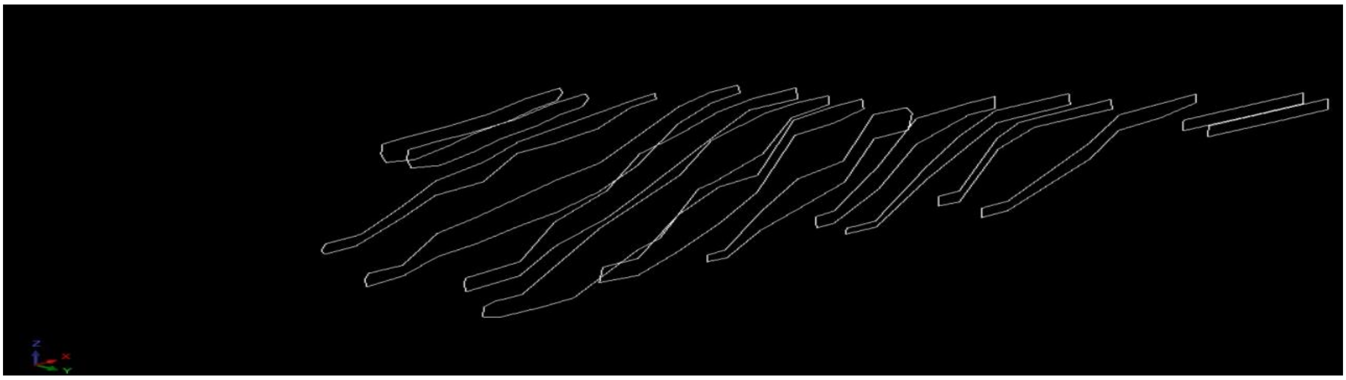

Figure: Creating strings

DTM's (Digital Terrain Models)

Digital Terrain Models or DTM's are how SURPAC models' surface. Surfaces are used in SURPAC for such things as 3D visualization and estimation calculating volumes. Almost any superficial feature can be modelled as a DTM: natural topography, lithological contacts, bedrock/overburden contact, or water table are such kinds of examples. DTMs should come from String data. Where string files contain the raw data, whereas DTM files contain a mapping of trios of points in the String file that constitute a triangle. DTM's are made of triangles, with each point of each triangle equivalent to a point in the original String file. Accordingly, DTM files are not valid without the original Stringfiles. That is, a DTM file cannot be opened if the original String file of the same name does not existin the database.

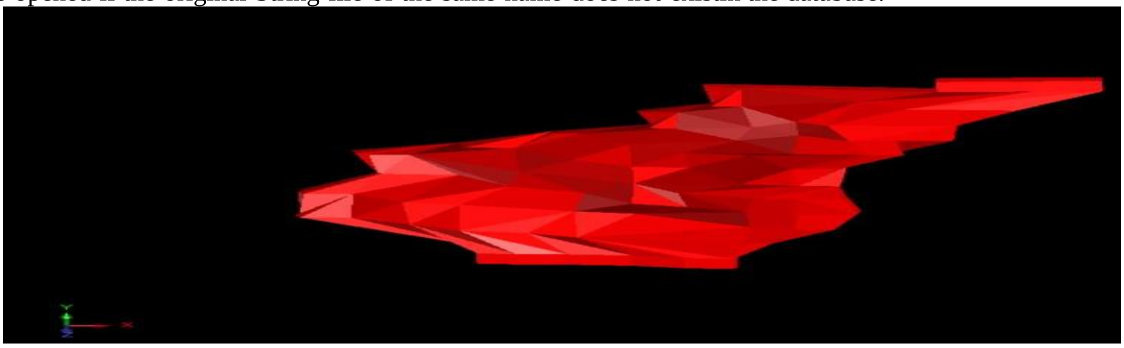

Figure:DTM (Digital Terrain Model)

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Block Modelling

The Block model is a form of spatially-referenced database that provides a means for modelling a 3-D body from point and interval data such as drill hole sample data. The Block model comprises interpolated values rather than true measurements. It provides a method of estimating the volume, tonnage, and average grade of a 3-D body from sparse drill hole data. From the available exploration data, a geological database is created to determine the extent of ore deposits and characteristics. The borehole data are composited to use to find geo-statistical values of the deposit. The boreholes are displayed based on the collar values taking into account the coordinates. It only involves the extent of the ore body. To design a block model of the ore body, constraints must be added to it which is the solid model itself. After the constraint has been connected a block model of the ore body is created. A full-body volume analysis has been done of the created block model to compare the volume of the ore body which has been determined earlier and the volume of the block model of the ore body. It has beenstrictly advised that the difference in the volume of the block model and the solid model should not exceed 1%. The above block model is also known as the parent block model. Here to view the ore body block model, the constraints must be added every time. If saved also it cannot be saved as the constraints have not been inputted in the database of the block model. Accordingly, a constrained block model has been created taking the input from the solid ore body model and saved to get theblock model in the shape of the ore body.

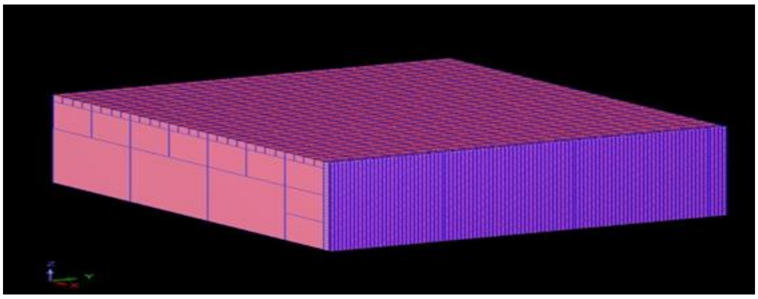

Figure: Display of Block modelling

IV.RESULTS AND DISCUSSIONS

4.1 Statistical Analysis

Brief analysis in SURPAC by using the mean and variance top cut diagram inside the Basic Statistics window. The diagram frames the mean against the Coefficient of Variation (COV) at various grade cut-offs, allowing the geologist to examine which cut-off will yield an acceptable COV and its effecton the mean grade. To help geologists in making these decisions, the development of a tool called the 'mean and variance top cut diagram', is located inside the Basic Statistics window. The diagram plots the mean against the Coefficient of Variation (COV) at various grade cut-offs, allowing the geologistto assess which cut-off will yield an acceptable COV and its impact on the mean grade. A histogram and cumulative frequency curve will then be exhibited.

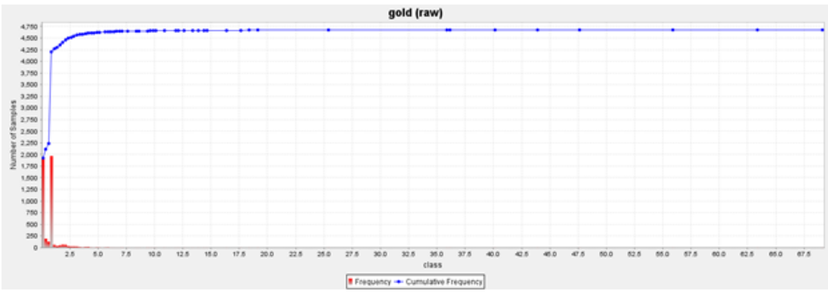

Figure 4. 1 Statistical analysis of gold for Cumulative Frequency vs Frequency (Number of samples onY-axis and class on X-axis)

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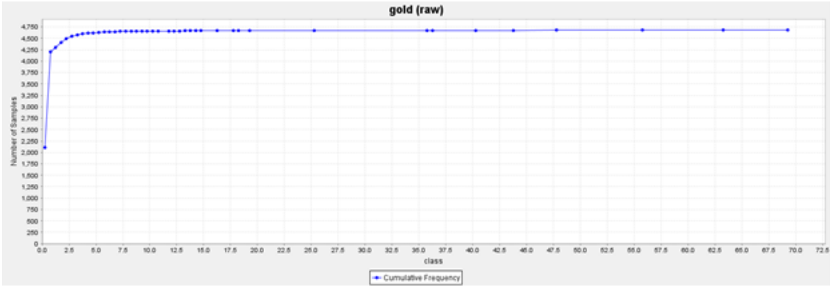

Figure 4. 2 Statistical analysis of gold for Cumulative Frequency (Number of samples on Y-axis andclass on X-axis)

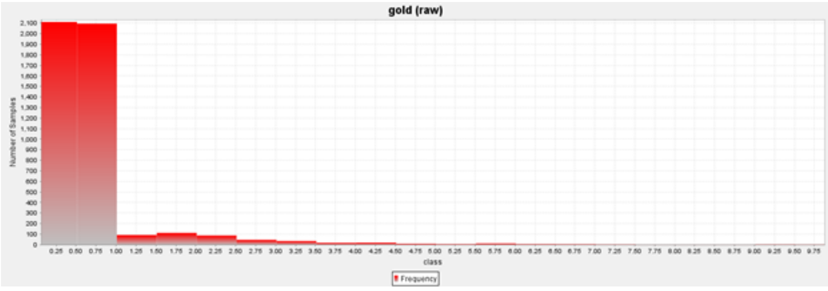

Figure 4. 3 Statistical analysis of gold for Frequency (Number of samples on Y-axis andclass on X-axis)

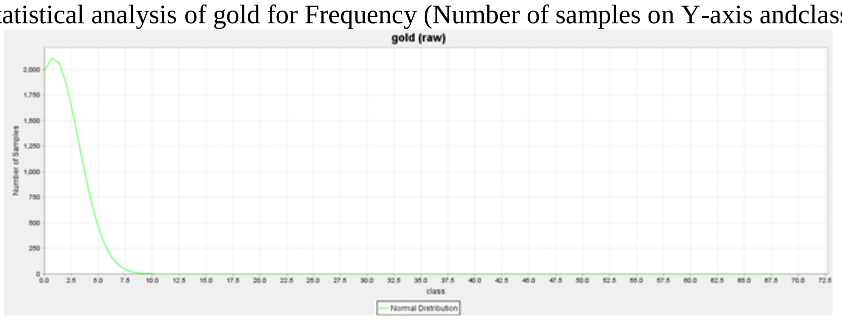

Figure 4. 4 Statistical analysis of gold for Normal Distribution (Number of samples on Y-axis andclass on X-axis)

Table 4. 1 Statistical Report on composite strings

Statistics Report

File	Composite Ore0.str	File	Compos Ore0.s
String range	All	Log Variance	3.776
Variable	gold		
		10.0 Percentile	0.01
Number of samples	4679	20.0 Percentile	0.02
Minimum value	0.01	30.0 Percentile	0.06
Maximum value	69.225	40.0 Percentile	0.21
		50.0 Percentile (median)	1
	Ungrouped Data	60.0 Percentile	1
Mean	0.855712	70.0 Percentile	1
Median	1	80.0 Percentile	1
Geometric Mean	0.243899	90.0 Percentile	1.04
Variance	5.703353	95.0 Percentile	2.147
Standard Deviation	2.388169	97.5 Percentile	3.257
Coefficient of variation	2.790857		
		Trimean	0.757
Moment 1 About Arithmetic Mean	0	Bi weight	0.6568
Moment 2 About Arithmetic Mean	5.703353	MAD	0.4368
Moment 3 About Arithmetic Mean	240.386869	Alpha	-0.00
Moment 4 About Arithmetic Mean	13049.97407	Sichel-t	1.6094
Skewness	17.648806		
Kurtosis	401.189087		
Natural Log Mean	-1.411003		

V.CONCLUSION

Once estimation of the ore body has finished the report of the ore body has been generated which shows the volume, tonnage, and average grade of the minerals of the ore body. Summary reports have also been generated as per attributes

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inputted which include calculating reserve as per depth and different mineral grades. The overall surface area is 357671m² and the volume is 3460976m³.

A common problem for all mining operations is the difficulty they face in accurately predicting the resource that can be mined at their sites. This is because every estimation is associated with an error. These errors are directly proportional to the negative effects on the mining business. The financial model could be grossly overstating the value of the actual resource, meaning the mine will never make money, or the estimation could understate the resource, and a viable and potentially very profitable deposit could be left in the ground. The solution to this problem is the application of an integrated software called Geovia SURPAC.

By using sampling data, drilling data, geological knowledge, informed interpretation, and geostatistical evaluation, GEOVIA SURPAC can provide accurate resource estimation, the results of which have many uses, including for Shareholder reports, to help raise finance, as the basis for a Whittle evaluation of the finances of the deposit, to help develop the long term mine planning schedule and for intermediate and short-term tactical scheduling in a software package such as GEOVIA Mine Sched. All of these are critical to the success of the mine, and effective resource estimation is often recognizedas being a critical factor for the success of a business.

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