A PROJECT REPORT ON

Application of SURPAC and 3D Geological Resource Modelling & Estimation of Iron Ore Deposit

Submitted in Partial fulfilment of the requirement for the degree

Of

BACHELOR OF TECHNOLOGY

In

MINING ENGINEERING

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CERTIFICATE

This is to certify that the project work entitled "**Application of SURPAC and 3D Geological Resource Modelling & Estimation of Iron Ore Deposit"** has been submitted in Partial fulfilment of the requirement for the award of ***Bachelor of Technology in Mining Engineering*** of the Malla Reddy Engineering College affiliated to JNTUH, Hyderabad for the academic year 2018-2022 is a record bonafide work carried out by

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We hereby declare that this project work dissertation titled "**Application of SURPAC and 3D Geological Resource Modelling & Estimation of Iron Ore Deposit**" is original and bonafide work of my own in the partial fulfillment of the requirements for the award of the degree of bachelor of technology in **Mining Engineering at Malla Reddy Engineering College** (autonomous) affiliated to JNTUH, Hyderabad under the guidance of Shri P. Taviti Naidu, Assistant Professor and has not been copied from any earlier reports.

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ABSTRACT

Geological 3D modeling is very important because it gives detailed information on management in the most optimal way to mine. In this project report, 3D modeling and reserve estimation of iron ore bodies was carried out through modeling software SURPAC.

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 modeling, designing of the open pit, volume, and reserve estimation and economical valuation.

With the help of a mine planning and design software SURPAC, a geological database was created into which the coordinates and alignment of the borehole points and their constituents along with their individual grades were fed into. The deposit which has been studied is an iron ore.

From this database, the boreholes were displayed graphically in the software graphical user interface (GUI). Further, surface generation using the points was done that facilitated for the manual task of sectioning of individual borehole row sets. After sectioning all the hole sets, a solid model representation of the ore deposit was generated, 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 downhole compositing method and statistical trends of individual constituents of iron were studied. Block modelling was done with the help of downhole composite and the volume of the total block model was also calculated. The anomalies in the volumes between solid model and block model was discussed.

Key words: Geological Database, Solid Model, Block Model, SURPAC Software, Reserve Estimation, Grade Measurement.

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CHAPTER-I

INTRODUCTION

1.0 INTRODUCTION

In the mining industry, there are two aspects which are highly essential to monitor and optimize apart from environment- money and time. Equivalently in a mining industry, time is money; one has to extract much resources in a limited period of time to earn profits. This necessitates proper planning on where to extract and how to extract resources and timely execution of the planning prospects.

Planning for opencast mines is done by assessing the total reserve and the average grade of the deposit. From this data, scheduling is done time to time based on where to extract the ore at a particular point of time. Sometimes the mine management may ask for rich grades of ore while sometimes it may ask for normal grades and ore blending.

Opencast mine planning is done by first generating a representative model of the ore deposit, then dividing the ore body into smaller blocks and sub-blocks which is basically referred to as block modelling. From the stage of block modelling, a suitable depth is selected from which the pit is to be designed. While designing the pit, it should be kept in mind that the stripping ratio should be economical in order to minimize losses.

For the process of geological modelling and opencast mine planning, several software's have come into use with the application of information technology in mining industry. Among them, SURPAC is one having multiple high-end functions of mine modelling. The software has been developed by GEMCOM international. It is a complete software of mine planning and designing.

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 estimations are 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 becomes possible 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 modeling. Drill hole data depth and layer information contribute to explaining how the geological structure is in the three dimensions. Drill holes also carry the knowledge about ore grade. Geological interpretation of stratigraphical layers provides a 3-dimensional ore body model.

This project aims at the modelling of an iron ore deposit using SURPAC software which will help in 3d visualization & ore reserve estimation of deposit consisting of 71 boreholes.

1.1 Objectives

- To develop a graphical representation of the ore deposit.
- To know the shape, distribution of ore deposit.
- Compute its reserve and estimate its grade with the purpose of better mineral resource evaluation.

1.2 Content of The Thesis

The thesis consists of five chapters they are introduction, literature review, method of working, results, conclusion and in this chapters, there are different kind of sub topics like in introduction chapter-I - introduction and objectives which explain about things we have done in this project, next literature review which show the research papers that we have referred and it also show about SURPAC software & its applications and advantages and also explains the mining operations & geological models.

Third chapter which explains the method of working step by step process like importing data into the software, graphical editing of drillholes, sectioning of drillholes, creating DTM’s, creating block models & solid models and finally the volume and surface area of the deposit and the next chapter is about results which represent the statistical data and conclusion.

CHAPTER-II

LITERATURE REVIEW

2.0 LITERATURE REVIEW

E.j. Cowan, r.k. Beatson, w.r. Fright (2002)

Have used leapfrog on a variety of exploration and grade control data, the models are updatable, and can be regenerated as new data or information becomes available. The only method available that allows subjective geological interpretation to be incorporated into an overall objective modelling workflow.

Sirelda bele (2018)

The 3d geological model for copper ore body, based on the methodology used and the results achieved was established. From the analysis of classical statistics such as: histogram, cumulative frequency and probability. It turned out that for the element of copper, we have a normal distribution of data. Based on the results of histogram and cumulative frequency we can find the appropriate interpolation method for our ore bodies, for this case we can choose classical interpolation method or geostatistical interpolation methods.

Akisa, d. M., mireku-gyimah (2015)

The SURPAC software has all the features that facilitate the block modelling of a deposit, and the detailed design of an open-pit incorporating benches, berms and ramps. The software is menu driven, and thus easy to understand and use. The input parameters required during the optimization include: the block model, technical parameters such as overall slope angle, and economic parameters such as the mining and processing costs. SURPAC and whittle software combine to form a useful tool for open pit optimization and design.

Zhang et al (2011)

The goal of geostatistics is to predict the spatial distribution of a property using two basic forms estimation and simulation. Estimation produces one “best” estimate of the spatial occurrence supported by sample data and modeling a variogram which represents the spatial correlation of the info at hand. This estimate is typically produced by kriging.

Godfrey moeng monyakeng (august 2020)

By using sampling data, drilling data, geological knowledge, informed interpretation and geostatistical evaluation, geovia SURPAC is able to 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 minesched. All of these are critical to the success of the mine, and effective resource estimation is often recognized as being a critical factor for the success of a business.

Agrawal (2012)

Data attained from the exploration team is used to construct a geological database. The geological database is created to determine the extent of ore deposit and its basic geo-statistical characteristics. ‘’the borehole data are composited in order to use it to find geo-statistical values of the deposit’’.

Saidoo (2017)

Whether creating designs and plans for open pit or underground operations, SURPAC software serves as a platform to assist engineers with all the tools they need. In this integrated environment, designs can be created to maximize ore recovery, while complying with project constraints such as cut- off grade, economic limits, and ground stability

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 neighborhood 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.

Saboror et al (december 2017)

Conventional and computer-aided ore reserve estimation, discusses the computer-aided methods and conventional methods. Through comparison, gave the proper accretional analysis of 71 drill hole records.

2.1 SURPAC Software

“SURPAC is a complete mine planning software which has various modules ranging from drilling and blasting, surveying, pit design, geo-statistics and grade control, block modeling, solid modeling, open pit design, underground design’’ (agrawal, 2012), and so on.

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‘’the boreholes are displayed on the basis of the collar values taking into account the coordinates of each and every borehole present in the database’’ (agrawal, 2012). The total volume of reserve can then be estimated by developing solid model comprising of all these borehole data.’’ in order to obtain the solid model the borehole present in the database are sectioned at regular interval and the strings are stitched together to form solid model’’ (agrawal, 2012).

‘’the solid model so developed is then fitted into a block model of regular size developed to generate a constraint block model. The block economic parameter is then calculated using ordinary kriging method, based on the grade of each block’’ (agrawal, 2012).

For the process of geological modeling and opencast mine planning, several software’s have come into use with the application of information technology in 7 mining industry. Among them, SURPAC is one having multiple high-end functions of mine modeling. It is a complete software of mine planning and designing. In the mining industry, there are two aspects which are highly essential to monitor and optimize apart from environment- money and time. Equivalently in a mining industry, time is money; one has to extract many resources in a limited period of time to earn profits. This necessitates proper planning on where to extract and how to extract resources and timely, safely execution of the planning prospects. This study aiming to find uncertainties in coal deposits by SURPAC application.

2.1.0 Work Flow of SURPAC

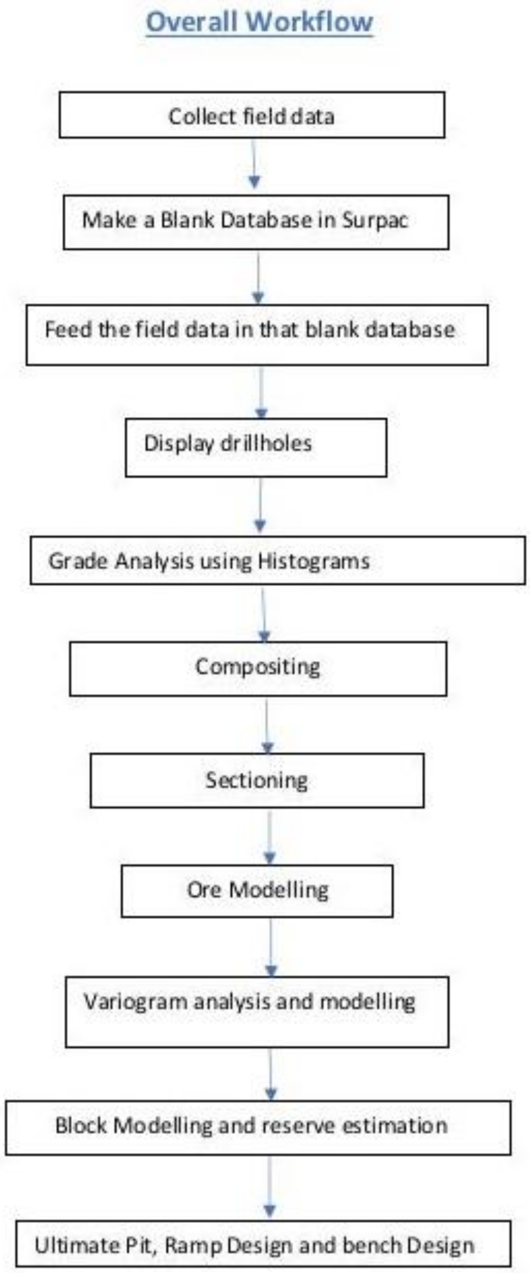

Figure 1: flow of work

2.1.1. Advantages of Using SURPAC

- It is multi-lingual
- Tasks in SURPAC can be automated for compliance with company-specific processes and data flows for increased time savings and consistency of execution
- SURPAC is modular and easily customized to adapt to changing needs
- SURPAC reduces data duplication and interfaces with common file formats from aerial survey, photogrammetry, gis, cad and other systems
- Different pieces of information can be viewed simultaneously to ensure designs are within the physical constraints of the mining area and to maximize the economic extraction of a resource.
- Interact with all mine design data: drillholes; existing orebody and surface models; optimized pit shells; block and grid models, colored by grade distribution; and many more
- Step through planes, delineate stope boundaries to create design solids and then divide these solids into practical mining shapes quickly and easily with underground stope design tools
- Data from various sources can be viewed and incorporated into plans to support feasibility projects

2.1.2. Applications of SURPAC

- geological resource and modelling
- data management
- estimation and modelling
- mine survey and ore control
- overall mine planning and production

2.2 Geological Models

Geologic modelling, geological modelling or geomodelling is the applied science of creating computerized representations of portions of the Earth's crust based on geophysical and geological observations made on and below the Earth surface. A geomodel is the numerical equivalent of a three-dimensional geological map complemented by a description of physical quantities in the domain of interest. Geomodelling is related to the concept of Shared Earth Model; which is a multidisciplinary, interoperable and updatable knowledge base about the subsurface.

Geomodelling is commonly used for managing natural resources, identifying natural hazards, and quantifying geological processes, with main applications to oil and gas fields, groundwater aquifers and ore deposits. For example, in the oil and gas industry, realistic geologic models are required as input to reservoir simulator programs, which predict the behaviour of the rocks under various hydrocarbon recovery scenarios. A reservoir can only be developed and produced once; therefore, making a mistake by selecting a site with poor conditions for development is tragic and wasteful. Using geological models and reservoir simulation allows reservoir engineers to identify which recovery options offer the safest and most economic, efficient, and effective development plan for a particular reservoir.

Geologic modelling is a relatively recent subdiscipline of geology which integrates structural geology, sedimentology, stratigraphy, paleoclimatology, and diagenesis;

In 2-dimensions (2D), a geologic formation or unit is represented by a polygon, which can be bounded by faults, unconformities or by its lateral extent, or crop. In geological models a geological unit is bounded by 3-dimensional (3D) triangulated or gridded surfaces. The equivalent to the mapped polygon is the fully enclosed geological unit, using a triangulated mesh. For the purpose of property or fluid modelling these volumes can be separated further into an array of cells, often referred to as voxels (volumetric elements). These 3D grids are the equivalent to 2D grids used to express properties of single surfaces.

Geomodelling generally involves the following steps:

1. Preliminary analysis of geological context of the domain of study.
2. Interpretation of available data and observations as point sets or polygonal lines (e.g., "fault sticks" corresponding to faults on a vertical seismic section).
3. Construction of a structural model describing the main rock boundaries (horizons, unconformities, intrusions, faults)

4. Definition of a three-dimensional mesh honoring the structural model to support volumetric representation of heterogeneity (see Geostatistics) and solving the Partial Differential Equations which govern physical processes in the subsurface (e.g., seismic wave propagation, fluid transport in porous media).

2.2.1 Building a Mineral Resource Model

This section includes a summary of the steps involved in building a block model, as discussed throughout the book. A typical workflow is summarized. The summary also includes a review of the applications described, emphasizing the practical usefulness of the tools described, and the (potential) benefits obtained by the owner/company. More time is spent on getting ready to do resource modeling than on actually applying specific geostatistical tools. It takes significant time to understand the geological setting, the data, and the study objectives and ensure that the modeling workflow is designed to meet those objectives. Cleaning the data takes a great deal of time. Often, the data are not dirty or incorrect, but the format is different and inconsistent, there is missing data, there are different vintages of data, different companies involved, and so on. Preparing the site-specific data takes significant time. Understanding the geological context of the data is essential to supplement sparse data and to make good choices of model setup and modeling workflow.

Sufficient time must be allocated to sort out the study objectives, site-specific data, analog data, and a conceptual understanding of the site. Of course, time must be left to perform the geostatistical study and meet the study objectives. Often, some data must be left out, some risk of error in the database must be accepted and an incomplete understanding of the geological context must also be accepted. Careful documentation must be assembled of the data inventory and the limitations that exist in the database and conceptual understanding. There must be a balance between satisfying prerequisites and getting on with the resource estimation to meet the study objectives.

Most geostatistical studies are repeated as more data become available or the objectives change. A particular geostatistical study is rarely the first analysis of completely new data for a site that has never been modeled before. It is important to assemble and review all relevant prior work such as reports, maps, models, and data files. Those that have studied the site in the past should be contacted to avoid making preventable mistakes and to address improvements that previous studies never had the time, data, or resources to address.

A generic workflow for geostatistics could be summarized in eight steps.

(1) specify the goals of the study and take inventory of the available measurements and conceptual data.

(2) divide the area/volume of interest into subsets that are relevant for the specific situation.

(3) choose how the mean of each variable depends on the location within each chosen subset.

(4) infer all required statistical parameters for creating spatial models of each variable within each subset.

(5) estimate the value of each variable at each unsampled location.

(6) thoroughly validate the estimated model, ensuring that the geologic and grade models are consistent with the assumptions, data, domaining geology, and methodology used in the estimation.

(7) simulate multiple realizations to assess joint uncertainty at different scales. Finally,

(8) post-process the statistics, estimated models, and simulated realizations to provide decision-support information.

2.2.2 Documentation and Reporting

Geologic modeling:

Document and describe the rationale for the methodology chosen. Is it appropriate for this type of deposit? What criteria have been used to interpret geology? What checks have been made to ensure the quality of the output models?

Exploratory data analysis: easy to access, an organized archive of parameter files, run files, and plots. Use backup binders, not just electronic files. Document the assumptions and conclusions reached.

Estimation domain definition:

Justification for logic; description of the process; supporting geology and statistical evidence; description of the sensitivities, if possible. Checks were performed to confirm the decision.

Block model:

Documentation and description of model limits; block size(s), with partial or whole blocks; is it rotated? Was it built using a coordinate rotation and transformation? Project and world coordinates. How were the geology and estimation domains assigned?

Variography:

Documentation of the estimators used; data transformations? Document parameters for obtaining the directional variograms, and the criteria used in modeling them. Document any data selection. By domain, or have domains been combined for practical reasons? Document all other assumptions made.

Grade estimation:

Document the method, with the parameter's files used, and validations performed. Maintain all relevant files and ensure that the block model has all the necessary variables for checking.

Resource classification:

Document methodology. What criteria were used? How was it implemented? Document the checks performed.

Resource validation:

Document in detail, summarizing all the checks performed, and explaining why the resource model is deemed adequate for its objective. Include statements regarding the main assumptions, limitations, and risk areas perceived.

Resource reporting:

Document in detail the checks performed that the reported tonnages and grades correspond to the estimated model. Use an appropriate number of significant digits. Include comparisons with previous models, and with reference (production models), and explain the reasons for the observed differences.

In summary, the audit trail has to demonstrate to third parties that each step of the process was completed with an appropriate methodology, which was implemented correctly, and was thoroughly validated.

2.2.3 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 modeling 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. The procedure can take a significant amount of time, particularly when all possible combinations of the available geologic variables are studied, but it is typically worth the effort. Estimates are improved when carefully constrained by geological variables. The definition of estimation domains is referred to as the definition of stationary zones within the deposit. An important part of stationarity is a decision of how to pool information within a specific zone within the deposit, within certain boundaries, or the deposit as a whole.

Decisions are based on oxidation zones, lithologies, alterations, or structural boundaries. The stationary domains cannot be too small; otherwise, there are too little data for reliable statistical description and inference. The stationary domains cannot be too big;

otherwise, the data could likely be subset into more geologically homogeneous subdivisions.

Defining the estimation domains in resource evaluation is often equivalent to defining the mineralized tonnage available in the deposit. Some units will be mostly mineralized (with the potential of becoming ore), while others will be mostly un-mineralized (almost certainly non-recoverable low-grade resources or waste). The mixing of different types of mineralization should be kept to a minimum to avoid smearing grades across geologic boundaries.

2.2.4 Grade Control

Grade control is an important task performed at the mine daily. It is a basic, economic decision that selects the destination of each parcel of material mined. Mistakes at this stage are costly, irreversible, and can be measured in terms of cash flow losses and increased operational costs. Grade control models are based on a large number of samples. In underground mines, production data is usually a series of tightly drilled holes, channel samples, or short holes to test production stops.

In an open-pit environment, blast hole samples are obtained on closely spaced grids, according to blasting requirements. Less frequently, grade control drilling is performed separate from blast hole drilling, for example using dedicated reverse circulation (rc) drilling. In some geologic settings, surface trenches and channel samples are used as well. Production samples are used to select ore from waste and are affected by several sampling issues. Often, blast hole samples are not as reliable as samples obtained from exploration or rc drill holes. This is explained by a combination of drilling and field sampling methods. Sometimes, the large number of samples available will tend to minimize the impact of the error of a single blast hole sample.

Geologic variables are mapped in the pit or stopes but are not always used in production control. Procedures for extracting some benefit from the local geology map should be implemented. The goal is to find practical ways of mapping and quickly processing geological information. The typical turnaround time for a grade control model in an open pit is 24–48 h. Conventional grade control methods include defining grade outlines and using inverse distance, polygonal estimation, or more commonly kriging of blast hole grades. These methods do not account for the uncertainty in prediction. Alternatively, simulation of multiple realizations provides the basis for different optimization algorithms, such as the minimum-loss/maximum profit method. In general, improvements from the simulation-based methods are evident in more erratic grade distributions and more marginal mixed ore-type zones. More complicated grade control scenarios, such as those including multiple processing options and stockpiling, will also lend themselves to optimization through simulation-based methods.

2.2.5 Data Collection

The mining industry collects more data than other natural resource industries. This provides an opportunity to better understand local variations and obtain robust local estimates. The abundance of data plays a major role in defining the modeling techniques used and their implementation and has historically influenced the development of geostatistical techniques. This is in contrast with, for example, some petroleum and environmental modeling applications, where the amount of data collected is limited, and the final results are more model-dependent.

The quality of the mineral resource estimate is dependent on the quality of the data collection and handling procedures used. Several technical issues affect the overall quality of the data, but only the most important ones are discussed here. The concept of data quality is used pragmatically, that is, with a view to how the data affect the tonnage and grade estimates in the resource model.

Sample data will be used to predict tonnages and grades. Statistical analyses will be used with geological and other technical information to make inference decisions. The sample database has to provide for sound and robust decision-making. Although there may be much data, only a small portion of the deposit is sampled; often less than one-billionth of the mass of a deposit is drilled.

The samples should be representative of the material intended for sampling which means that the sample obtained should result in a value that is similar to any other sample that could have been obtained for the same volume of material. The samples should also be represented in a spatial sense, which means that the spatial coverage of the deposit is adequate. For example, the samples may have been taken in an approximately regular or quasi-regular sampling grid, such that each sample represents a similar volume or area within the orebody of interest. In practice, this is rarely the case and some decluttering may be required.

To ensure sample representation, strict quality assurance and quality control programs should be put in place. If the samples are not representative, then there may be sample bias that will directly affect the final resource estimate. Several issues need to be considered about sample collection, handling, preparation, and analysis.

2.2.6 Location of Drill Holes

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 rock it 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-magnetite alterations 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 be corrected for magnetic declination, particularly in high latitudes.

2.3 Stages of Mining

there are 5 key stages that all miners follow that form the backbone of mine-development.

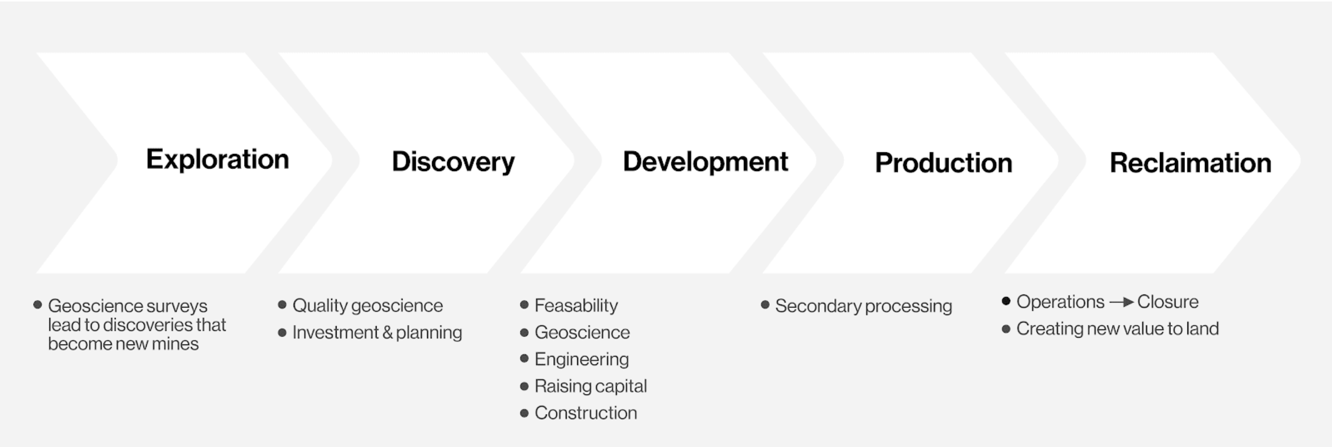

Figure 2: life cycle of mine

2.3.1 Exploration & Prospecting Stage

This is the first and most essential step of the mining process: in order to open a mine, companies must first find an economically sufficient amount of the deposit (an amount of ore or mineral that makes exploitation worthwhile.)

Geologists are enlisted by the companies to understand the characteristics of the land to identify the presence of mineral deposits.

2.3.1.1 What Is a Geologist

A geologist studies the solid, liquid, and gaseous matter of the earth as well as the processes that shape them. A mining geologist is responsible for mapping out the locations of valuable minerals and will use aerial photographs, field maps, and geophysical surveys, to determine where valuable materials are and estimate how much of those materials are in that location.

Exploration geologists search for mineral resources and get involved in the planning and expansion of mining operations. They locate and evaluate potential deposits of precious metals, industrial minerals, gemstones, pigments, construction materials or other minable commodities.

2.3.1.2 What Mining Techniques are Used by Geologists

Geological surface mapping and sampling:

A geologist will record all geological information from the rocks that outcrop at the surface and will look for boundaries between different rock types and structures, look for fault-lines and evidence of the rocks undergoing deformation. The geologist will look for ore minerals, evidence of metal-rich fluids passing through the rock, and recording mineralised veins and their distribution.

Mining companies need to target and prioritise their drilling activity so will use this data to target more specific areas where rock and mineral sampling might be appropriate. High-resolution geological mapping can also delineate areas of likely mineralisation which will lead to potential deposits.

Geophysical measurements:

Geophysical measurements are taken for mineral exploration to collect information about the physical properties of rocks and sediments. Geophysical companies employ the use of magnetic, radiometric, electromagnetic and gravity surveys to detect responses which may indicate the presence of mineral deposits.

Exploration geophysics is used to detect the type of mineralisation, by measuring its physical properties. It is used to map the subsurface structure of a region, to understand the underlying structures, the spatial distribution of rock units, and to detect structures such as faults, folds and intrusive rocks.

Geochemical analysis:

A chemical analysis that determines the proportion of metallic or non-metallic presence in a sample is called an assay. A wide variety of geological materials can be chemically analysed which include water, vegetation, soil, sediment and rock.

Assay labs can provide single and multi-element analyses by a variety of methods. Rock and soil samples are crushed, powdered, fused or digested in acid and then analysed using several different analytical methods and instruments.

Water, Oil and Soil Tests:

Most metallic ore deposits are formed through the interaction of an aqueous fluid and host rocks. Baseline samples are taken to determine hydrologic conditions and natural occurrences of potentially toxic elements in rocks, soils, and waters.

Surface geochemical analysis of soil, rock, water, vegetation, and vapour for trace amounts of metals or other elements that may indicate the presence of a buried ore deposit. Geochemical techniques have played a key role in the disCOVery of numerous mineral deposits, and they continue to be a standard method of exploration.

Rock, water, soil and vegetation samples collected by prospectors and geoscientists can either be tested on-site or in laboratories called assay labs.

Airborne Or Ground Geophysical Surveys:

Through either ground or airborne methods, geophysical companies undertake magnetic, radiometric and electromagnetic surveys to detect a response which may indicate potential deposits of mineral resources.

Airborne geophysical surveys are used for mineral exploration for mapping exposed bedrock, geological structures, sub-surface conductors, paleochannels, mineral deposits and salinity. There are several airborne geophysical methods used for minerals exploration including aero magnetics, radio metrics. A digital elevation model (DEM) is also used as an addition to most airborne geophysical surveys. Gravity surveys can also be conducted from the air as well as from the ground.

Ground-based geophysical surveys are implemented once mining companies have identified potential deposits at a regional scale and are performed from the soil surface, through boreholes, excavations or in a combination of placing sources and detectors.

Drilling:

Mineral exploration involves drilling to probe the contents of known ore deposits and potential sites to produce rock chips and samples of the core.

Drilling is used in areas that have been identified as targets with potential deposits based on geological, geophysical and geochemical surveys which have led to the design of the drilling programme. The aim is to obtain detailed information about rock types, mineral content, rock fabric, and the relationship between the rock layers close to the surface and at depth.

Samples taken from the orebody are taken to the lab and geologists can analyse the core by chemical assay and conduct petrologic, structural, and mineralogical studies of the rock.

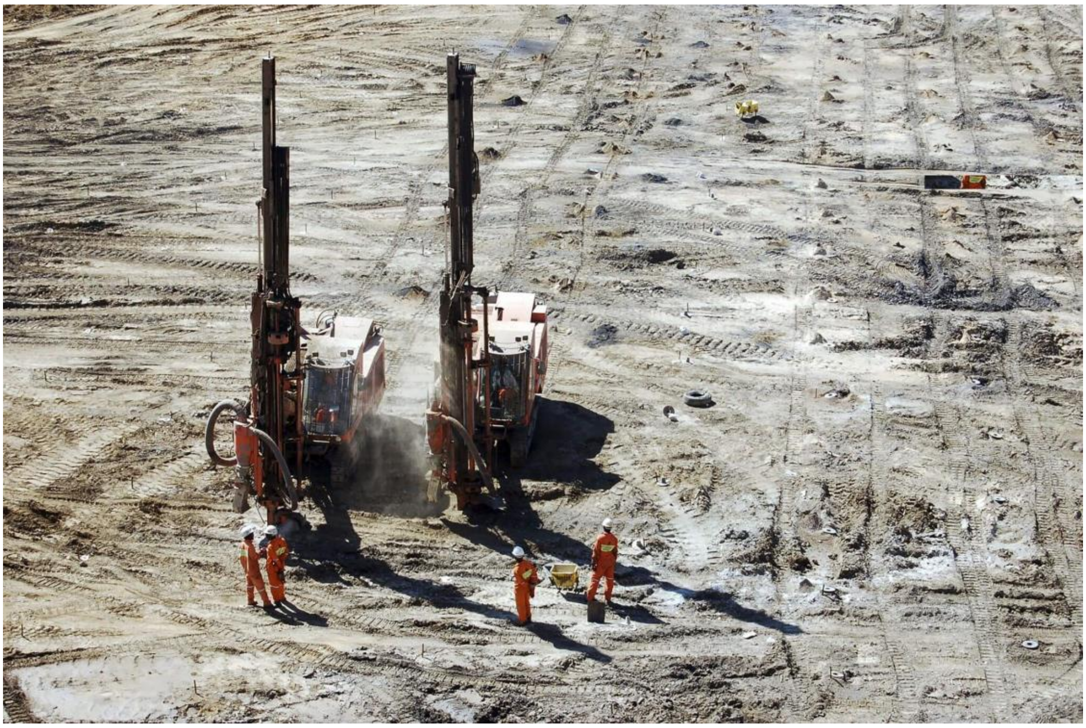

Figure 3: drilling boreholes

Sampling:

Exploration objectives are to find the ore and the drilling and sampling will provide the information upon which to base estimates of its quantity and grade.

Estimates of ore grade are based on the assays of samples obtained from drill holes into the ore. The accuracy of the estimates will depend on the care taken in procuring the samples and the judgment used in deciding on sample interval required, the accuracy in assaying, and the proper weighting of the individual assays in combining them for determining average grades of individual ore blocks, especially the treatment of erratic high values.

Valuable minerals are distributed unevenly and are present in varying degrees of purity throughout the material so that assays of individual samples may vary widely throughout sampling.

Socio-economic factors:

Companies must also take into account the socio-economic effects that the presence of a new mine could have on the area and surrounding communities.

Mining activities, including prospecting, exploration, construction, operation, maintenance, expansion, abandonment, decommissioning and repurposing of a mine can impact social and environmental systems in a range of positive and negative ways. Mining companies need to integrate environmental and social impact assessments into mining projects.

These assessments are the process of determining, analysing and evaluating the potential environmental and social impacts of a mining project, and designing appropriate implementation and management plans for the mining life cycle.

2.3.1.3 Orebody Models

At the end of the exploration stage, miners are able to draw up a preliminary outline of the potential size of the deposits found using 2d or 3d models of the geological ore. An orebody model serves as the geological basis of all resource estimation and starts with a review of existing drill hole and surface or underground sample data as well as maps and plans with current geological interpretation.

2.3.2 Discovery Stage

2.3.2.1 Mine-Site Design & Planning

Once the miners are sufficiently confident that there is a financially viable amount of deposit, the project can progress to the planning stage.

Companies will create multiple plans with different variables (time-span, amount of ore mined) to evaluate which fulfils the most criteria.

2.3.2.2 Planning Criteria & Permit Considerations

Safety:

From exploration to mining of mineral resources, it is vital to ensure that critical safety and operational risks are considered in designing a mine. The mine plan should allow the miners to work in the safest way possible.

The safety and wellbeing of employees, contractors and local communities is a big concern for responsible mining companies and a mine plan will look at any aspect of mine operations that could have a direct impact on the wellbeing of workers, contractors and communities.

Environmental impact:

The mine plan needs to be designed to keep the damage to the environment to a minimum using strategies that can reduce environmental impact. Lower impact mining techniques will reduce interference at the mining site. Mining waste such as tailings, rocks and wastewater can be reused on or off-site.

Eco-friendly equipment such as electric engines which will result in big carbon savings and longer lasting equipment will cut down on waste over time.

Many former mine-sites are left unusable by landowners once the mine life has come to an end. Mine companies can employ land rehabilitation techniques such as topsoil replenishment and reforestation schemes to make the land productive again and speed up the land’s natural recovery process.

Illegal mining is a significant issue for the industry so preventing illegal or unregulated mining operations will help ensure that all mining is bound by the same environmental standards and ensure accountability.

Economical viability:

Mine development starts when a deposit is discovered and continues through to the start of construction. The technical feasibility and the economic viability of each project are determined during the phases of mine development, with more detailed engineering data required at each stage.

- The preliminary economic assessment (PEA) is an early level study and the preliminary evaluation of the mining project. A pea is useful to determine if subsequent exploration activities and engineering studies are warranted. However, it is not valid for economic decision making or for reserve reporting.

- The pre-feasibility study (PFS) is an intermediate step in the engineering process to evaluate the technical and economic viability of a mining project. The pre-feasibility study is a critical step for project development as it represents the minimum prerequisite for conversion of a geologic resource into a reportable reserve.

- A feasibility study (FS) represents the next and most detailed step in the engineering process for evaluating a mining project and is a comprehensive technical and economic study of the development.

- A bankable feasibility study (BFS) also known as a definitive feasibility study (dfs) is the final piece of the financing puzzle. The results of the study serve as the basis for a final decision whether to proceed with the mine plans. It would be unusual for a company to get finance in place without one.

Corporate social responsibility:

Social responsibility is very important in the world of mining and companies are finding it beneficial to strengthen their corporate social responsibility (CSR) efforts and find ways to give back to the surrounding community.

Mines often employ a large percentage of the local residents as their workforce and some companies get involved by financing local suppliers and so promoting local trade and growing the local economy. They also fund shared infrastructure in power distribution, roads, and water treatment and distribution.

Other companies become involved in local communities by supporting climate change programmes and environmental stewardship and wildlife projects, contributing to local and regional programmes including sponsorship of educational and sporting events, local medical facilities and the funding of local children's schemes and arts festivals.

Companies aim to employ local labour and trades people wherever possible and focus on educational, health and infrastructure improvements that will have the greatest impact on the quality of life.

2.3.3 Development Stage

Figure 4: opencast mine

Once the plan has been confirmed, the real work can begin. This is the longest stage of the process so far, and can take anywhere from 10-20 years before the mine is ready for production, depending on the site size.

2.3.3.1 Does a Mines Size Affect the amount of Ore Produced

Measuring mine productivity can be difficult given how unique each operation is mines set their production goals but productivity at some mines is restricted by location. Mines are trying to minimize operating expenditure while continuing to increase productivity.

2.3.3.2 What Does Construction Involve

Building roads:

The construction of roads, rail, air-strips or ports to access the mine plus the services such as water, sewage and power is similar to the work required for establishing other types of industries except that this construction could be in remote areas with added logistical challenges.

Mining roads are a critical component of mining infrastructure and the performance of these roads has a direct impact on operational efficiency, costs and safety. A significant proportion of a mine's cost is associated with material haulage and well-designed and managed roads contribute directly to reductions in cycle times, fuel burn, tyre costs and overall cost per tonne hauled and critically, underpin a safe transport system.

Processing facilities:

Development of the mine itself is different for an open pit to an underground mine and will require different experience and equipment. Porphyry deposits are often large and many of the deposits are near the surface and mined as open pits with large mining equipment; however, at depth some may have suitable characteristics to convert to large underground block caving mines. Vein type deposits are often narrow, can go to depth and are mined by underground methods with smaller equipment.

Once the mineral is extracted from a mine, it is processed and the processing operation depends on which material is excavated. The crushing and processing facility is constructed based on the testing, flow sheet and design determined in the fs. Processing of the ore starts with understanding the mineralogy and the metallurgical testing for crushing, grinding and recovery of the metals and treatment/management of the tailings.

Environmental management systems:

Environmental aspects are included on the fs which has determined the current environmental habitat and the long-term impact of building the mine. The fs will also have determined the quantity and quality of all ore and waste to be mined plus tailings, the potential to generate acid and other deleterious metals plus how to treat these issues while operating and at closure.

Also included in the fs is the amount and quantity of water that will be used during operation and whether the water will need long-term treatment. Some countries require the fs as the basis for submitting plans for required mining permits.

An environmental management system (EMS) is part of the management system and includes organizational procedures, environmental responsibilities, and processes and will help the mining company comply with environmental regulations, identify technical and economic benefits, and ensure that corporate environmental policies are adopted and followed.

Mining companies with economical and technological flexibility have implemented comprehensive EMS at current sites but these require input from governments, international environmental organizations, educational facilities, and the companies themselves.

Employee housing:

Mine planning includes decisions on workforce accommodation which will affect not only employee quality of life but also the impacts and relationships with existing local communities. Workforce accommodation are usually community-based (either as purpose-built company towns or integrated within existing local communities) or commuter (fly-in, fly-out) mine camps which will depend on the location of the mine and how remote it is.

The quality of accommodation underpins the fulfilment, morale and motivation of employees. This is not only relevant to productivity and safety, but also to recruitment and retention, particularly with the significant human resources crisis. If communities exist close to a proposed mine then the accommodation strategy can influence the value-adding potential for the sustainable development of such communities.

Where mine locations are isolated in remote areas and/or face significant economic, social and political adversity, the decisions on employee housing are more challenging. The mine company will need to understand the complexity of local planning issues and consider environmental, social, economic and political implications, together with the proposed accommodation strategy.

Other facilities:

- Maintenance facilities - location for service and repair of mine equipment to reduce downtime and ensure that production capacity and safety objectives are met.

- Management offices, workshops, storage, refueling, and power generation facilities. In some cases, a control tower may also be constructed to offer a complete view of processing operations.

- Transportation for mine personnel - miners, contractors, and supervisors need to move between work areas which may be spread across a wide area.

2.3.4 Production Stage

2.3.4.1 What Are the Two Common Methods of Mining

Surface mining:

Figure 5: surface mining

surface mining is a broad category of mining in which the soil and rock overlying the mineral deposit is removed. It has been estimated that more than two-thirds of the world's yearly mineral production is extracted by surface mining.

Surface mining is the preference for mining companies because removing the terrain surface to access the mineral beneath is often more cost-effective than digging tunnels and shafts to access mineral resources underground.

Surface mining methods:

- Strip mining involves stripping the surface away from the mineral that's being excavated (usually coal). Soil, rock, and vegetation over the mineral seam is removed with huge machines, including bucket-wheel excavators.

- Open-pit mining is a technique of extracting rock or minerals from the earth by their removal from an open-air pit. Open-pits are sometimes called 'quarries' when they produce building materials and dimension stone.

- Mountaintop removal mining for retrieving minerals from mountain peaks and involves blasting the overburden with explosives above the mineral seam to be mined. The broken mountaintop is then shifted into valleys and fills below.

- Dredging is the more sophisticated version of panning for gold where a scoop lifts material up on a conveyor belt, and the mineral is removed, then the unwanted material is put back into the water.

- Highwall mining collects ores from a "highwall" with overburden and exposed minerals and ores.

Underground mining:

Underground mining is used to access ores and valuable minerals in the ground by digging into the ground to extract them. There are several underground mining techniques used to excavate hard minerals, usually those containing metals such as ore containing gold, silver, iron, copper, zinc, nickel, tin and lead, but also for excavating ores of gems such as diamonds and rubies.

Underground mining methods:

- Ore is natural rock that contains valuable minerals, typically metals and is extracted from the earth through mining and extracting the valuable metals or minerals. The grade of ore refers to the concentration of the valuable material it contains.

- Subsurface mining involves digging tunnels or shafts into the earth to reach buried ore deposits. Ore and waste rock are brought to the surface through the tunnels and shafts.

- The recovered minerals are processed using large crushers, mills, reactors, roasters and other equipment to consolidate the mineral-rich material and extract the desired compounds and metals from the ore.

- Ore is separated from the waste rock; the rocks are crushed and the minerals are separated from the ore by:

- Heap leaching - addition of chemicals such as cyanide or acid to remove the ore. This is often done at very high temperatures.

- Flotation - addition of a compound that attaches to the valuable mineral and floats.

- Smelting facilities - roasting rock at a temperature greater than 900oc. This causes it to segregate into layers. The valuable minerals are then extracted.

- Once the mineral is extracted, it is often processed to extract the valuable metal from its ore through chemical or mechanical means which will depend on the mineral resource present.

- The ore is then poured into moulds to create bars of bullion (metal formed into bars or ingots) ready for sale.

2.3.5 Reclamation Stage

Figure 6: example of reclamation

Before the company can be issued a permit to build the mine, they must first prove that they have the funds and plans to close the mine in a safe and structured way.

Mining is a temporary activity, once the deposit is gone it's time to relocate to a new site. But before they can do this, they must first close and rehabilitate the mine.

2.3.5.1 What Needs to Happen Before a Mine Can Close

The final step in mining operations is closure and reclamation. Mine companies have to think about a mine closure plan before they start to build as governments need assurances that operators have a plan and the required funds to close the mine before they are willing to issue permits.

Detailed environmental studies form a big part of the mine closure plan on how the mine site will be closed and rehabilitated. A comprehensive mine rehab programme will also include.

Ensuring public health and safety:

There are many dangers with abandoned mines, many of which are not visible from the outside, including horizontal openings, vertical shafts, explosives and toxic chemicals, dangerous gases, deep water, spoils piles, abandoned unsafe buildings and high walls. Mine companies need to ensure mines are fully closed and sealed to make them safe for the public.

Removing waste and hazardous material:

There is a high-volume of waste material that originates from the processes of excavation, dressing and further physical and chemical processing of metalliferous and non-metalliferous minerals and mine companies need to remove waste and hazardous material from the site both during operation and at closure of the mine.

Establishing new landforms and vegetation:

Reclamation of mined areas involves the re-establishment of viable soils and vegetation at a mine site. For example, a simple approach could add lime or other materials that will neutralize acidity plus a cover of topsoil to promote vegetation growth. Modifying slopes and planting vegetation will stabilise the soil and prevent erosion.

Minimizing environmental effects:

A landscape affected by mining can take a long time to rehabilitate and mine companies need to minimise environmental effects during mine life and mitigate the impacts of mining from the discovery phase through to closure:

Preserving water quality:

The initial closure plan usually focuses on water quality and where the water will go after closure and the quantity of water which will either discharge or migrate into the groundwater system after flooding.

Mine companies must find ways of protecting groundwater and surface water resources and to understand the risks related to water quantity and quality and to develop appropriate engineering controls and reclamation measures.

Stabilizing land to protect against erosion:

Reduction of slopes by land infill and reclamation, growing plants and trees on mined areas will stabilise the soil and reduce erosion by binding the soil and protecting the ground. Good erosion control will help keep valuable soils on the land and allow natural growth and regeneration.

2.3.5.2 Mine Closure Plans Can Aim to Renovate the Site to Varying Degrees

1. Remediation:

Cleaning up the contaminated area, removing all mine wastes including water and the treatment of water. Isolating contaminated material.

2. Reclamation:

Stabilising the terrain, infill, landscaping and topsoil replacement to make the land useful once again.

3. Restoration:

Rebuilding any part of the ecosystem that was disturbed as a result of the mine such as flora and fauna. The planting of trees and vegetation native to the area to allow regeneration.

4. Rehabilitation:

Rehabilitating the site to a stable and self-rejuvenating state, either as it was before the mine was built or as a new equivalent ecosystem to take local environmental conditions into account. Mines can be repurposed for other uses such as for agriculture, solar panel farms, biofuel production or even recreational and tourist use.

2.3.5.3 Mine Closure Process:

1. Shut-down:

Production stops and workers are reduced. Some skilled workers are retained to permanently shut down the mine. Re-training or early retirement options are sometimes provided.

2. Decommissioning:

The mine is decommissioned by workers or contractors who take apart the mining processing facilities and equipment which is cleaned to be stored or sold. Buildings are repurposed or demolished, warehouse materials are recovered, and waste is disposed of.

3. Remediation/reclamation:

The land and watercourses are reclaimed to a good standard to ensure any landforms and structures are stable, and watercourses are of acceptable water quality. Hazardous materials are removed and land is reshaped and restored by adding topsoil and planting native grasses, trees, or ground cover.

4. Post-closure:

It is important to assess the reclamation programme post closure and to identify any further actions required. Mines may require long-term care and maintenance after mine closure such as ongoing treatment of mine discharge water, periodic monitoring and maintenance of tailings containment structures, and monitoring any ongoing remediation technologies used such as constructed wetlands.

CHAPTER-III

METHOD OF WORKING

3.0 METHOD OF WORKING

The geological database module in SURPAC is an important area of functionality when you are conducting feasibility studies, or want to perform estimations from drill hole data.

A geological database consists of several tables, each of which contains different types of data. Each table contains several fields. Each table also has many records, with each record containing the data fields.

SURPAC 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. A database can contain up to 50 tables and each table can have a maximum of 60 fields.

The database creation procedure mainly includes collecting all exploration data in the mining area. The geological data includes trenching, drilling, and exploration results which can be used for recording the distribution of lithology and geological disturbances through geological logging, and then importing the data into SURPAC to establish a 3d geological database with proper format. The use of geological databases to store geologically relevant information can establish a 3-d geological model of the mining area more accurately, and completely and construct the foundation for subsequent resource estimation.

In this project report, the relevant geological information of 94 boreholes in the mining area was collected, and four basic tables such as the collar, geology, assay, sample, and survey tables were established. Among them, the collar table mainly comprises the collar coordinates of the borehole, drilling depth, drilling type, drilling time, and hole path; the geology table includes the drilling depth, rock, hole_id, sample_id; the sample table mainly includes the hole depth, gold, sample_id; the survey table mainly includes the azimuth and dip of the drilling and the depth of the inclination.

3.1 Experimental Details

6 geological databases were incorporated into the SURPAC software which are

- assay
- collar
- composite
- geology
- survey

The basic steps which were carried out using the data are shown below:

Two mandatory fields were required within the data base which are collar and survey.

Table 1: geological database

BoreHoles							
Collar	hole_id	X	Y	Z	Max_depth	Hole_path	
Survey	hole_id	depth	dip	azimuth			
Geology	hole_id	sample_id	depth_from	depth_to	rock_codes		
Assay	hole_id	sample_id	depth_from	depth_to			

Table 2: part of collar table

Hole_Id	Y	X	Z	Max_Depth	Hole_Path
B01	100	50	856.66	82.95	Linear
B02	0	0	871.82	75.65	Linear
B03	0	100	845.79	130.9	Linear
B04	100	-50	874.81	10.05	Linear
B05	0	-50	875.66	92.95	Linear
B06	190	0	869.07	6.4	Linear
B07	200	0	868.23	13.05	Linear
B08	300	-50	866.23	93.49	Linear
B09	0	-90	865.68	91.8	Linear

Table 3: part of survey table

Hole_Id	Depth	Dip	Azimuth
B01	82.95	-90	0
B02	75.65	-90	0
B03	130.9	-90	0
B04	10.05	-90	0
B05	92.95	-90	0
B06	6.4	-90	0
B07	13.05	-90	0
B08	93.49	-90	0
B09	91.8	-90	0

Table 4: part of assay table

Hole_Id	Depth_From	Depth_To	Fe	Sio2	Al2o3	P
B01	0	2.44	61.6	2.5	5.01	0.06
B02	18.9	21.1	64	0.74	2.54	0.06
B03	0	2.1	45.4	10.3	14.35	0.06
B04	0	1.2	54.8	7.62	8.02	0.05
B05	8.55	10.65	60.3	2	5.38	0.06
B06	0	1.8	55.3	8.48	6.9	0.06
B07	0	1.8	49.4	18.2	6.8	0.07
B08	0	1.85	63.2	1.66	2.33	0.06
B09	0	1.83	56.4	4.9	6.05	0.05

Table 5: part of geology table

Hole_Id	Depth_From	Depth_To	Lcode
B01	0	2.44	9
B02	21.1	22.85	1
B03	3.95	6.1	5
B04	0	1.2	5
B05	4	5.5	5
B06	0	1.8	5
B07	0	1.8	8
B08	0	1.85	4
B09	0	1.83	4

The above data has been collected from Geological Survey of India.

3.1.1creating Geology Data Base File

- choose database > open/new.
- you can also create optional tables for sample a
- choose database > close.
- in the navigator, right-click new database.ddb, and select edit.
- the file is opened in your default text editor. Nd geology data

3.1.2 Importation of Data into New Database

- choose database > import data.
- select the text file name and load type for the tables.
- viewing data.
- you can view data directly from the access database by dragging the .accdb file into the graphics.
- when selecting view table constrained, the define query constraints form allows the

data to be.

- filtered depending on the values for a particular field from that table. You can also use multiple
- constraints, but all of the conditions must be met for the data to be displayed.
- Creating a new data base for geological database creating a new data base involved creation of an information platform in SURPAC software which will be used to construct the geology data. It was done using the following command procedure:
- choose database > open/new.
- you can also create optional tables for sample a
- choose database > close.
- in the navigator, right-click new_database.ddb, and select edit.
- the file is opened in your default text editor.nd geology data
- the value for db_specific can be any folder on your local drive or on a network drive.
- the database definition file (.ddb) contains:
- the type and name of database
- where the database is located (that is, a path location)
- table names, field names, and formatting of each field type
- the .ddb file is a text file and contains no data. It allows SURPAC to connect to a relational database and usually has the same name as the database.
- close the text editor.

3.1.3 Importation of New Data into The New Data Base

The next step was to incorporate new data into the new data base which has just been created by the previous procedure using the following commands:

- choose database > import data.
- select the text file name and load type for the tables.
- viewing data
- you can view data directly from the access database by dragging the .accdb file into the graphics
- when selecting view table constrained, the define query constraints form allows the data to be
- filtered depending on the values for a particular field from that table. You can also use multiple
- constraints, but all of the conditions must be met for the data to be displayed.

3.1.4 Displaying the Drillholes Apply Styles to 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 color variants. The mineral concentrations down the borehole are differentiated with different colors. 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.

- choose display > drill hole display styles.
- expand the geology folder and locate the lithology field.
- right-click on the lithology field and choose get field codes
- expand the lithology folder. B yellow
- for each of the 7 lithological codes,
- select a different color for graphics
- and plotting.

3.1.5 Manipulating the Drillholes

Manipulating the drillholes involved displaying the cylinders, displaying the lithological codes on the right-hand side, displaying the assays on the left-hand side, displaying color filled bar graphs of the gold assays on the left-hand side and offsetting them by 5m. It was done with the following command procedure:

- choose display > drillholes.
- select the rescale view to display all holes in plan view check box, to allow graphics to
- resize and display all data after you have applied the changed styles.
- clear the add constraint to holes check box, to display all data in graphics.
- enter the information as shown, and click apply

3.1.6 Displaying the Lithological Codes on The Right-Hand Side

- 1. Choose display > drillholes.
- 2. Enter the information as shown on each the trace styles, collar styles, and labels tabs, and then click apply. Examining the drillholes
- choose display > identify drill hole.
- follow the prompt and click in graphics to select a hole.
- press esc.
- a message similar to the following is displayed in the message window:

3.1.7 Graphically Editing the Drillholes

- task: run edit drill hole
- choose display > edit drill hole.
- follow the prompt, and click in graphics to select the hole of interest.
- select the sample table and the gold field, and then click add.
- select the geology table and the lithology field, and then click add.
- the results for hole wrc065 are displayed
- note: to remove charts from the editor, right-click on the field headings (in this case, sample/gold or geology/lithology) and choose remove from the shortcut menu.

3.1.8 Sectioning the Drillholes

- creating sections graphically
- task: create sections graphically
- choose section > define.
- enter the information
- as shown, and click apply

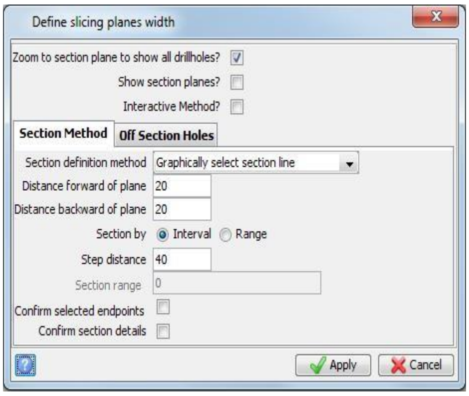

Figure 7: define slicing planes width

3.1.9 Digitizing Ore Outlines

- in the planes panel, double-click 7280n in the cross sections group.
- zoom in on the area of interest as shown:
- choose create > digitise > properties.
- enter the information as shown, and click apply.

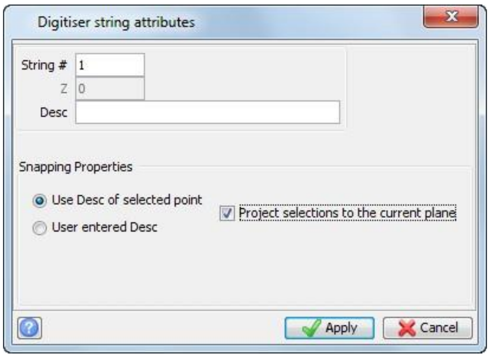

Figure 8: digitiser string attributes

- in the layers pane, click new.
- Enter the information as shown, and click apply.
- this creates a layer called "ore_interp" to store the new data you are digitizing

Figure 9: create a new layer

- choose create > digitise > new point.
- the following options can be seen under the database > display menu.

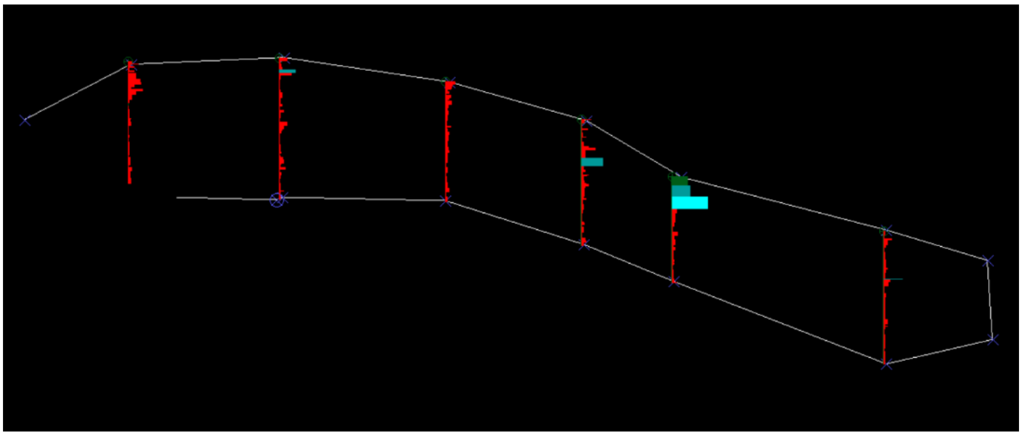

Figure 10: drawing strings

- digitize some end points for the ore zone by clicking the points as shown

3.1.10 Determination of Grade After Digitizing

- when a segment has been digitized on a section, the grade for that segment can be calculated using the digitized segment grade function.
- choose sections > digitized segment grade.
- enter the information as shown, and click
- apply.
- click the segment.
- the results are displayed in the message window
- choose inquire > point properties and click any point on the segment.
- the point properties are displayed in the message window. The segment grade is written o in the d1 field. Press esc.

close the database

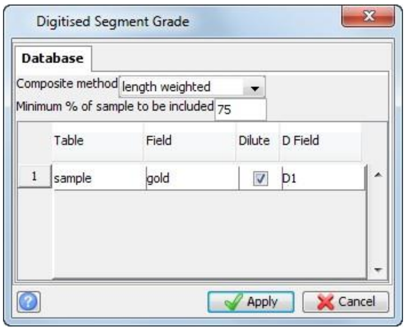

Figure 11: digitised segment grade

3.1.11 Creating A Solid Model After Digitizing Segments

- click reset graphics.
- open mod1.str in graphics.
- choose display > strings > with string numbers.
- enter the information as shown, and click apply
- choose solids > triangulate > between segments.

- enter the information as shown, and click apply

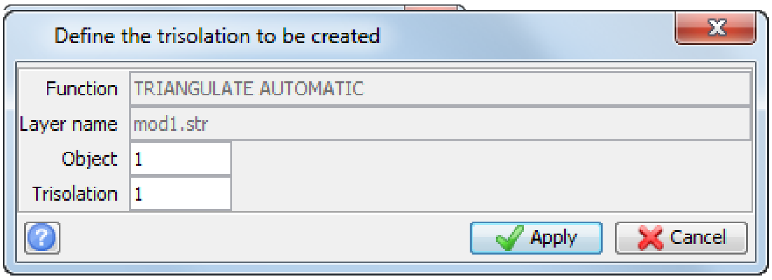

Figure 12: define the trisolation to be created

- you are prompted to select a point on the first segment to be triangulated.
- click string 1.
- you are prompted to select a point on the next segment to be triangulated.
- click string 2.
- continue using the between segments function up to and including string 5.
- press esc.
- the part of the solid created using triangulate between segments is displayed.

3.1.12 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 is an 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

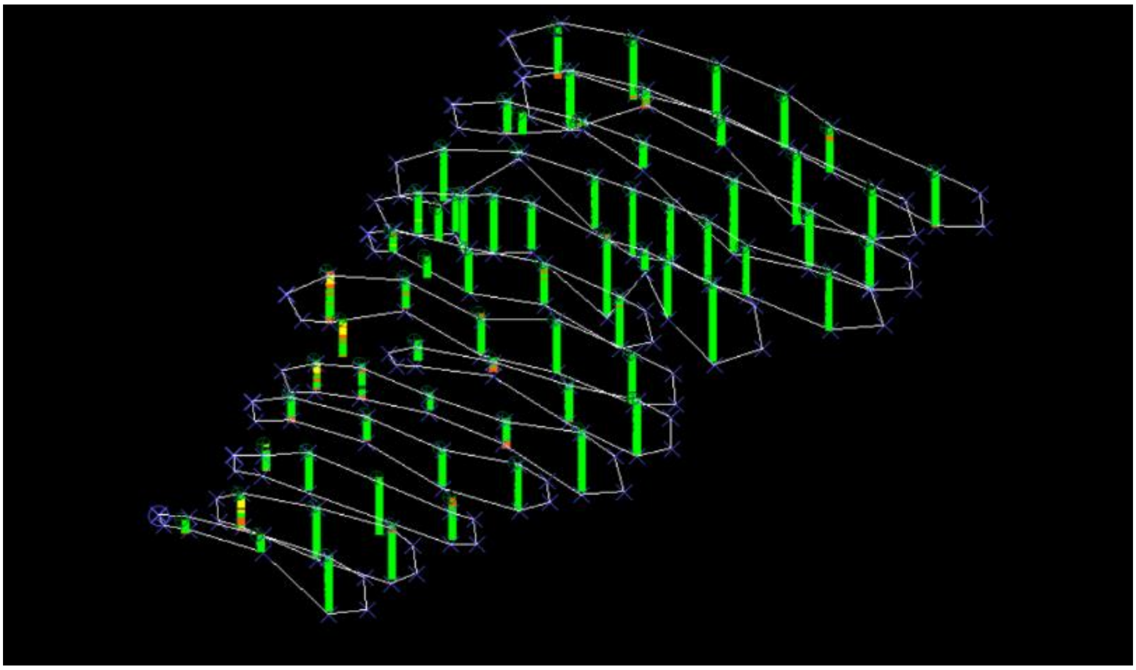

Figure 13: string with boreholes

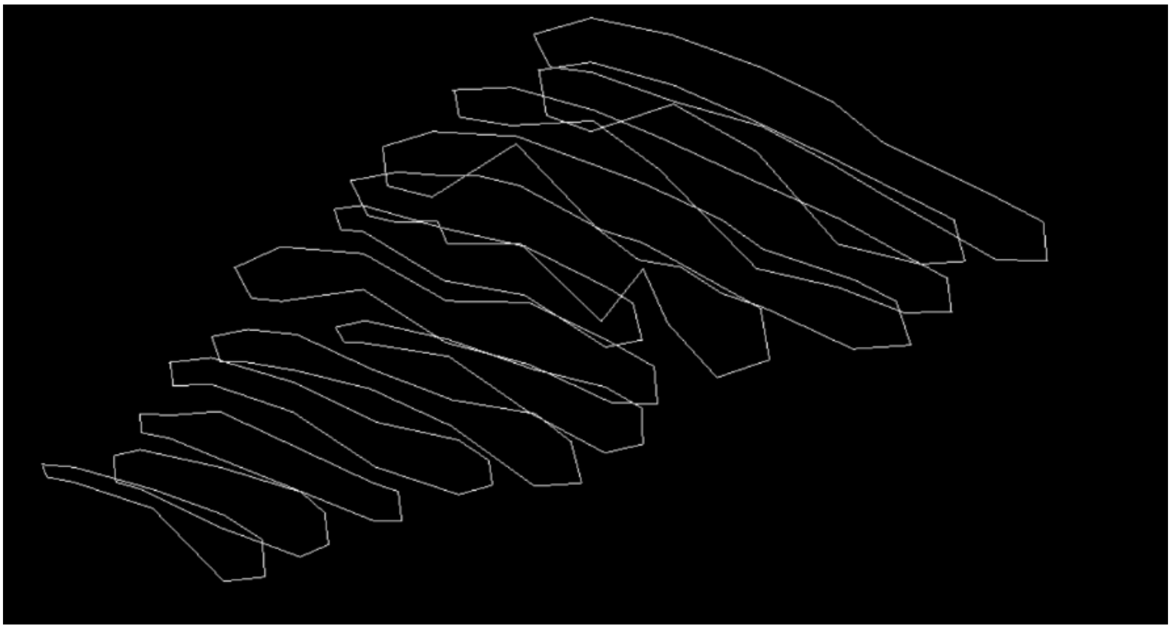

Figure 14: strings without boreholes

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 member of a set of files. This is a numeric character identifier.

3.1.13 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 modeled 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 string files. That is, a DTM file cannot be opened if the original string file of the same name does not exist in the database.

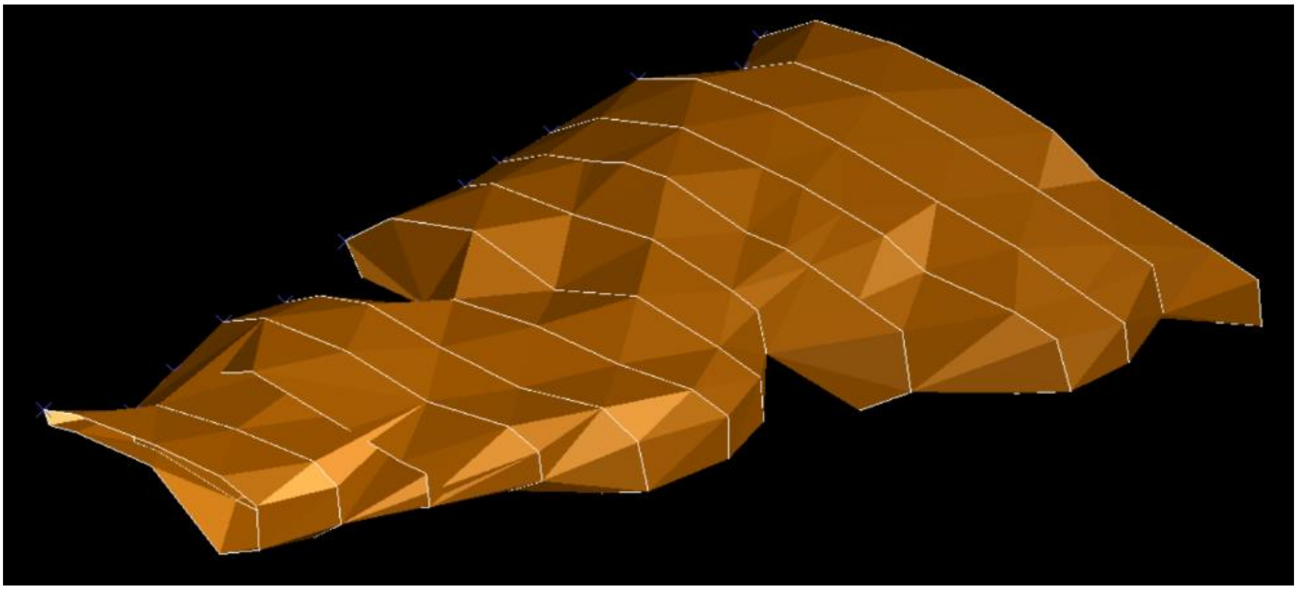

Figure 15: DTM

3.1.14 Composite Modeling

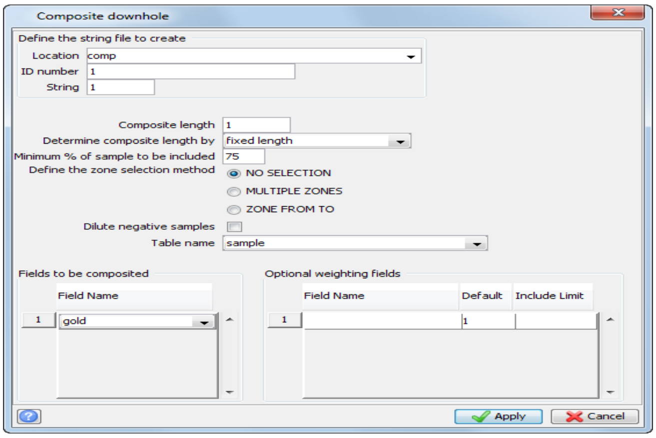

Figure 16:composite downhole

For grade value evaluation of the block, the model should be processed with the assay values of the mineral, but they are in a different database which is geological database. So, the data has to be extracted from the database in a string file, and this file should be used in the 1st model of estimation. Here the samples at equal intervals should be normalized. One block will take samples at an equal interval of different samples from different boreholes by using the string file generated after compositing has been done. While processing the attributes in the table while processing the description field number appropriate to each attribute should be remembered as it will be needed for future utilization. Once the string file has been created it is used for the grade estimation of the block model. Once the process has been completed, the attributes for each block can be viewed by using the option in the drop-down menu.

3.1.14.1 Steps to Perform Composite Modelling

- task: perform composite downhole
- choose composite > downhole.
- enter the information as shown,
- and click apply
- open comp1.str in graphics.
- choose display > hide strings > in a layer.
- enter the information as shown, and click apply
- choose display > point > markers.
- enter the information as shown, and click apply.

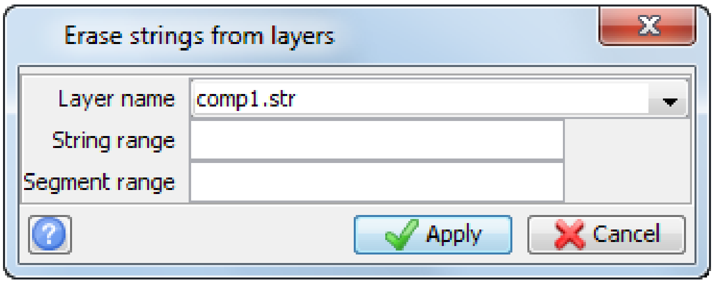

Figure 19: erase strings from layers

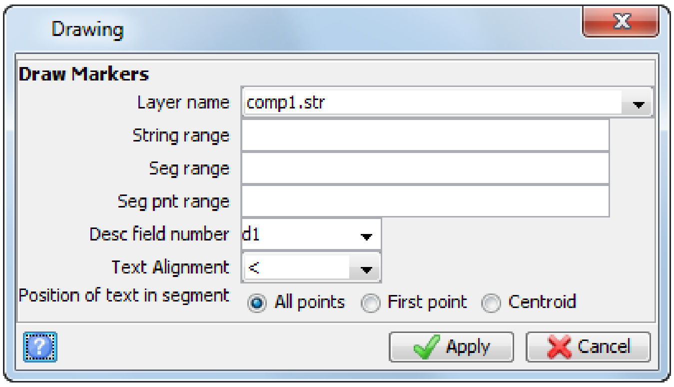

Figure 18: drawing

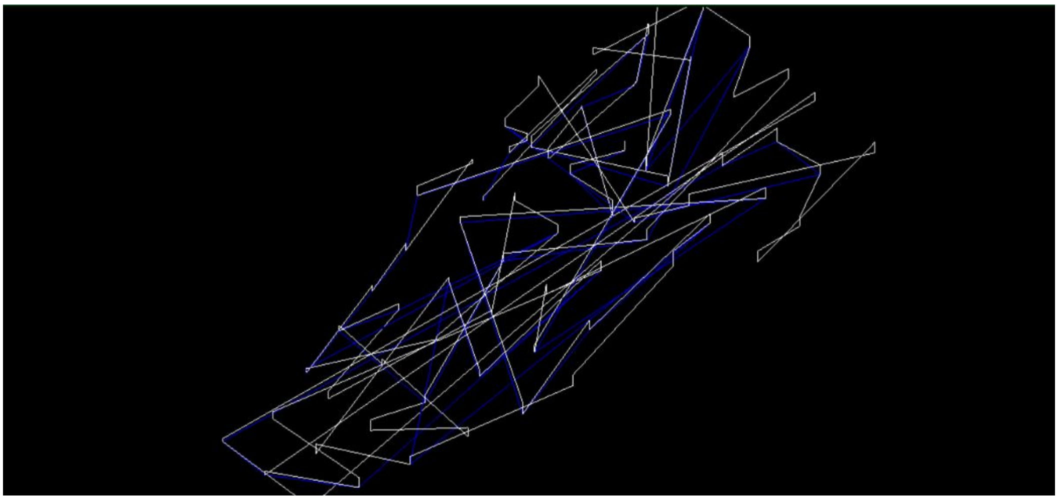

Figure 17: composite model

3.1.14.2 Displaying Basic Statistics

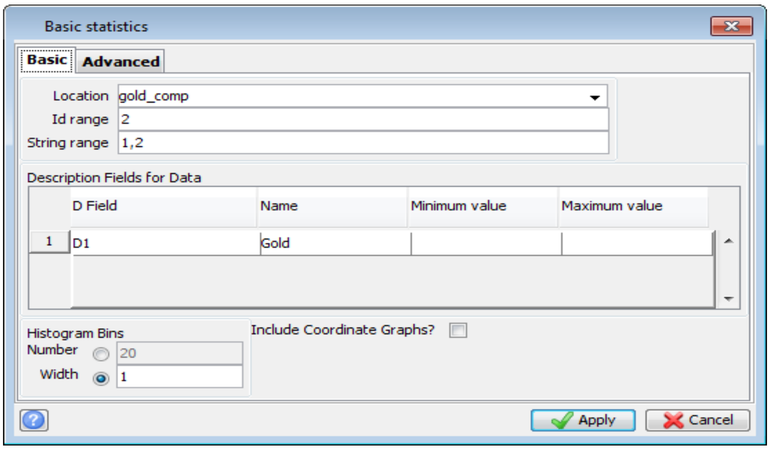

Figure 20: basic statistics

- displaying histograms in SURPAC
- analysis > basic statistics window to open the basic statistics window.

3.1.15 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 effect on 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 geologist to 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.

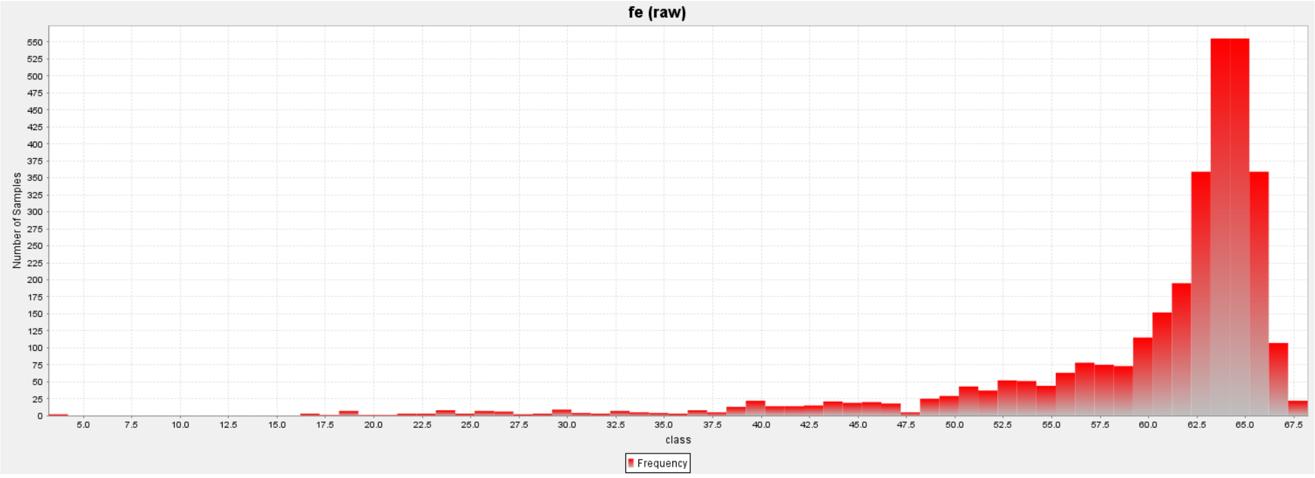

Figure 22: frequency fe(raw)

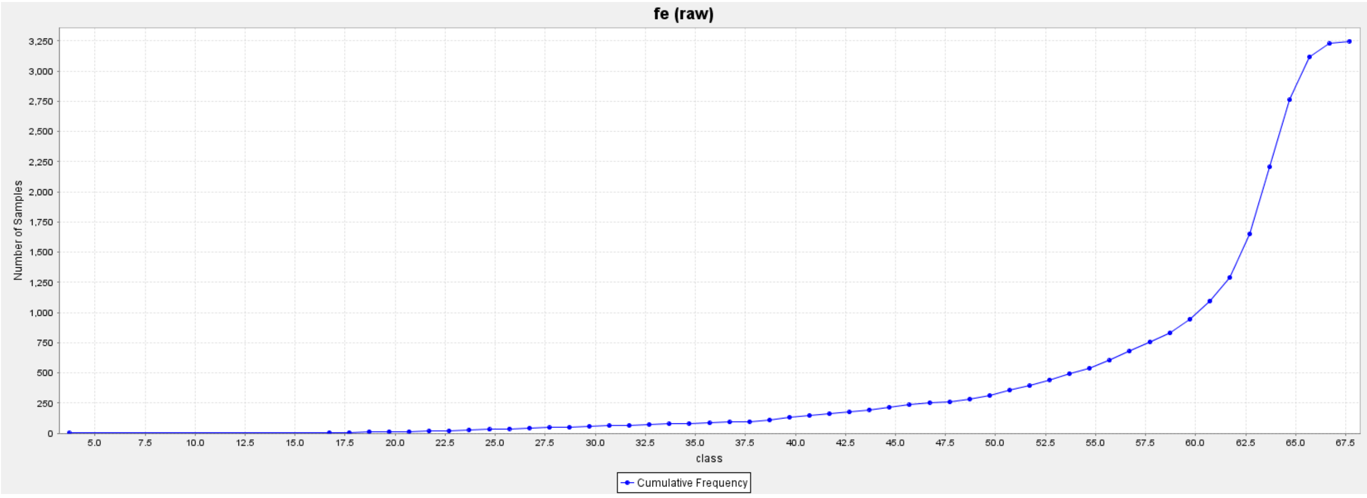

Figure 21: cumulative frequency fe(raw)

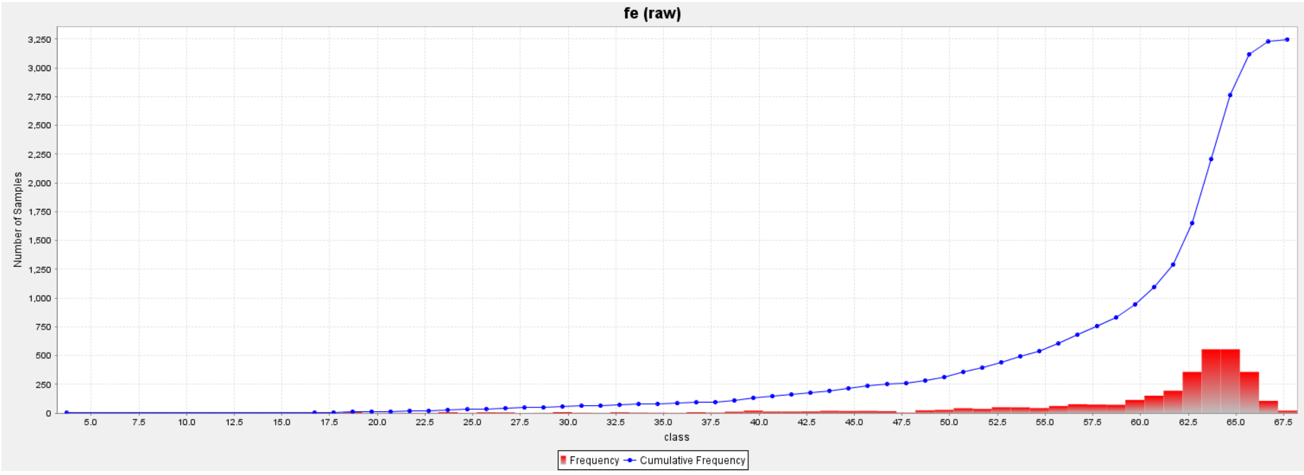

Figure 23: frequency & cumulative frequency fe(raw)

3.1.16 Block Modelling

The block model is a form of spatially-referenced database that provides a means for modeling 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 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 been strictly 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 the block model in the shape of the ore body.

3.1.16.1 Steps to Create Block Modelling

- choose block model > new / open.
- enter the information as shown, and click apply.

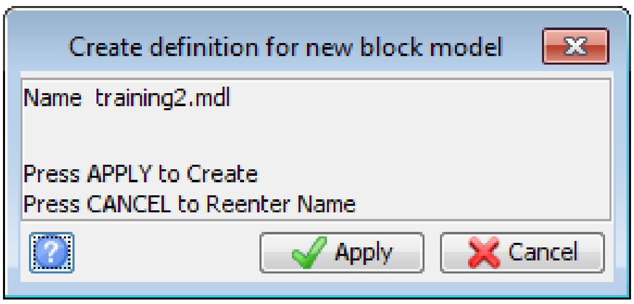

Figure 24: create definition for new block model

- select the get extents from string file box.

- in the location box, type ore1, press tab, and click open.

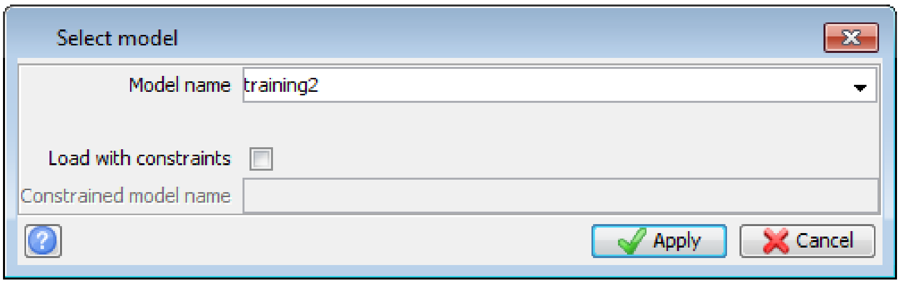

Figure 25: select model

- the model's coordinates are filled in based on the values in ore1.str.
- in the description field type a description of the block model.
- adjust the values as shown to create a block model which completely COVers the extents of the ore body.
- click apply.
- enter the information as shown, and click create model.

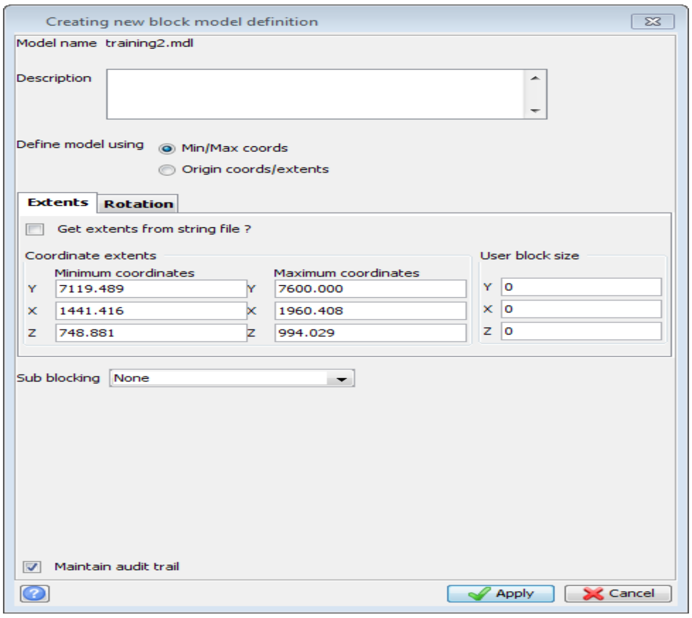

Figure 26: creating new block model definition

3.1.17 Final Diagram of Block Model

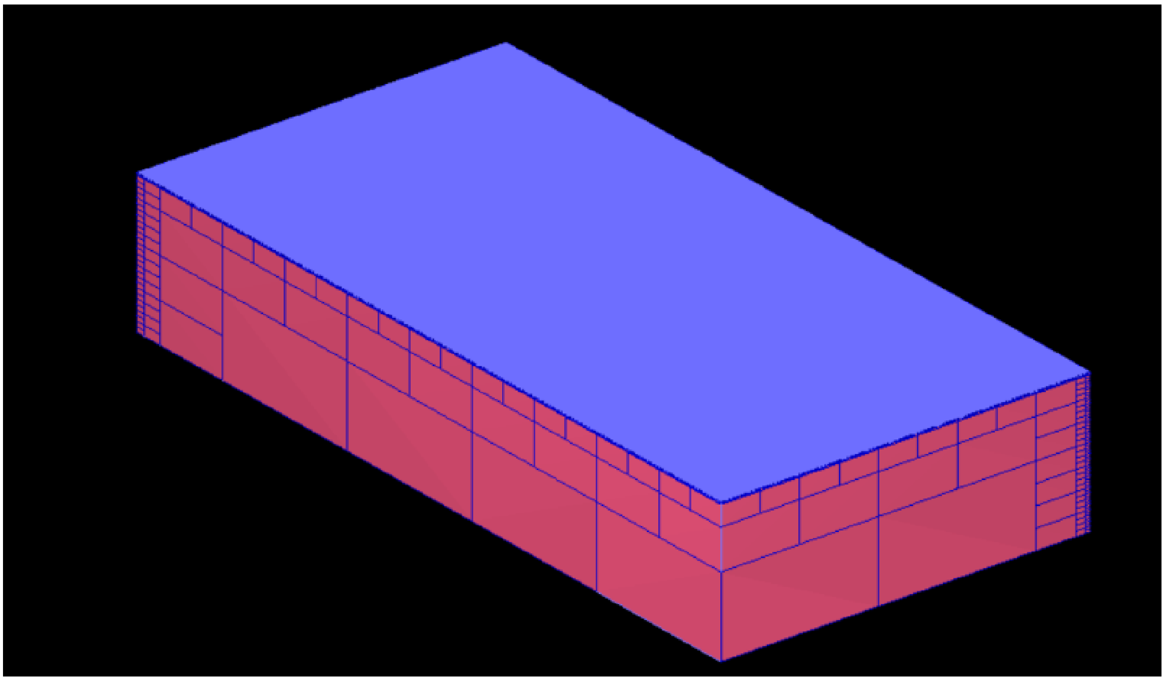

Figure 27: block model

- The block model is created and its name is displayed in the status bar.
- Click reset graphics.
- Choose block model > save to save the block model.
- Choose display > display block model.
- Enter the information as shown, and click apply.
- The block model is displayed.
- rotate the view in graphics.

3.1.18 Solid Modelling

The ore body has been developed from the boreholes through frequent sectioning and digitizing of the boreholes. To prepare an orebody, several sections are developed, and all the sections are joined together using a triangulated method to generate an orebody. Before the development of the ore body, it should be known that all the boreholes have not been useful in the evaluation and estimating of the ore body as they contain less percentage of mineral concentration that has to be mined.

The calculation of the ore body is completely dependent on the user of the software. During sectioning, firstly, a section has been defined and then a row of boreholes has been set for digitizing. Through computerization, the volume of ore to be mined has been determined. Some boreholes have been exempted from sectioning. This means that the grade of the mineral which will give profit is quite less or absent.

So, it could increase the cost of extraction adding to the overall cost of mining. After sectioning a row of boreholes, the section has been saved, and then the sectioning of the next row is carried out. All the section files have been saved in the same file initiating it each time. After sectioning all the boreholes have been done and saved which is in the form of a string file. These are the segments that have evolved by the sectioning and digitizing of the boreholes. The following work is the development of the required ore body by joining the segments, but before this, the interior of the segment has been triangulated, and then between the segments has been triangulated to create the final ore body. But once the triangulation job has been done it requires justification so that it does not have any error in triangulation. Sometimes triangulation gives an error due to the generation of open segments. The triangulation inside the segment has assured that the segment is closed. If the justification becomes false, the area and the volume of ore cannot be determined.

Thus, the ore body has to be justifiable. A 2d or 3d grid system can also be executed to know the layer extents of the ore body where max z value- (-20.442m) and min z value- (237.734m). Once the ore body has been developed and validated, the calculation of the area covered by the solidified ore body and the volume of ore can be determined, and the report has been saved in '.pdf.' format or any other text format that the software maintains.

<u>X, Y, Z Min and Max values</u>

Ymin = -808.238, Ymax = 480.529,

Xmin = -246.71, Xmax = 483.663,

Zmin = 656.284, Zmax = 874.521

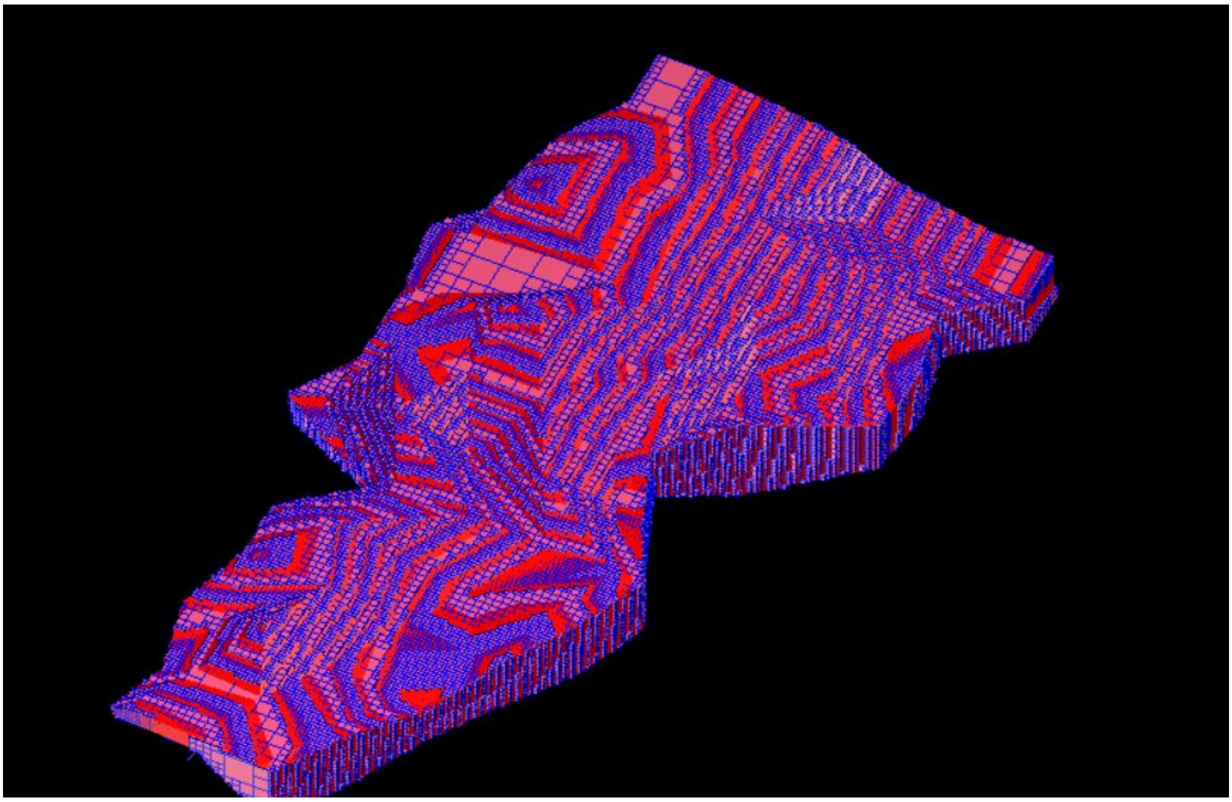

Figure 28: solid validation

```
GEOVIA                                                                  May 06, 2022
                             Solid validation report

Layer:1st_proj_strings.dtm

Object  Trisolation  Valid  Open/closed  Connected  Duplicate (removed)  Invalid Edges  Intersecting  Reversed
--------------------------------------------------------------------------------------------------------------
     8            1  Valid       Closed  Connected                    0              0             0         0
                                            Totals                    0              0             0         0

Solid validation report                                                             1/1
```

Figure 29: solid validation report

```
SOLID MODELLING OBJECT REPORT
Layer Name: 1st_proj_strings.dtm

Object: 8
Trisolation: 1
Validated = true
Status = solid

Trisolation Extents
X Minimum: -246.710 X Maximum: 483.663
Y Minimum: -808.238 Y Maximum: 480.529
Z Minimum: 656.284 Z Maximum: 874.521
Surface area: 1455648
Volume : 36712838
```

Figure 30: solid modelling object report

CHAPTER-IV

RESULTS

4.0 RESULTS

4.1 Statistical Analysis

Brief analysis in SURPAC by exploitation the mean and variance high cut diagram within the fundamental statistics window. The diagram frames the mean against the constant of variation (COV) at varied grade cutoffs, permitting the man of science to look at that cut-off can yield an appropriate COV and its result on the mean grade. To assist geologists in creating these selections, the event of a tool known as the 'mean and variance high cut diagram', is found within the fundamental statistics window. The diagram plots the mean against the constant of variation (COV) at varied grade cut-offs, permitting the man of science to assess which cut-off can yield an appropriate COV and its impact on the mean grade. A bar graph and cumulative frequency curve can then be exhibited.

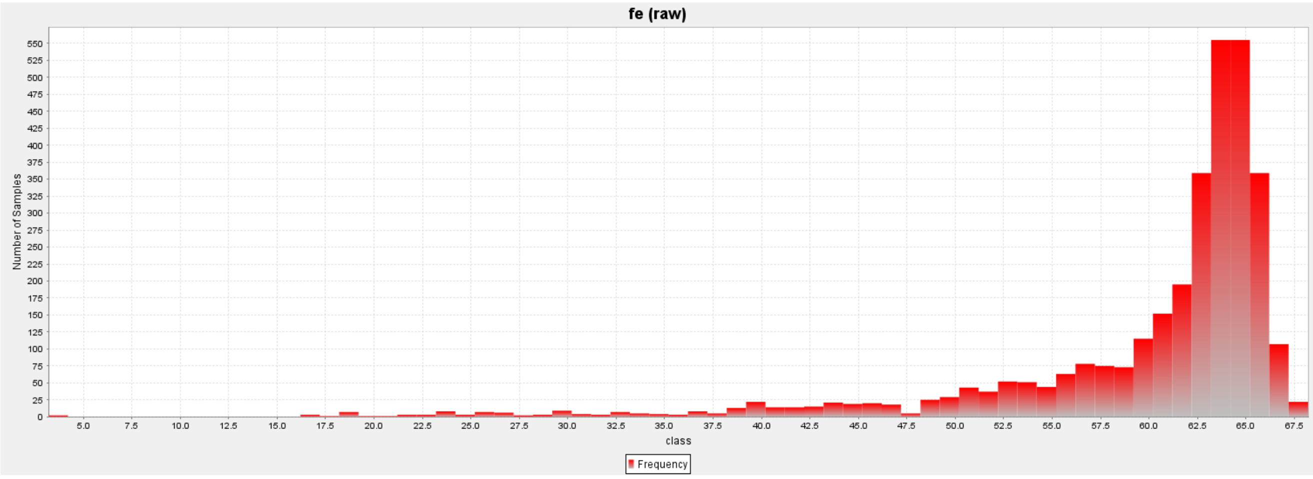

Figure 31: frequency fe(raw)

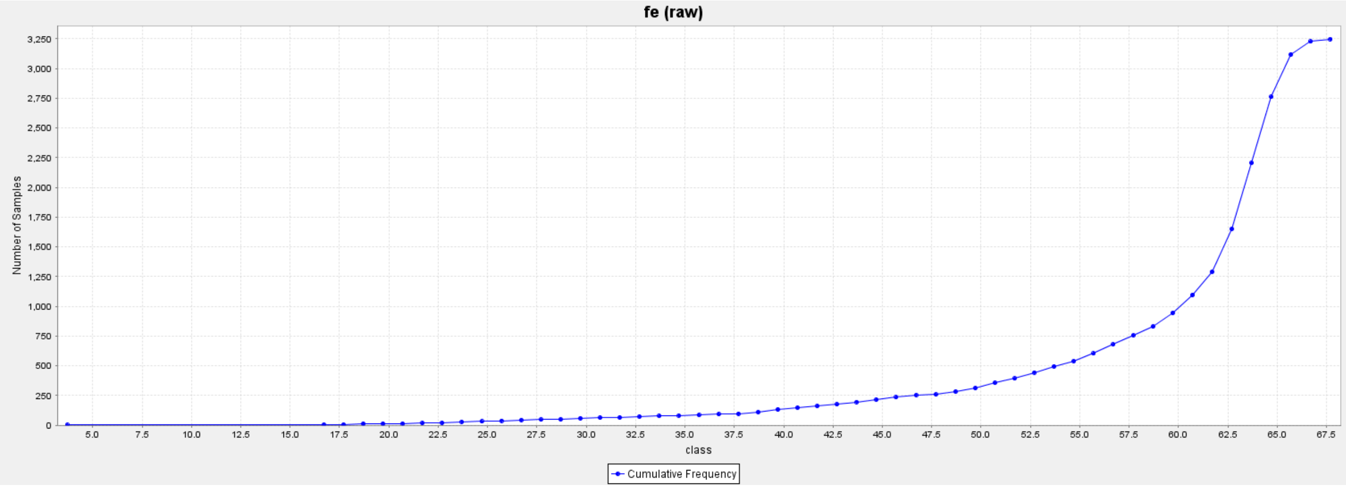

Figure 32: cumulative frequency fe(raw)

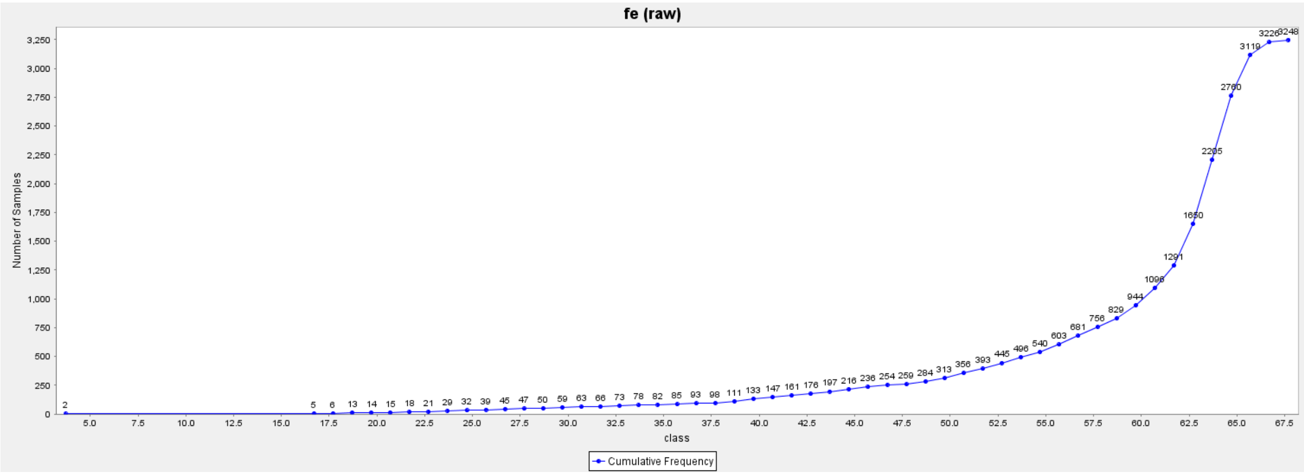

Figure 33: cumulative frequency with values fe(raw)

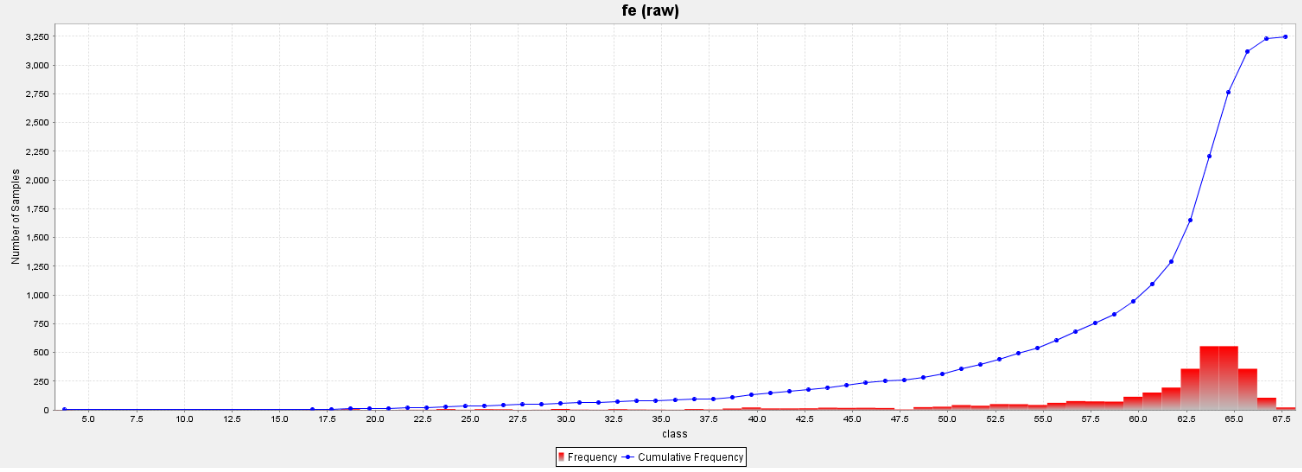

Figure 34: frequency & cumulative frequency fe(raw)

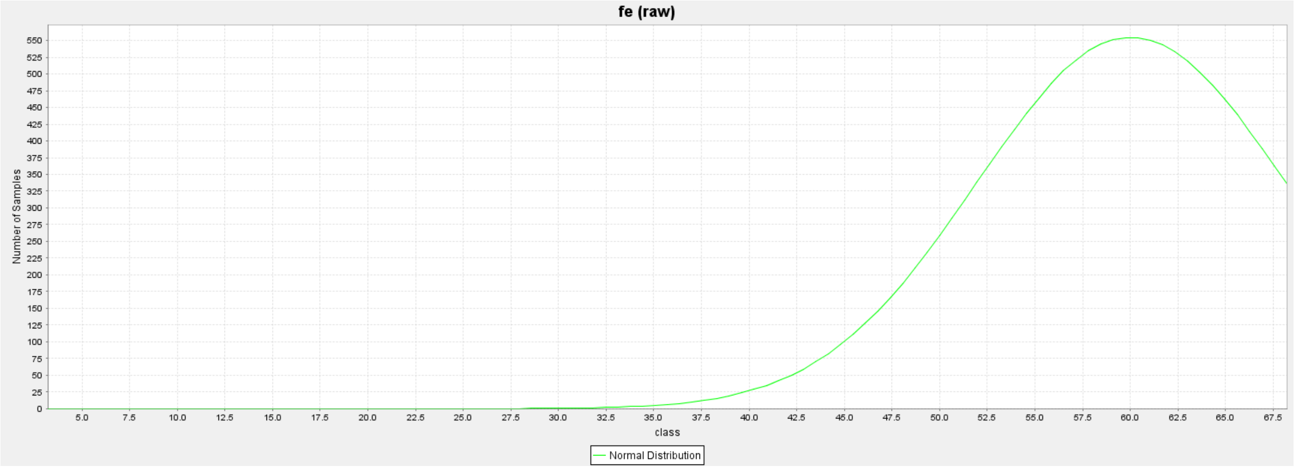

Figure 36: normal distribution fe(raw)

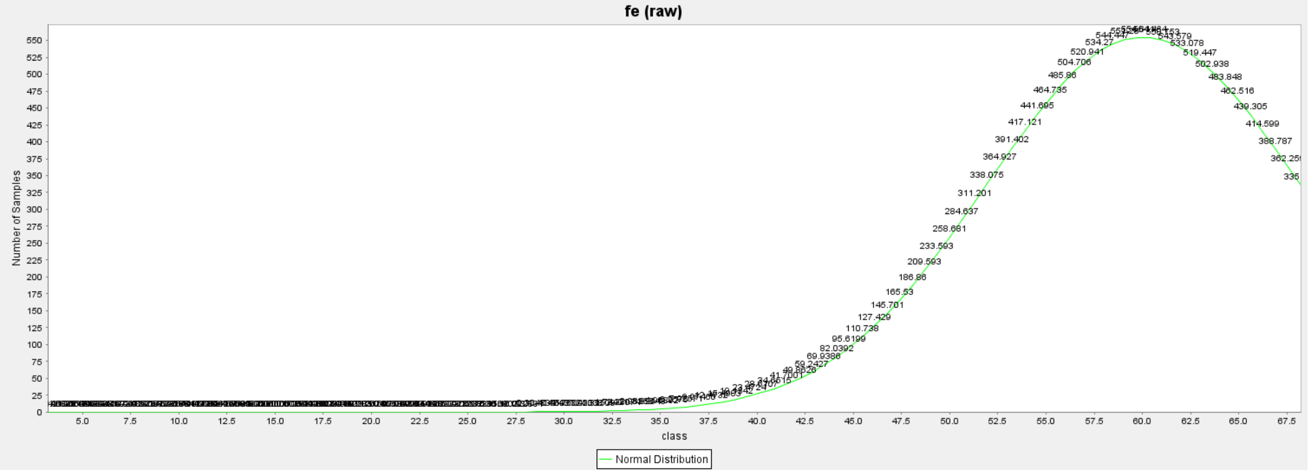

Figure 35: normal distribution with values

Table 6: statistics report of composite model

Output Filename: D:\Major Project\SURPAC DATA\123 May 25, 2022

Statistics Report

File	D:/major Project/surpac Data/comp.str
String range	1,2
Variable	fe
Number of samples	3248
Minimum value	3.200000
Maximum value	68.200000
	Ungrouped Data
Mean	60.042566
Median	63.156650
Geometric Mean	59.231816
Variance	66.057503
Standard Deviation	8.127577
Coefficient of variation	0.135364
Moment 1 About Arithmetic Mean	0.000000
Moment 2 About Arithmetic Mean	66.057503
Moment 3 About Arithmetic Mean	-1395.587521
Moment 4 About Arithmetic Mean	47819.483254
Skewness	-2.599404
Kurtosis	10.958739
Natural Log Mean	4.081459

Log Variance	0.034941
10.0 Percentile	50.400000
20.0 Percentile	56.918000
30.0 Percentile	60.419150
40.0 Percentile	62.237500
50.0 Percentile (median)	63.156650
60.0 Percentile	63.851650
70.0 Percentile	64.317350
80.0 Percentile	64.900000
90.0 Percentile	65.600000
95.0 Percentile	66.097650
97.5 Percentile	66.500000
Trimean	62.475663
Biweight	62.817302
MAD	2.135348
Alpha	-3.168000
Sichel-t	60.275401

Table 7: normal histogram tabulation fe

Normal Histogram Tabulation
fe

Class From	ClassTo	Count	Mean	Freq %	Cum Count	Cum Mean	Cum Freq %	Dec Count	Dec Mean	Dec Freq %
3.200000	4.200000	2	3.381350	0.001	2	3.381350	0.0616	3248	60.042566	100.0000
16.200000	17.200000	3	16.450000	0.001	5	11.222541	0.1539	3246	60.077477	99.9384
17.200000	18.200000	1	17.990000	0.000	6	12.350450	0.1847	3243	60.117836	99.8461
18.200000	19.200000	7	18.738614	0.002	13	15.790231	0.4002	3242	60.130830	99.8153
19.200000	20.200000	1	19.700000	0.000	14	16.069500	0.4310	3235	60.220396	99.5998
20.200000	21.200000	1	20.990000	0.000	15	16.397533	0.4618	3234	60.232925	99.5690
21.200000	22.200000	3	21.725567	0.001	18	17.285539	0.5542	3233	60.245064	99.5382
22.200000	23.200000	3	22.751533	0.001	21	18.066395	0.6466	3230	60.280840	99.4458
23.200000	24.200000	8	23.667125	0.002	29	19.611424	0.8929	3227	60.315729	99.3534
24.200000	25.200000	3	24.905567	0.001	32	20.107750	0.9852	3219	60.406810	99.1071
25.200000	26.200000	7	25.762814	0.002	39	21.122762	1.2007	3216	60.439927	99.0148
26.200000	27.200000	6	27.039217	0.002	45	21.911622	1.3855	3209	60.515570	98.7993
27.200000	28.200000	2	27.679500	0.001	47	22.157064	1.4470	3203	60.578280	98.6145
28.200000	29.200000	3	28.760667	0.001	50	22.553281	1.5394	3201	60.598835	98.5530
29.200000	30.200000	9	29.874033	0.003	59	23.670005	1.8165	3198	60.628702	98.4606
30.200000	31.200000	4	30.587500	0.001	63	24.109211	1.9397	3189	60.715498	98.1835
31.200000	32.200000	3	31.933333	0.001	66	24.464853	2.0320	3185	60.753335	98.0603
32.200000	33.200000	7	33.068100	0.002	73	25.289822	2.2475	3182	60.780507	97.9680
33.200000	34.200000	5	33.740161	0.002	78	25.831510	2.4015	3175	60.841605	97.7525
34.200000	35.200000	4	34.965425	0.001	82	26.277067	2.5246	3170	60.884352	97.5985
35.200000	36.200000	3	35.336667	0.001	85	26.596818	2.6170	3166	60.917098	97.4754
36.200000	37.200000	8	36.638088	0.002	93	27.460583	2.8633	3163	60.941361	97.3830
37.200000	38.200000	5	38.024860	0.002	98	27.999577	3.0172	3155	61.002985	97.1367
38.200000	39.200000	13	38.810869	0.004	111	29.265764	3.4175	3150	61.039459	96.9828
39.200000	40.200000	22	39.887968	0.007	133	31.022820	4.0948	3137	61.131576	96.5825
40.200000	41.200000	14	40.712221	0.004	147	31.945620	4.5259	3115	61.281611	95.9052
41.200000	42.200000	14	41.679329	0.004	161	32.792030	4.9569	3101	61.374475	95.4741
42.200000	43.200000	15	42.466933	0.005	176	33.616595	5.4187	3087	61.463795	95.0431
43.200000	44.200000	21	43.775510	0.006	197	34.699525	6.0653	3072	61.556554	94.5813
44.200000	45.200000	19	44.674916	0.006	216	35.576990	6.6502	3051	61.678940	93.9347
45.200000	46.200000	20	45.607620	0.006	236	36.427044	7.2660	3032	61.785496	93.3498
46.200000	47.200000	18	46.665811	0.006	254	37.152626	7.8202	3012	61.892919	92.7340
47.200000	48.200000	5	47.665740	0.002	259	37.355581	7.9741	2994	61.984464	92.1798
48.200000	49.200000	25	48.745984	0.008	284	38.358258	8.7438	2989	62.008417	92.0259
49.200000	50.200000	29	49.787038	0.009	313	39.417154	9.6367	2964	62.120279	91.2562
50.200000	51.200000	43	50.547872	0.013	356	40.761595	10.9606	2935	62.242141	90.3633
51.200000	52.200000	37	51.840965	0.011	393	41.804691	12.0998	2892	62.416018	89.0394
52.200000	53.200000	52	52.759537	0.016	445	43.084808	13.7007	2855	62.553068	87.9002
53.200000	54.200000	51	53.843101	0.016	496	44.191003	15.2709	2803	62.734753	86.2993
54.200000	55.200000	44	54.707207	0.014	540	45.047879	16.6256	2752	62.899533	84.7291
55.200000	56.200000	63	55.697659	0.019	603	46.160542	18.5653	2708	63.032644	83.3744
56.200000	57.200000	78	56.756818	0.024	681	47.374213	20.9667	2645	63.207352	81.4347
57.200000	58.200000	75	57.643251	0.023	756	48.392967	23.2759	2567	63.403356	79.0333
58.200000	59.200000	73	58.754826	0.022	829	49.305410	25.5234	2492	63.576714	76.7241
59.200000	60.200000	115	59.710658	0.035	944	50.572999	29.0640	2419	63.722227	74.4766
60.200000	61.200000	152	60.719134	0.047	1096	51.980127	33.7438	2304	63.922458	70.9360
61.200000	62.200000	195	61.723468	0.060	1291	53.451817	39.7475	2152	64.148715	66.2562
62.200000	63.200000	359	62.755617	0.111	1650	55.476098	50.8005	1957	64.390372	60.2525
63.200000	64.200000	555	63.774187	0.171	2205	57.564733	67.8879	1598	64.757629	49.1995
64.200000	65.200000	555	64.688092	0.171	2760	58.997147	84.9754	1043	65.280937	32.1121
65.200000	66.200000	359	65.662559	0.111	3119	59.764343	96.0283	488	65.955177	15.0246
66.200000	67.200000	107	66.602773	0.033	3226	59.991160	99.3227	129	66.769519	3.9717
67.200000	68.200000	22	67.580514	0.007	3248	60.042566	100.0000	22	67.580514	0.6773

CHAPTER-5

CONCLUSION

5.0 CONCLUSION

Estimation of the ore body has finished the report of the ore body has been generated which shows the volume, heftiness, average grade of the minerals of the ore body. Summary reports have also been generated as per attributes inputted which include calculating reserve as per depth and different mineral grades. The overall face area is $1455648m^2$ and the volume is $36712838m^3$. A common problem for all mining operations is the difficulty they face in directly predicting the resource that can be booby- trapped at their spots. This is because every estimation is associated with an error. These crimes are directly commensurate to the negative goods on the mining business. The financial model could be grossly overstating the value of the factual resource, meaning the mine will no way make plutocrat, or the estimation could understate the resource, and a doable and potentially truly profitable deposit could be left in the ground. The result to this problem is the operation of an integrated software called GEOVIA SURPAC.

By using slice data, drilling data, geological knowledge, informed interpretation, and geostatistical evaluation, GEOVIA SURPAC can give accurate resource estimation, the results of which have multitudinous uses, including for shareholder reports, to help raise finance, as the base 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 politic scheduling in a software package analogous as GEOVIA MINESCHED. All of these are critical to the success of the mine, and effective resource estimation is constantly recognized as being a critical factor for the success of a business.

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