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Delineating the Orebody of a Mineral Deposit Using Subsurface Models

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Abstract.

Minerals and orebodies are very important source of foreign exchange, mineral exploration entailsvarious approaches, but the interest of this research is in exploration geochemistry, basically geochemical survey. In this study, a geochemical survey was performed for lead (Pb) and magnesium (mg) mineralization. The data was acquired from the data bank of RockWares' RockWork Version 2017. The objective of this study is to delineate the configuration (shape) and orientation (positioning) of the orebodies of Pb and Mg mineralization using 3D subsurface models. The grid statistic report show the volume of the ore bodies for Pb and Mg to be 182,646.271128 m^3 and 431,290.197522 m^3respectively within the area of study and suite of boreholes used. The disperse nature of the Mg orebody suggest secondary (sedimentary) process as the origin of the orebody, while that of Pb suggest hydrothermal process. The various models could serve the purpose for choice of cutoff grades.

Keywords**: Hydrothermal deposit, Orebody, Mineral Exploration, Models.**

1.0 INTRODUCTION.

Minerals arenaturally occurring, inorganic, homogeneous elements, or compoundswith a definite chemical composition, distinctive crystalline habit and may occur in well-formed crystals or aggregates(Haldar, 2013)(Gandhi & Sarkar, 2016).While ore can be defined as a naturally occurring deposit of one or more mineralsof economic value that can be exploited at a profit.

Mineral exploration is the scientific search for minerals or ore in any given place using any of the methods which include geochemical, geological, and geophysical.The stages of mineral exploration includes target generation, target drilling, resource evaluation drilling, feasibility study and target mining. Amongst all the stages, the very crucial stages that involves modeling are target evaluation and target defining drilling. Target evaluation involves geological mapping, geochemical survey, analysis and interpretation and preparation of 3D geochemical models, while target defining drilling entails ore body and geometry defining drilling and resource evaluation by estimating cutoff grade and tonnages of mineral in the reserve. A vital aspectis the ability to know the cut-off grade for a particular mineral(Talapatra, 2020)(Macheyeki, et al., 2020).

Minerals or ore deposits are known to occur in the subsurface, their occurrence also depends on their origin which could either be

- magmatic mineral deposits that get concentrated in igneous rocks;
- hydrothermal mineral deposits in fissure and veins by rich hot fluids;
- sedimentary mineral deposits that are precipitated from a solution, typically seawater;
- placer minerals sorted and distributed by flow dynamics of water and
- residual mineral deposits formed by weathering reactions at the earth's surface(Haldar, 2013)

Hydrothermal deposits are formed after their host rocks had been deposited. The fissures and vein are impregnated by hydrothermal fluid that are rich (concentrated) in dissolved minerals at high temperatures which become deposited at lower temperatures(Haldar, 2013).

Both hydrothermal and magmatic ores assume some-kind of ore body which varies from isomeric, flat and pipe shapes, these shapes are of interest as in exploration and needs defining the area, this is where the 3D modeling becomes pivotal, and its usefulness is maximized. The depth and spread of the ore or mineral body should be defined for efficient exploitation.

3D models will provide for target delineation and determine the optimum pit configuration of the mineral deposit. Deposit due to magmatic processes may be intrusive thus buried below the surface, in this case the drive for modeling is to make certain the subsurface configuration of the mineral deposit or delineate the body geometry of the deposit. In this study, interval data or point data can be used. The model type could be based on triangulation networks or solid block models based on IDW (inverse distant weighting anisotropic modeling),(RockWare, 2017)

The study is to highlight the fact that there are available tools with which exploration data can be visualized for better understanding and prospecting.

2.0 GEOLOGY OF NIGER DELTA BASIN.

The Niger Delta Basin was deposited as mega sequences within regular interval of 5Ma, these sequences linked together to form the Niger Delta Basin.Stratigraphically, the Niger Delta Basin is divided into three stratigraphic formations, these are the Benin Formation that is lithologically composed of sand, sandstone, and shale intercalations in the lower series of the Formation. The underlaying formation to the Benin Formation is the Agbada Formation, whose descriptive lithology entails intercalations of sandstone and shale facies in the upper series and mainly shale in the lower series, while Akata Formation which is the last in the series is composed of mainly marine shales(Reijers, 2011), (Short & Stauble, 1967).

3.0 MATERIAL AND METHODS

In this research study, sample data was obtained from the RockWares' RockWork data bank. The data showed that 43 sample points were drilled to a depth of 40m to 50m. Samples were obtained at a regular depth of about 1.5m deep interval. Samples were analyzed for Lead and Magnesium.The studyobjective is to delineate the geometry of Pband Mg Ore within the study area and for the suite of samples that were collected. Samples were analyzed for Lead and Mg using Pekin Elmer2380 computerized AA Spectrophotometer. The result obtained were i–data (interval data) and were interpolated to the corresponding GPS coordinates.

RockWares' RockWork Version 2017 was used for generating a solid model with a view to delineating the ore volume, the shape/geometry of the orebody within the sample area as represented by the suit of boreholes drilled and samples obtained(RockWare, 2017).

4.0 RESULT AND DISCUSSION.

The grid model statistics report was obtained by which the volume of the ore bodies of interest was estimated using Delaunay triangulation method by the EZ volume tool.The ore bodies of interest were those of Mg and Lead.

The volume of lead as Model Volume (Sum(Cell Area*Z)) .... 182,646.271128 Cubic Meters, and Magnesium as Model Volume (Sum(Cell Area*Z)) .... 431,290.197522 Cubic Meters.

Extracts from the Grid model statistics report is as below in figure 1 and figure 2 GPS locations.

The models for various ppm thresholds values for both Mg (Magnesium) and Pb (Lead) are presented in figures 3 and 5 respectively, this could be used to estimate the cutoff grade of a mineral. The higher the concentration, the higher the cutoff grade and it provides for a choice of grade for optimum benefits(Roonwal, 2018)(Fletcher, et al., 1987).

The stripping ratio can also be estimated from the models, for the ore body to be accessed. This provides a guide to the ore body provided the GPS coordinates are within 95% confidence level.


```
Grid Name ................................. C:\Users\USER PC\Documents\RockWorks17 Data\Mineral Deposit\Lead.RwGrd
   File date .............................. 03/09/2022 14:50:18

Area/Volume:

   Center of Mass (x,y) ................... 482,022.453134 Meters , 4,399,865.364741 Meters
   Cell Area .............................. 25.0 Square Meters
   Map Area (X*Y) ......................... 81,200.0 Square Meters
   Grid Area (Sum(Cell Area)).............. 84,075.0 Square Meters
   Model Volume (Sum(Cell Area*Z)) ........ 182,646.271128 Cubic Meters*
   Non-Zero node area ..................... 84,075.0 Square Meters
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Grid Name ................................. C:\Users\USER PC\Documents\RockWorks17 Data\Mineral Deposit\Mg.RwGrd
   File date .............................. 04/09/2022 21:50:05

Area/Volume:

   Center of Mass (x,y) ................... 482,025.63399 Meters , 4,399,870.48609 Meters
   Cell Area .............................. 25.0 Square Meters
   Map Area (X*Y) ......................... 81,200.0 Square Meters
   Grid Area (Sum(Cell Area)).............. 84,075.0 Square Meters
   Model Volume (Sum(Cell Area*Z)) ........ 431,290.197522 Cubic Meters*
   Non-Zero node area ..................... 84,075.0 Square Meters
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Figure 1. The extracts from the Grid model statistics report showing the estimated both Lead and Mg mineralization in area of study.

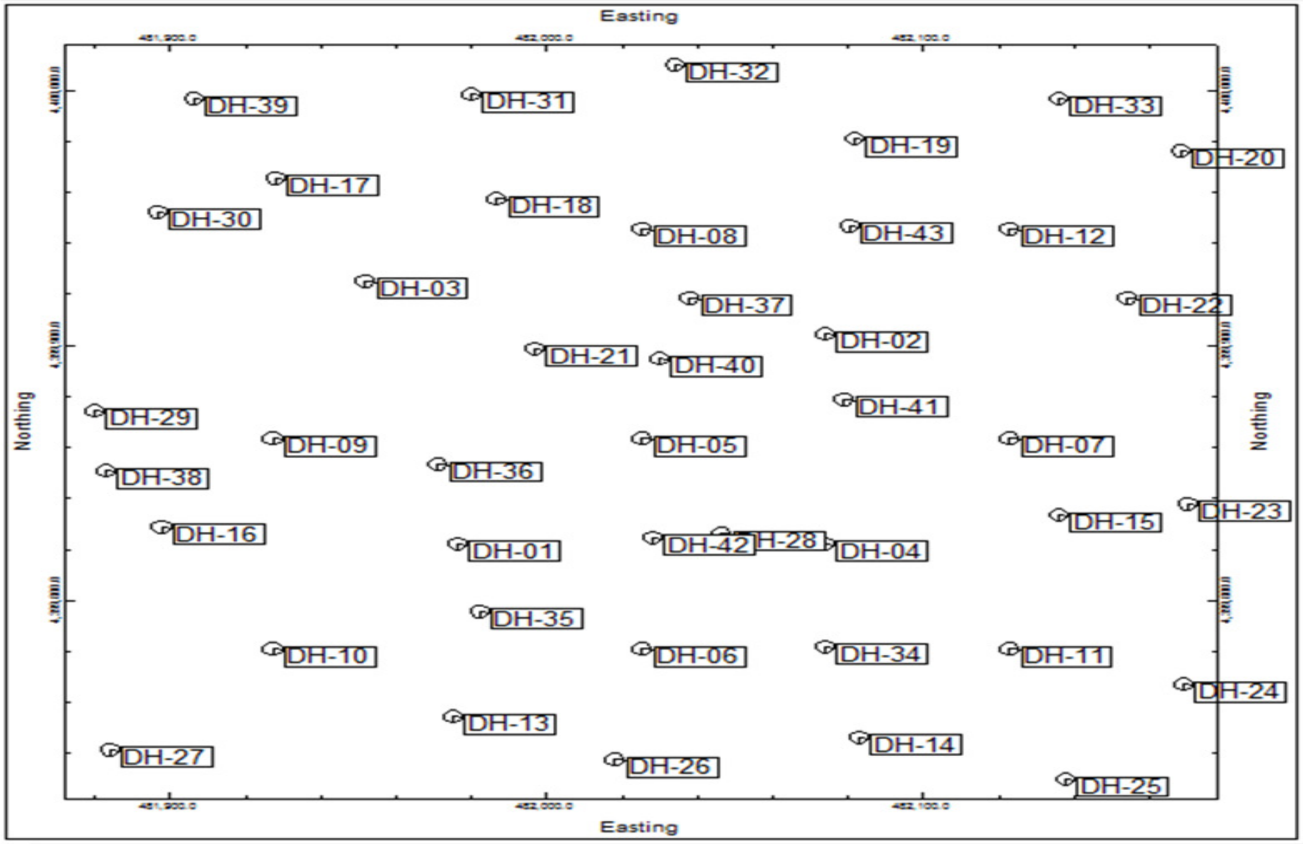

Figure 2. Map showing GPS Location of sample boreholes.

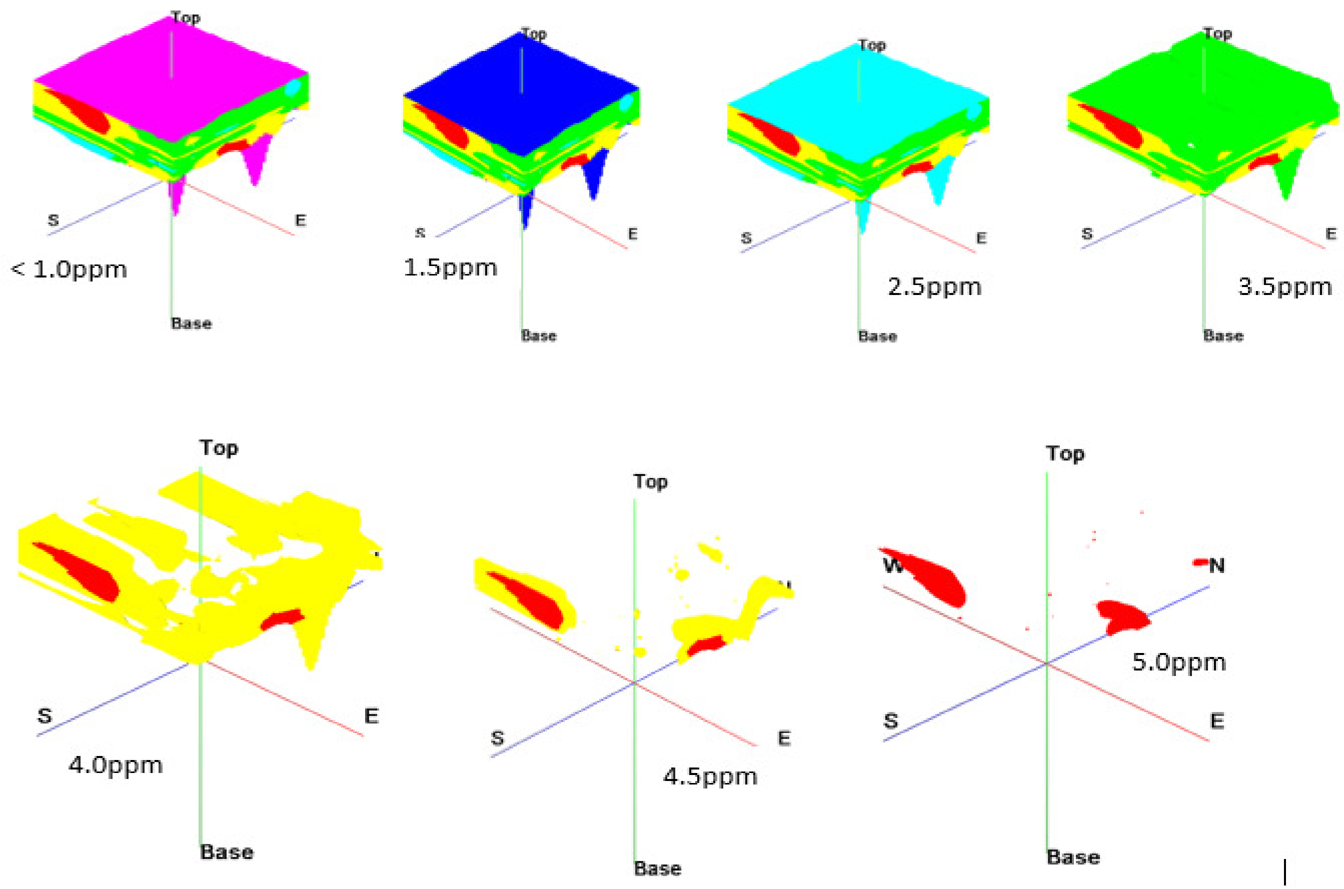

Figure 3. The various 3D models for Magnesium (Mg) mineralization and various threshold concentration

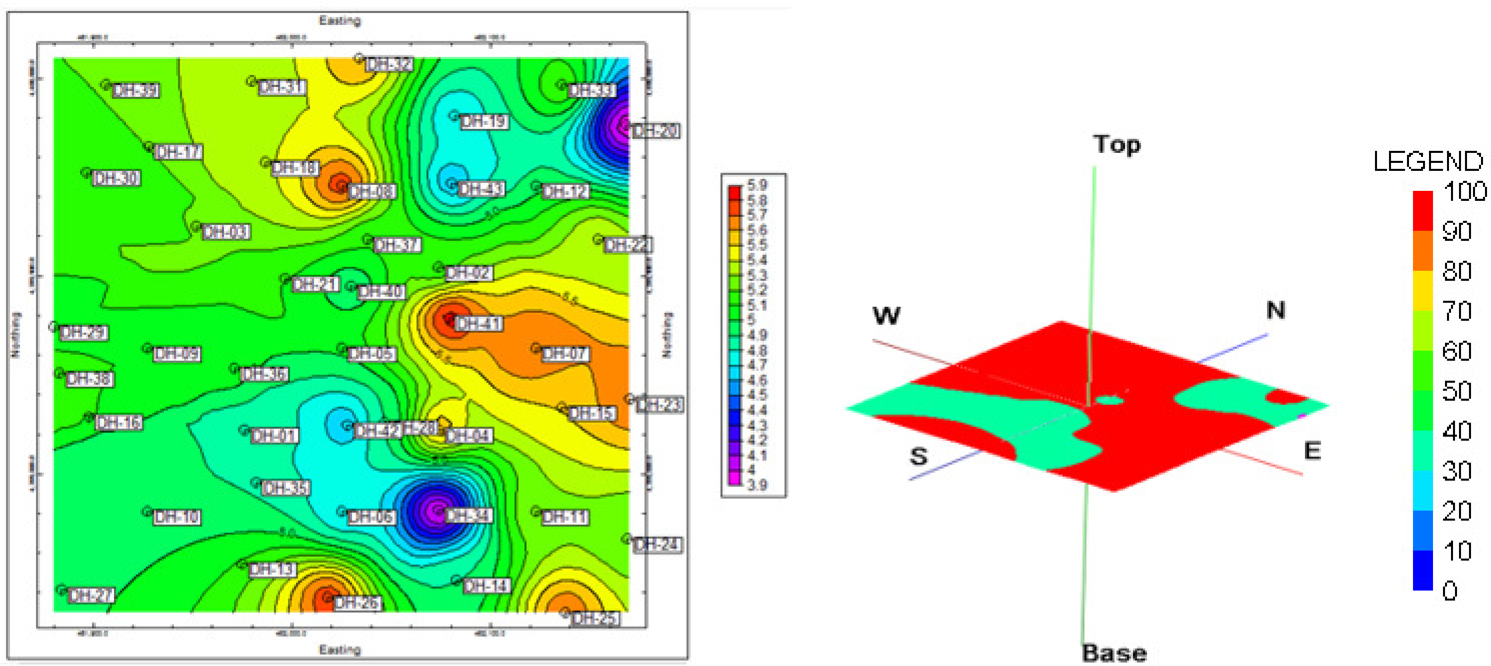

Figure 4 Contoured location Map and 3D statistics map based on higher values Mg Concentration values.

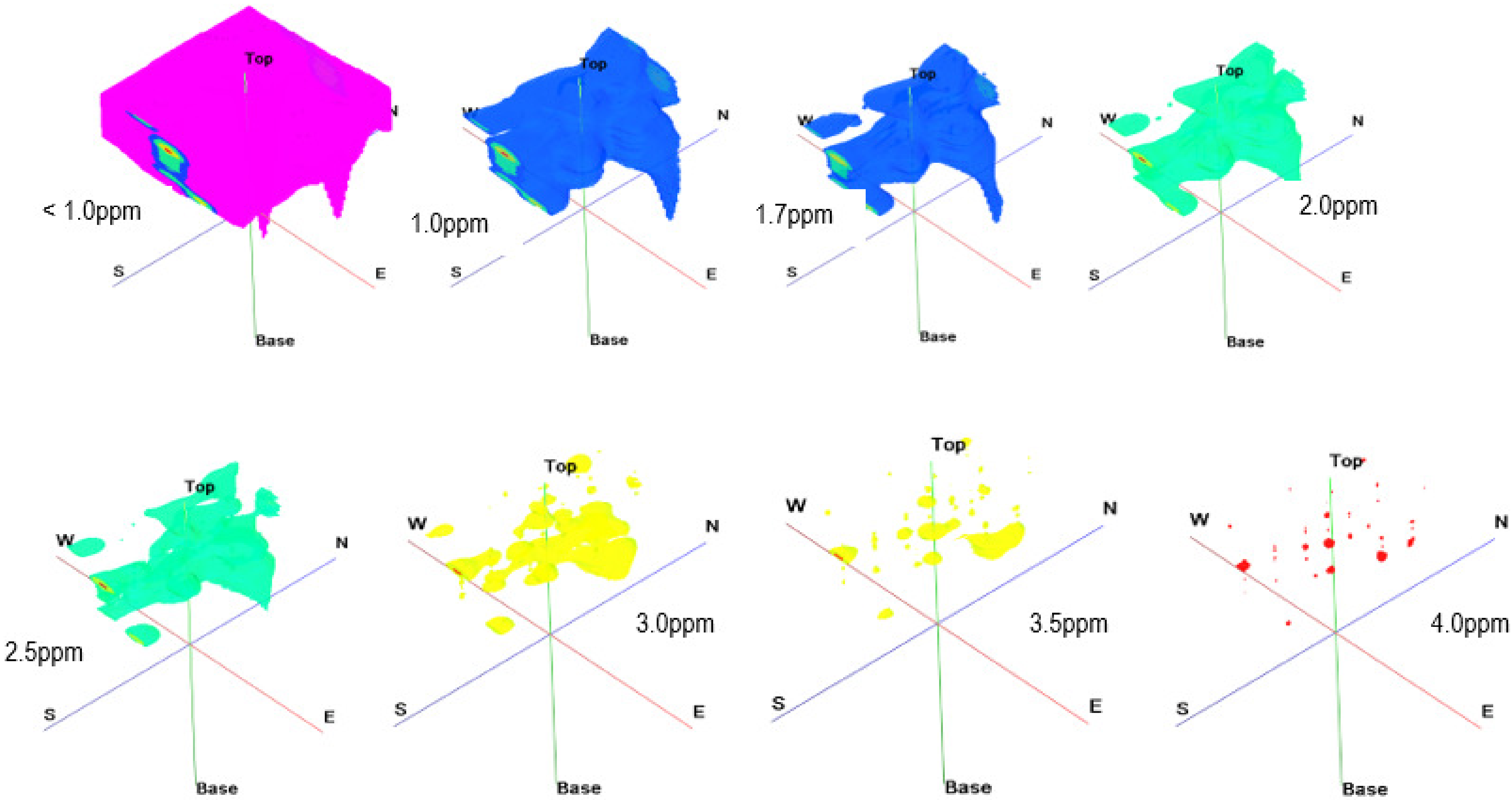

Figure 5. The various 3D models for Lead (Pb) mineralization and various threshold concentration

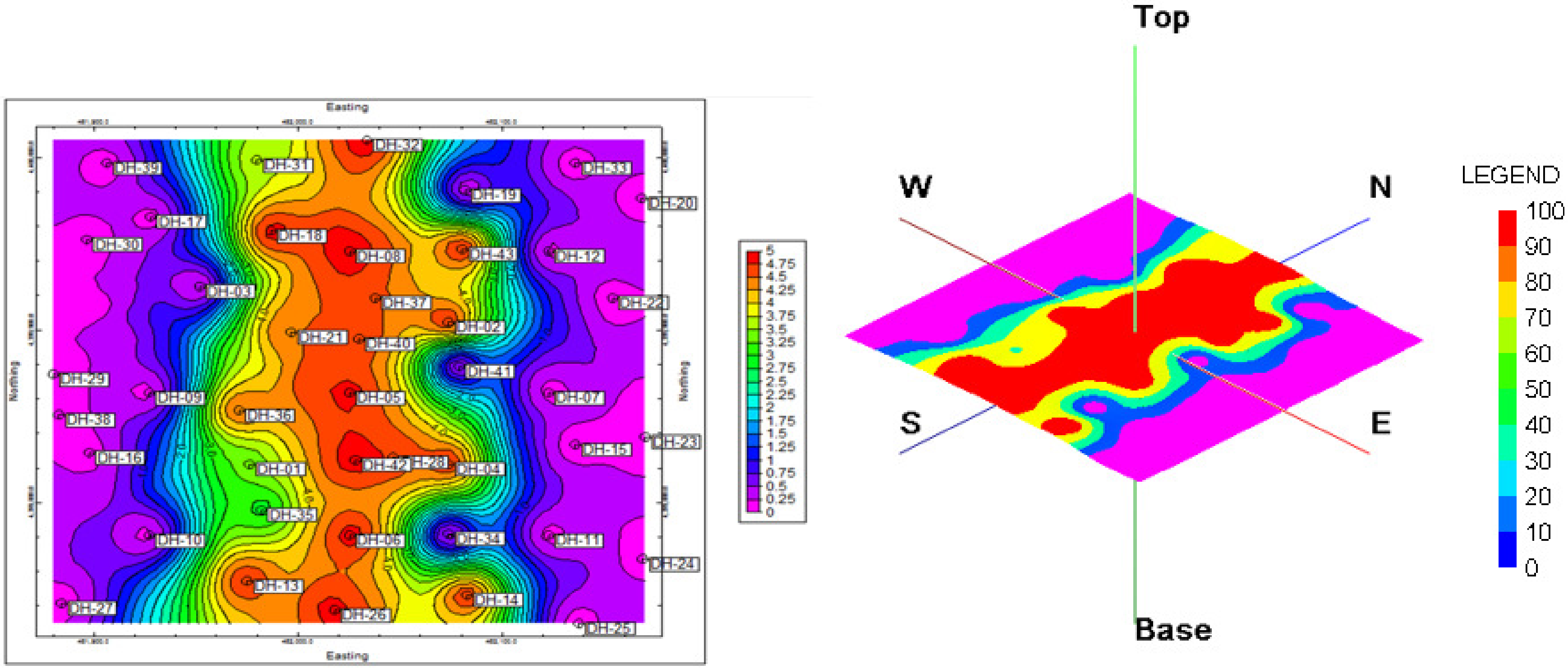

Figure 6 Contoured location Map and 3D statistics map based on higher values Pb Concentration values.

Figure 3 represents the GPS location of the sample points (boreholes) and Mg dispersion and areas of major deposits. The various models and the corresponding concentration of Mg infers that the depositional system is that of surface or secondary processes.The variable concentrations and models show the shape and geometry of the deposit. In figure 4, the GPS location of areas of higher concentrations can be identify in correspondence with the legend. The various models can also serve the purpose of estimating the cutoff grade, which implies the concentration range at which the production process will be at optimum cost. In relation to the stripping ratio, pit optimization can be achieved, the amount of waste that need to the taken off to get to the ore can be estimated, on the overall volumetric estimations can be performed with the data available.

Figure 5 shows the volumetric of the Lead (Pb) ore body corresponding to the different ranges of concentration. The higher the threshold value of the concentration, the smaller the volume of the ore body. Figure 6 shows the contoured location map indicating the areas of low and higher concentration of Lead, this information can serve as a guide in determining the percentage for the cutoff grade(Grunsky, 1998)(Haldar, 2013).

The objective of this study is to highlight the fact that this research method can serve the purpose for mineral exploration. The profile of the orebody of Pb show a linear section from the North to the South, the geometry of the Lead mineralization as in figures 5 and 6 represents some kind of hydrothermal deposits, thus the present of a fault along the North–South transverse is suggested(Robb, 2005).

Each of the models in figures 3 and 5 has a concentration listed beside it, this infers that the models bear the orebody of higher concentrations than indicated.

The potential cutoff grade can be estimate corroborating the legend in figures 3 and 4 for Magnesium mineralization and figures 5 and 6 for lead mineralization, the percentage provides the choice for the amount to be stripped to obtain the grade that will be optimal for economic production. This study is basically to delineate the structure of the mineralization (geobody or orebody) in the subsurface. This also provides a preliminary estimation of the volume of the mineral within the area of study considering the wellbores.

5.0 CONCLUSION

The shape of orebodies and orientation of the Lead (Pb) and Magnesium (Mg) mineralization in the subsurface are visualized, the respective cutoffs can be estimated.

The volume and mass of the orebodies can be estimated. Accurate GPS coordinates infers actual location of the orebodies can be determined. The structure of the orebodies provides hints for determination of the ore origin and formation processes. The Pb mineralization is suggested to be due to hydrothermal fluids, while the magnesium is due to sedimentary processes.

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