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AZ ZABIRAH CENTRAL ZONE PROJECT PRELIMINARY TECHNICAL AND ECONOMICAL STUDY

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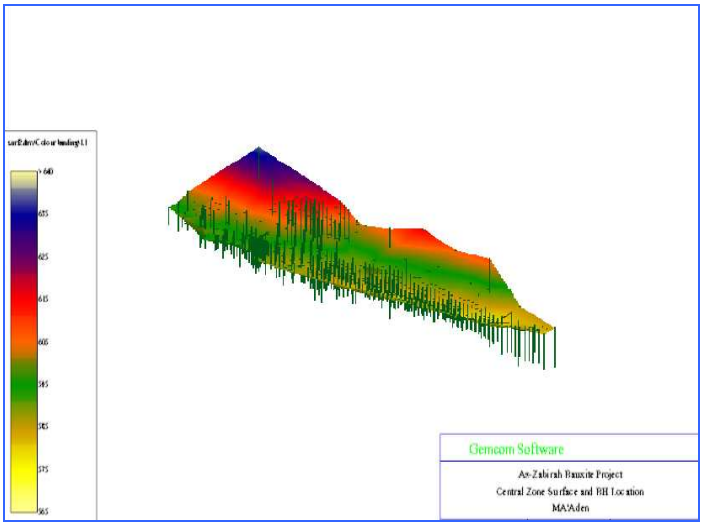
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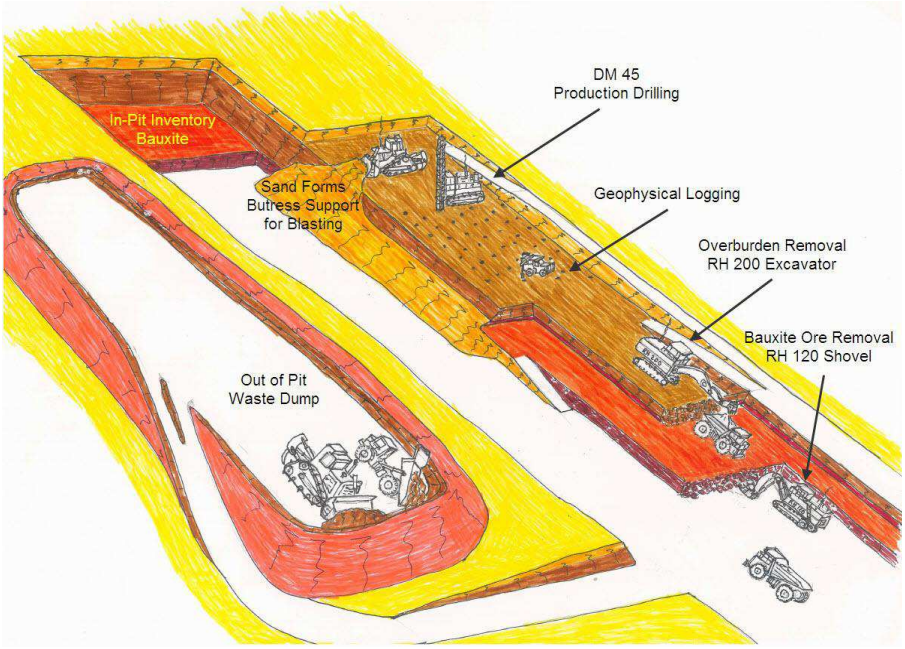
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Az Zabirah Central Zone Bauxite Project Preliminary Technical and Economic Study



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Executive Summary

The objectives of this study are to estimate and the resource of Az Zabirah central zone and upgrade a part of the inferred to be indicated and to perform a preliminary technical and economic evaluation to extend the life of mine on the south zone.

The last resource were done on the Central zone was by Hatch on 2004, the total resource was 135.55 dry Mt at 51.45 TAA, 8.22 SiO_2 and SG of 2.01 within cut off 40% TAA.

The current study estimated about 135.43 dry Mt at 50.27 TAA, 8.15 SiO_2 within Cut off 40% TAA.

The indicated area was increased due to the last drilling program performed by Ma'aden, within closed spacing grid, thus the total tonnage increased as well to 32.33 Mt compared to 15.5Mt on Hatch's report.

The Reserve was calculated total of 26.01 dry Mt at 50.2 TAA, 8.32 Sio_2 and 4.81 Fe_2o_3 at cut off 40% Taa, within loss of 0.25m and 0.15m dilution were applied and no optimization.

A capital cost was estimated of 49.65 M$ for 5 years mining contractor.

The complete economic study was given NPV of 31.94 M and 43.99% IRR within 12% actualization was applied.

At 25.29 selling price which is around 10% reduction on the used prices (27.8$/t), we have break even, and at 23.38 selling price we have cash break even.

The Central zone is very good advantage for Ma'aden to extend the proposed mine in the south zone and it could be more attractive if Ma'aden complete the drilling plan to upgrade the inferred resource to be an indicated and increase the reserve to increase the Central zone mine life.

List of Abbreviations

Abbreviation	Description
Al_2O_3	Aluminium Oxide
Anisotropy	Having different values when measuring in different directions.
BRGN	Bureau de Recherches Geologiques et Minieres
Bxz	Bauxite Zone
C	The different between gamma (h) value at which the variogram curve leaves off (the sill) and the nugget.
Fe_2O_3	Iron Oxide
Isotropy	Having the same value in different direction
JORC	The joint Ore Reserves Committee of the Australasian institute of Geosciences, and Mineral Council of Australia.
Lcz	Lower Clay Zone
m	Meter
Mt	Million tones
Nugget	The nugget is the value of gamma (h) at zero distance on the variogram. The nugget represents the inherent variability of the data.
PBP	Pay Back Period
Range	The distance at which the variogram reaches the sill called range, beyond this distance there is no any correlation between samples.
SiO_2	Silicon Oxide
TAA	Total Available Alumina (Al2O3 – Sio2).
Ucz	Upper Clay Zone
Variogram	The variogram is the basic tool of geostatistics, describing the variation of value within distance and direction.
Zakat	Islamic concept of Alms, it is an obligation on Muslims to pay 2.5% of their wealth to specific categorises.

1 Introduction

1.1 Company overview (Ma'aden)

The Saudi Arabian mining company (Ma'aden) was established in 1997 as a joint stock company 100 percent owned by the government of the Kingdom of Saudi Arabia. The purpose of formed Ma'aden is for promoting the development and exploration of the Kingdome's mineral resource. In early 2008 Ma'aden became a public limited company with 50% of its shares for the public and 50% remained for the states.
Ma'aden is a major resource company in the Middle East, it currently operates five gold mines (Al-Hajar, Bulgah, Sukhaybarat, Mahd Ad Dahab mine and Al-Amar which is producing also silver, copper and zinc) and it is developing one more mining property in Al-Duwayhi.

Ma'aden is now expanding its activities beyond its gold business with the development of its Phosphate Project, Aluminum Project, and Other Projects (Magnesite & Kaolin).

1.2 Az Zabirah Aluminum project

1.2.1 General overview

Ma'aden is undertaking a project to exploit Saudi Arabia's extensive bauxite reserves as well refining it in its own refinery & smelter, taking the advantage of the low cost of fuel to produce the power by its own captive power stations.

Ma'aden has finished the feasibility study of developing a bauxite mine at Az Zabirah in the central northern of Saudi Arabia and an industrial city comprising an alumina refinery, aluminum smelter, power station, desalination plant, administration building, accommodation and port at Ras Az Zawr on the western shore of the Arabian Gulf in east province of Saudi Arabia. (Figure 1)

According to the latest feasibility study Ma'aden will build a refinery with capacity of 1.8 million tonne (Mt) of Alumina per annum as well as building a smelter to smelt as much as possible of the alumina to produce aluminum.

The study estimated that 720,000 tonne of Aluminum per annum using Pechiney technique (AP35) will require 5.1 Mt of bauxite to be mined every year.

The crushed bauxite will be transported from Az Zabirah mine to the refinery at Ras Az Zawr by railway system.

This rail head will support the Aluminum project as well as the phosphate project which will be required to transport the phosphate from Al Jalamid deposit in Northeastern of Saudi Arabia near the border with Jordan.

Construction of this rail head has been started in 2008 as an independent project by consortium of Ma'aden and the Saudi Public Investment Fund (PIF). Ma'aden has current investment $500 million in the railway project which expected to be completed in mid - 2011.

1.2.2 Deposit location

The Az Zabirah bauxite deposit is located in Ha'il province and about 180 km north of Buraydah the capital city of Al Qassim province in the Northeastern regain of Saudi Arabia, about 535 to 600 meters above see level. The closet airport to the deposit is Buraydah domestic airport. The deposit is located about 410 km north of Riyadh the capital City of Saudi Arabia. (Figure 1)

The deposit named came after Az Zabirah village which located between the Central zone and the north zone but it's not inside the exploration and mining license, the village consists of about 70 houses.

AlBi'ithah is a small village consists of 24 houses, is located over the portion of the south zone's bauxite resource (inside the mining license).

The township of Qiba, which located about 50 km south from the end of the south zone and about 35 km south of AlBi'ithah village and 95 km from Az Zabirah village, is the main settlement and the regional center for administration and commercial activities. It was founded before than 80 years ago, it consists of more than 3000 houses with shops and community facilities and supports a population of 14000 to 16000 people.

The access to Qiba from Burydah is by seald road and from Qiba to Az Zabirah by desert tracks only.

The proposed mine target is the south zone, the mine processing facilities would be located approximately 43 km Northwest of Qiba, the coordinates for the approximate center of the mine processing facilities are:

- WGS84 latitude/ longitude 27˚39'52.8"N/ 44˚o'38.5"E
- UTM zone 38 3 060 750N/ 404 600E

1.2.3 Climate

The Az Zabirah deposit is located in arid environment in the north central region, with rainfall commonly less than 100mm per annum. The summer is longer than winter, the average temperatures approximately 32 ˚C through the summer months (June-September) but regularly it's exceeding 40 ˚C. Daytime winter temperatures average approximately 12 ˚C (November-March). Night time winter temperatures can be fall below 0 ˚C. Prevailing winds are from North to Northeast during the winter and South to Southwest during the summer. Vegetation is very spars and comprises perennial shrubs along the valleys.

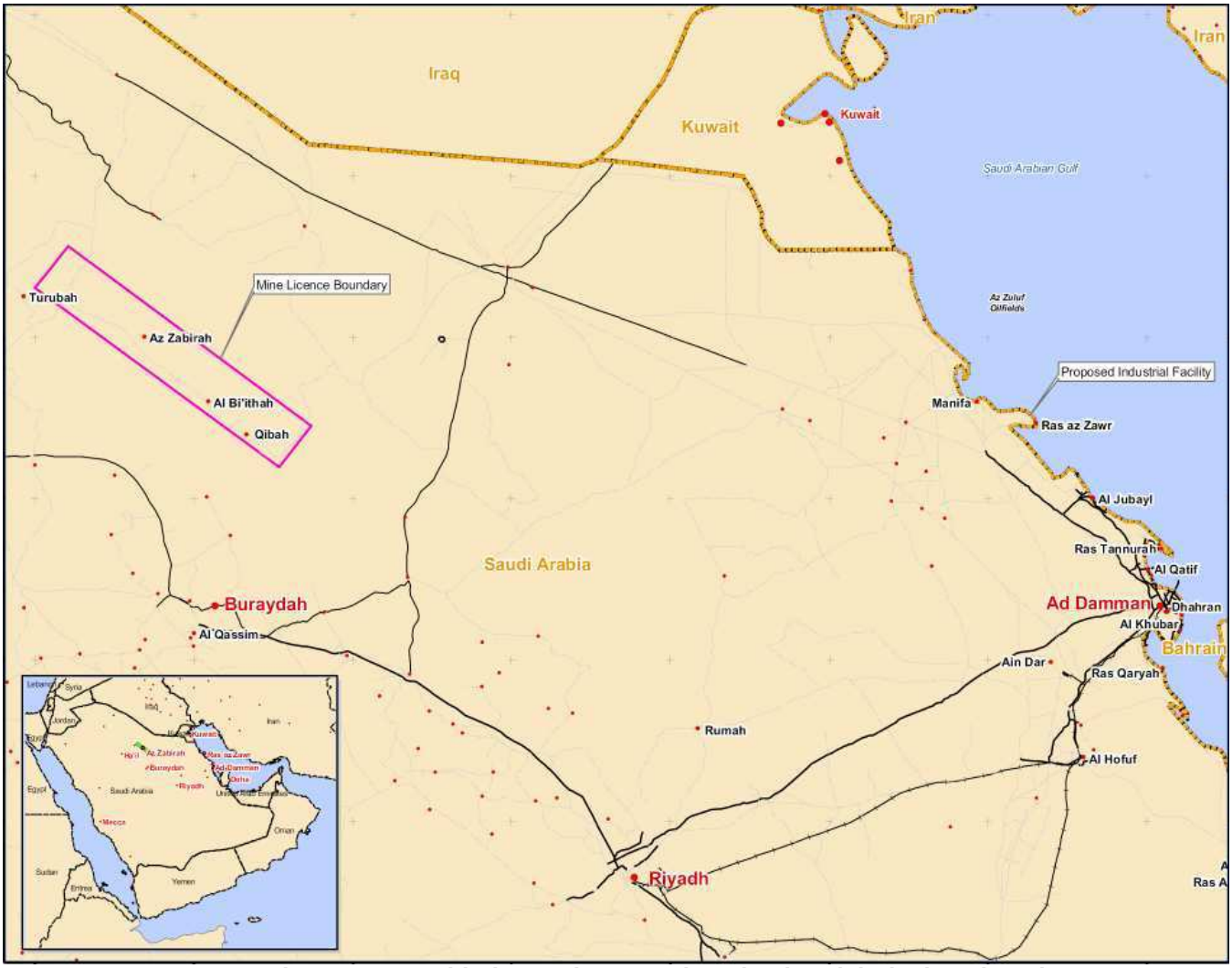


Figure 1. Az Zabirah Bauxite Deposit and Industrial City location plan

1.2.4 Exploration and Mining License

Ma'aden had an exploration license to explore the deposit with 192 km long by 35 km wide.

The early infill program approved that the north zone has insufficient resource, that leaded Ma'aden to excluded it from the new exploration license which included only the Central and the South zone, with area of 425 km2 (85 X 5 km).

In 2007 the company has got permission from the ministry of petroleum and mineral resource the South zone with an area of 147 km2. (Figure 2)

In 2006 and 2007 Ma'aden conducted exploration program in the central zone, which aimed to upgrade the resource. That program clarified that the bauxite is disappear in south part of the Central zone, which leaded again to reduce the exploration area to 80.1

Sq km, after excluded the kaoline project license which located Northwest of the Central zone. (Figure 3)

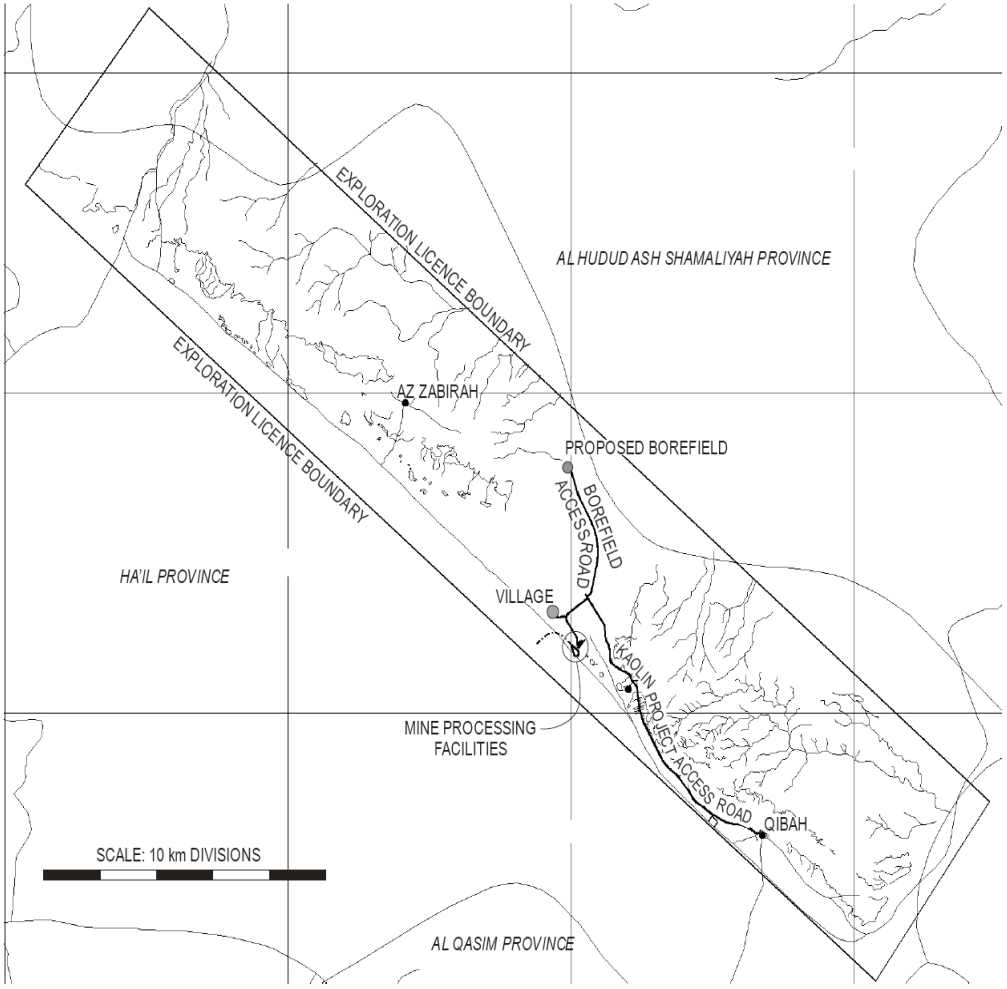


Figure 2. Exploration and Mining license, with the Mine Processing Facilities.

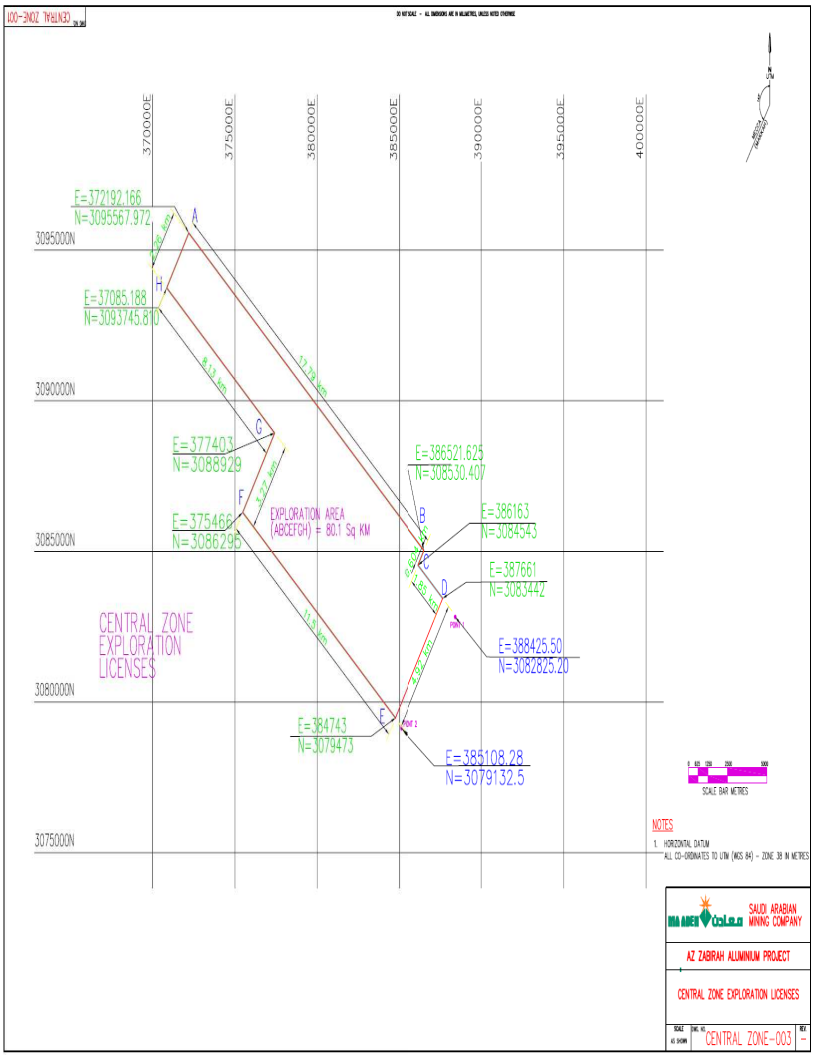


Figure 3. The Latest Exploration License on Az Zabirah Central Zone.

1.3 Project History and Previous study

In 1963 commissioned United States Geological Survey (USGS) to do mapping and geological survey for many sites and they compiled occurrence of “laterite clay and bauxite” north of Qiba.

From 1979 to 1984, Riofinex conducted an exploration program and discovered the deposit, the program included a reconnaissance study, regional mapping and outcrop and channel sampling. Riofinex continued the exploration program by conducting a regional drilling program and finally some additional closed spaced drilling. The Riofinex Report dated 1982, identified three distinct zones (the North Zone, Central Zone and South Zone), spaced approximately 30 kilometers apart along the strike that exhibited economic potential. The Riofinex program included test work on bauxite quality and beneficiation possibilities.

The Drilling program was nominally at 2000 to 4000 meters north-south (local grid) with a nominal spacing of 500 meters on section for the South Zone and Central Zone, and

5000 meters with a nominal spacing of 500 meters on section for the North Zone. In additional, fence of 24 holes at 50-meter spacing were drilled along a selected east-west gridline in order to assess the short range characteristics of the bauxite. Riofinex drilled a total of 331 holes during its data acquisition program.

From 1987 to 1993, Bureau de Recherches Géologiques et Minières (BRGM) geoscientists, in conjunction with the Saudi Deputy Ministry for Mineral Resources (DMMR), conducted a prefeasibility study of the Deposit, and summarized their findings in a report (BRGM Report) dated 1993. The BRGM program entailed drilling 430 holes in the south and Central zone, where 361 boreholes were drilled on a nominal 500m X 500m grid, 37 holes were drilled as cross drilling in a closed space ranged from 5 to 50m, 25 holes were drilled to obtain geotechnical data, 3 holes were drilled to investigate the LCZ and 4 holes were drilled for density assessment.

In December 2001, Ma'aden commissioned Hatch to prepare technical and preliminary economic evaluation report for the project and review the geological data collected from exploration programs conducted by Riofinex and BRGM. February 2002 Hatch completed a report recomming drilling and assaying program aimed to delineate sufficient proved and probable reserves to provide refinery feedstock for two assumed time periods.

Ma'aden commenced the data acquisition program recommended by Hatch in April 2002 and Completed the data acquisition program in February 2003. Hatch used the data from this Ma'aden data acquisition program, in conjunction with the data from the Riofinex and BRGM programs, to prepare resource estimates for the South Zone and the Central Zone of the Deposit.
After Ma'aden acquired the rights to the Deposit in 1999, Hatch used the previous Riofinex Report and BRGM Report and results of the related studies as the basis of a Prefeasibility study, which Hatch commenced in December 2001 and completed in September 2002.

Ma'aden also engaged Hatch in 2001 to prepare a mine plan (Mine Plan). This Mine Plan was based upon the results of the Resource Modeling Study, and assumed a specified limited period of production, exclusively within the South Zone.

In April 2003 Ma'aden commissioned Saudi Arabian Bechtel Company (Bechtel) to prepare a Feasibility Study Report for the Feasibility Study Project. Ma'aden also contracted with other entities to conduct investigations and studies in support of the Feasibility Study Report.

During the period from August to November 2003, Ma'aden conducted infill drilling and trial mine program on the south zone. The aimed of the infill drilling program was to upgrade the resource of the south zone in the regions classified as inferred to Indicated by infill drill that regions using a drill spacing of 250m. A total of 306 holes were drilled in this program. The trial mine was carried out within the northern part of the south zone. The trial pit was 50 X 150 block with total area of 750m^2. The objective of trial mine program was to obtain reliable data on:

- The extent of the possible dilution at the upper clay zone and Bauxite zone interface.

- The requirement of the light blasting for the economic bauxite horizon.
- The extent of the possible dilution at Bauxite zone and the lower clay zone interface.
- The rippability of the overburden material including the clays overlying the bauxite.
- The accessibility of the mining equipment below the economic bauxite horizon.

In August 2003 Ma'aden appointed GHD Pty Ltd, through Bechtel to prepare an Environmental Impact Assessment. This Study includes Environmental Management Plan, description of the project Quality, Health, Safety and Environment Management System.

In July 2004, while Bechtel was going on the feasibility study, Ma'aden requested Runge Ltd., who was also working with Bechtel to develop mine capital and operating parameters for this Feasibility Study Report, to prepare a new mine schedule using the Hatch resource model and ultimate mining limits with the goal of reducing the amount of prestripping required.

In December 2004 Ma'aden commissioned SMG Consultants to prepare a Geological and Mine Planning report for the Az Zabirah Mining Project (South Zone). The scope of the mine planning component of this study was to ensure the delineation of Proven Reserves for the Measured Reserve and Probable Reserves for the Indicated Reserves, with a target of producing 1.4 Mtpa of Alumina from the refinery for the life of mine.

In January 2005, Ma'aden requested that SRK Consulting ('SRK') carried out an independent technical review of the geology, resources, mining and reserve sections of SMGC work.

In November 2005 MA'ADEN was appointed SRK Consulting (SRK), in conjunction with Consolidated Mining Company Limited (CMC), to carry out a mining geotechnical investigation for the Az Zabirah Bauxite Project in the Kingdom of Saudi Arabia, which would be suitable for inclusion into the project's bankable feasibility study. Up to that date, the Az Zabirah mine design has been based on mining operations elsewhere in the world.

During the period from July 2006 to June 2007 Ma'aden conducted infill drilling program on the central zone. The aimed of the infill drilling program was to upgrade the recourse of the Central zone in the regions classified as inferred to Indicated by infill drill that regions using a drill spacing of 250m. A total of 365 holes were drilled in this program and remaining of 464 holes to be drilled on the future.

In July 2007 Ma'aden commissioned Hatch to conduct a resource estimation study for Az Zabirah south zone bauxite deposit, due to SRK recommendation in their independent technical report that resource should re-estimated again due to the differences between Hatch 2004 and SMGC 2005 reports.

1.4 Study Objectives and Scope

The objectives of this study are to estimate the resource of Az Zabirah central zone and upgrade a part of the inferred to be indicated and to perform a preliminary technical and economic evaluation to extend the life of mine on the south zone.

The technical exercise will include the mining method, machine selection and operation and capital cost estimation.

The economic study will aimed to study the possibility of mining the central zone within the possible maximum benefit and minimum cost.

Another objective of this study is to update and upgrade the resource in the study already done by Hutch in the year 2004 for the central zone, since some additional boreholes have been done in the area in the year 2006 & 2007.

To include the impact of additional drill holes to the study of since the last technical and economical study on the Central zone which was done by Hatch in 2004 and the Resource was calculated, no more study was conducted although there was an infill drilling program from 2006 to 2007, therefore this study was plan to be done.

2 Geology

2.1 Regional Geology

The deposit has an overall strike length of approximately 105 km, trending in occurs a Northwest- Southeast direction, and an identified width of 5 km. It comprises of three main zones, South zone, Central zone and the North zone, with each zone being approximately 30 km long. (Figure 4)

The deposit displays very subdued topography relief. The sequence of footwall, host and hanging wall sediments dip to the Northeast at approximately 5˚. To the Southwest, the deposit is bounded by a discontinuous scarp defined by the outcropping bauxite. The scarp is reasonably prominent in the Central Zone region but non existent or poorly defined in the in the South Zone. The height of the scarp rarely exceeds 10m above the alluvial plains that have formed on Biyadh sandstones to the southwest.

To the Northeast, the landform is defined by gently rising duricrust plains developed on the lower beds of the Wasia formation. Approximately 3 Km Northeast of the Bauxite scarp, a low scarp (□10m high) occurs a long the outcrop of the upper units of the Wasia formation, another scarp approximately 4 Km Northeast of the bauxite scarp, formed at the base of the Aurma formation. In Places, it rises up to 50m above the duri crust plain and represents the most prominent topographic feature in the region.

The bauxite deposit comprises a Cretaceous paleolaterite which has been uplifted and exposed to erosion due to Quaternary elevation of the area. The bauxite occurs within a Mesozoic sedimentary sequence, represented by the Triassic to Jurassic Jihl, Tuwaiq

Mountain, Minjur, Marrat and Dhurma Formations respectively, with the Biyadh Sandstone (Lower Cretaceous) constituting the immediate footwall and the Wasia and Aruma Formations (Upper Cretaceous) the hangingwall. The angular discordance between the strike of the parent rock formations and the overburden is approximately 25°. The Mesozoic sedimentary sequence was deposited on a stable platform without any major tectonic disturbances subsequent to the Cambrian.

The Biyadh Sandstone (Lower Cretaceous) represents the oldest rock formation, outcropping south west of the bauxite outcrops. The unevenly eroded bauxite assemblage (Lower Clay Zone, Bauxite Zone, Upper Clay Zone) is overlain by the Wasia Formation (Upper Cretaceous) and Aruma Limestone on the north eastern limb of the deposit.

Relative to other world bauxite deposits, the ore has higher reactive silica content, balanced by reasonable alumina content. The deposit has a higher proportion of boehmite (monohydrated alumina) in relation to gibbsite (trihydrated alumina) than most bauxite, and therefore requires alumina extraction at relatively high temperature and pressure conditions.

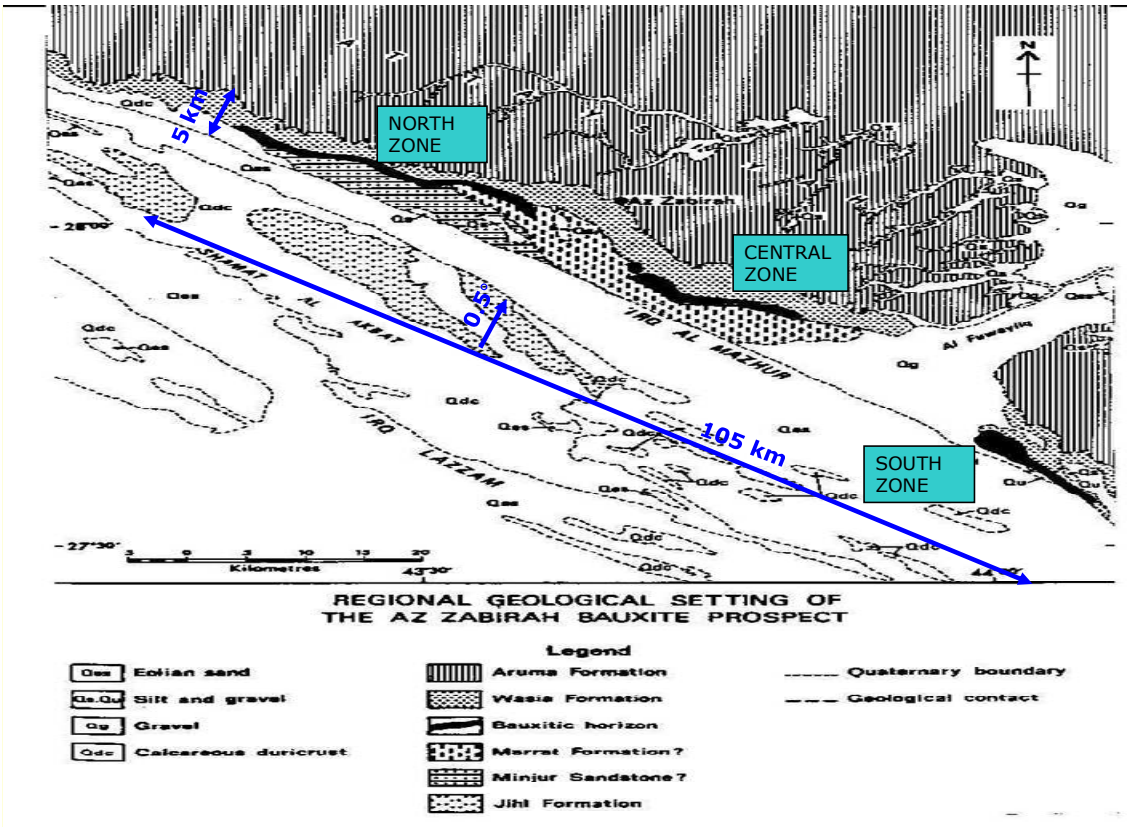


Figure 4. Az Zabirah Bauxite Deposit Regional setting

2.2 Local Geology

2.2.1 Lower Cretaceous

- **Biyadh Sandstone (Bi)**

The Biyadh Sandstone outcrops along the south western portion of the south zone area, striking NW-SE over a distance of approximately 3km to 11km North West of the village of Al Bi'ithah. The sandstone outcrops are frequently associated with rough, rocky desert, hammadah, chaotic heaps of flat, platy blocks, or steep, rocky hills. The exposed thickness of the Biyadh Sandstone is approximately 5m. (Figure 5)
The Biyadh Formation comprises primarily fine-grained, well-bedded sandstone (15cm 20cm thick) with either a kaolinitic, hematitic or siliceous matrix. Depending on the matrix type, the color varies from white, dark brown to black. Similarly, the Intact Rock Strength (IRS) may vary from weak to extremely hard rock. The texture of the kaolinitic sandstone is grain supported, while the hematitic and siliceous varieties are typically matrix supported.
Interbedded white kaolin and purple to red, extremely hard hematitic cherty mudstone beds or lenses occur within the sandstone sequence; typically south west of the basins of the two large sebkhas, North West of the village of Al Bi'ithah.



Figure 5. Biyadh Sandstone outcrops

- **Lower Clay Zone (LCZ)**

The lower clay is characterized by by the gradational reduction with the depth in the intensity of bauxitisation. It is essentially the transition zone between Bxz and the Parent rock Sequence. The upper part of the LCZ exhibits similar pisolitic textures to the BXZ, which change with increasing depth to bauxitic clays, Kaolinitic clays, Kaolinised parent rock and finally unaltered parent rock. The characteristics of the LCZ differ between the Central and south zone. This has been attributed to variations in permeability of the parent rock sequence. Over the more permeable rocks in the central zone, the intensity of bauxitisation decreases with depth in a uniformly gradation manner. Over the less permeable rocks in the south zone, bauitisation at depth has preferentially occurred along

joints and bedding planes, resulting in a more discontinuous contact and discrete lenses of claystone and pisolitic bauxite. (Figure 6) & (Figure 7)

AZ ZABIRAH BAUXITE DEPOSIT

TYPICAL BAUXITE PROFILE OVER PERMEABLE PARENT ROCK

From LE NINDRE & OTHERS, 1989
after BLACK & OTHERS, 1982

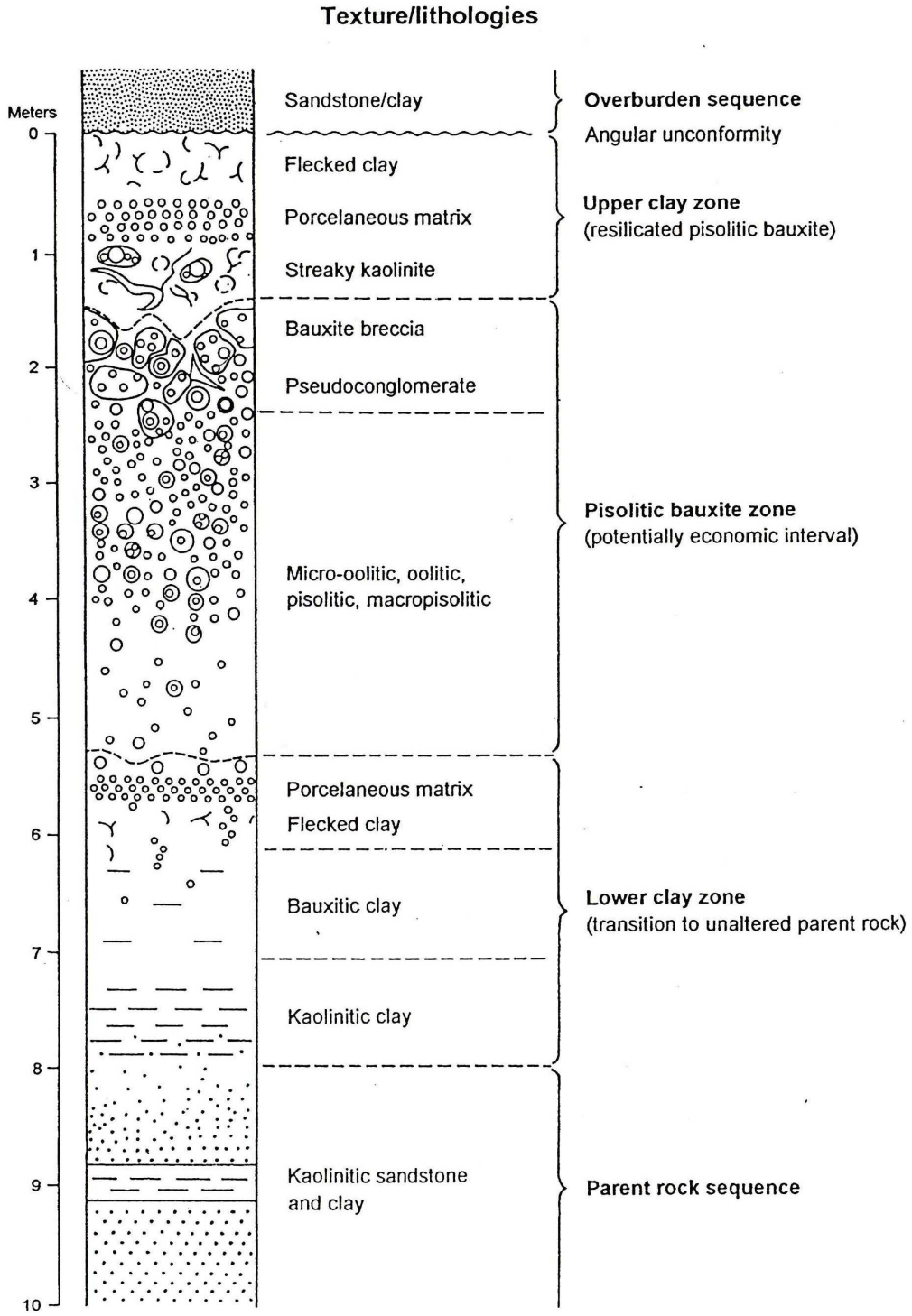


Figure 6. Typical Bauxite profile- Central Zone

AZ ZABIRAH BAUXITE DEPOSIT

TYPICAL BAUXITE PROFILE OVER IMPERMEABLE PARENT ROCK

From LE NINDRE & OTHERS, 1989
after BLACK & OTHERS, 1982

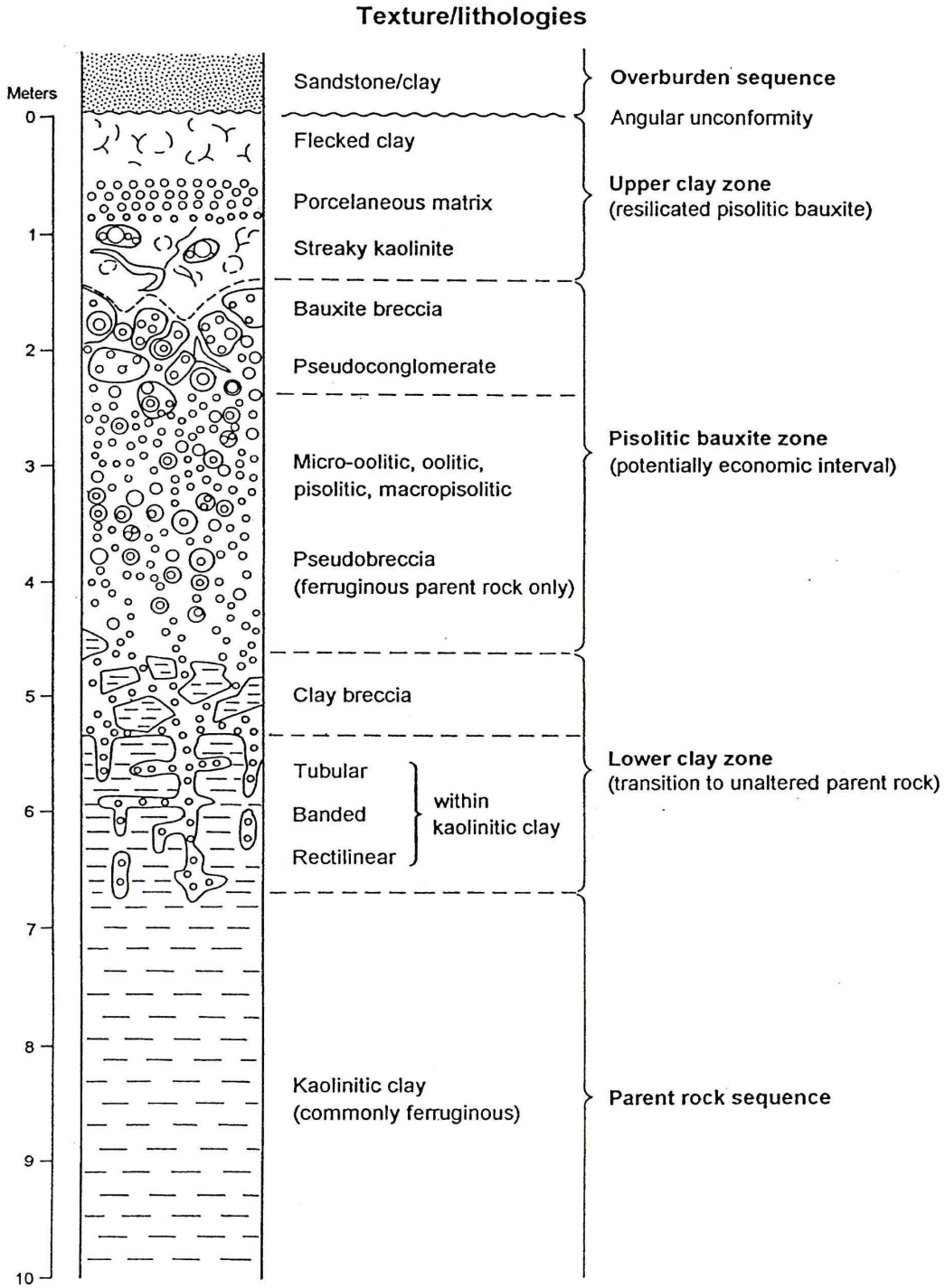


Figure 7. Typical Bauxite profile- South Zone

Surface exposures extend discontinuously over a distance of approximately 25km a long south western margin of the bauxite outcrops in the south zone.
The LCZ is comprised predominantly of variegated clay, which may be white, violet, blue, reddish brown, grey or green-grey in colour.
Iron-rich hematitc beds, hematitic pisolites and thick kaolin strata frequentely occur within the upper portion of the LCZ.
The LCZ is approximately 2m to 5m thick with a gradational contact to the overlying Bauxite Zone, frequently making the delimitation between the respective zones is difficult.

- **Bauxite Zone (BXZ)**

The BXZ lies directly under the UCZ and constitutes the potentially economic portion of the Bauxite Zone. The contact with UCZ is thought to be represent a solution front and is usually identified by a sharp reduction in silica from the UCZ to the BXZ. The BXZ exhibits a variety of textures that are generally described in terms of the pisolite size. The BXZ thickness is variable between 0 to 10m, but it is on average approximately 3m.

The Bauxite outcrops of the AZ Zabirah deposit were mapped in details by Riofinex exploration team in 1982.
In the south zone, the bauxite can be traced along a discontinuous, 15 km long NW-SE trending zone from the sebkhas basin escarpment, some 9km north west of the village of Al Bi'ithah, continuing through the village for approximately 6km to the south east. (Figure 8)

The generalized stratigraphic sequence of the bauxite zone is as follows:

-A 20cm to 40 cm thick layer of typically slightly pisolitic hematite which overlies the bauxite (this hematite layer was founded in only the trial mine area and the not exceed 1 km north of the trial mine). The hematite has largely been eroded, its remnants forming the black proluvial deposits of the sebkhas basin.

-Underlying the iron cap is an approximately 1m thick zone of bauxitic conglomerate, formed from clasts of pisolitic bauxite and hematite, which have been cemented by a bauxitic or kaolinitic matrix.

-The bauxitic conglomerate is, in turn, underlain by a 1,0m -1,5m thick pisolitic bauxite horizon. Typically, the pisolitic bauxite is hard, reddish brown in colour and is comprised of approximately 50% -70% of fine, medium to coarse pisolites embedded in bauxitic matrix. (Figure 6)

-The pisolitic bauxite grades into a kaolinitic bauxite, which has a gradational contact with the re-silicated pisolitic kaolin or variegated clay, of the Lower Clay Zone. The pisolitic bauxite horizon may also grade laterally into either clayey pisolitic bauxite or bauxitic clay respectively, or alternatively, it may be truncated by erosion.



Figure 8. Bauxite outcrops

- **The Upper Clay Zone (UCZ)**

The Upper Clay (UCZ) comprises the top of the BXZ and usually exhibits a sharp, reasonable flat contact with the Overburden sequence. The UCZ generally consists if kaolinitic claystone, often exhibiting indistinct pisoliths and concretions.
Riofinex concluded that the UCZ formed as a result of the resilication of the top of the BXZ. The UCZ is, on average, approximately 2m thick but this may vary from several centimeters to more than 4m. (Figure 9)



Figure 9. The Sharp Contact between the Upper Clay and Overburden

2.2.2 Upper Cretaceous

- **Wasia Formation**

The Waisa Formation is characterized by a cyclic internal structure with alternating continental and shallow marine phases. The Wasia Formation has been sub-divided into three informal units and several horizons, namely:

➢ ***The Lower Unit (W1)***

The lower Wasia Formation comprises predominantly loose, almost matrix-free sandstone and sand, with occasional lenses of, or interbedded, clay up to a few meters thick. (Figure 10)
In some area the lower Wasia contains fine to medium grained, silicified, extremely hard, whitish grey sandstone outcrops on surface. In other areas, the sandstone may be characterized by the presence of either calcareous or limonitic cement. The limonite-hematite saturated, dark grey to black sandstone varieties are probably a function of surface chemical weathering and iron accumulation processes, as similar sandstone varieties have not been intersected in drill cores, only sandstone containing only hematitic grains and concretions.
The cyclic sand -sandstone sequence is probably the result of a fluvial environment following on from the terrestrial bauxite formation in the area.

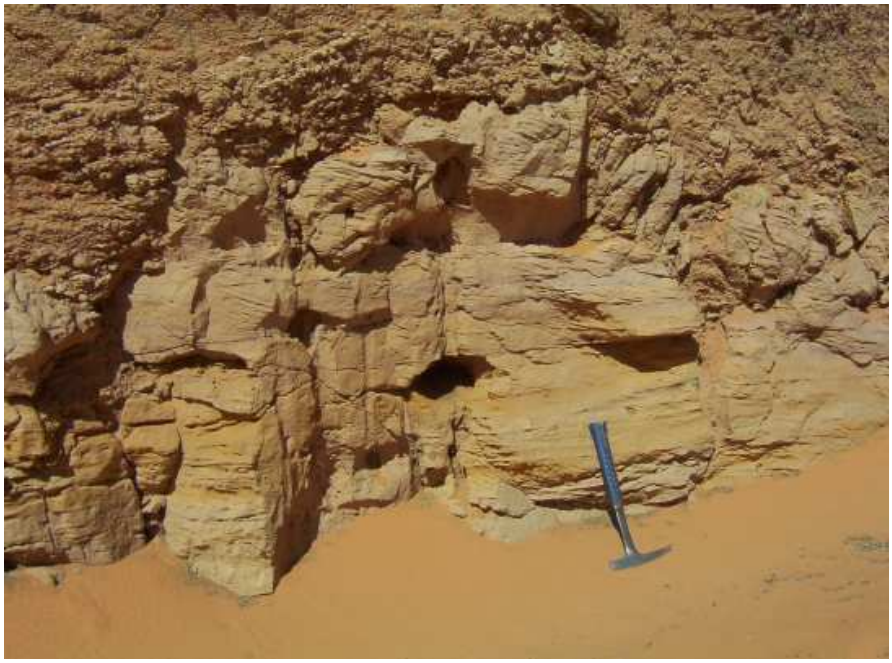


Figure 10. Lower Wasia formation Sandstone

➢ ***The Middle Unit (W2a, W2b)***

The Middle Unit of the Wasia Formation may be sub-divided into lower clay (W2a) and an upper, siltstone horizon (W2b) respectively.

The lower horizon (W2a) comprises variegated clay in a variety of colors, namely: grey, white, yellow, bluish grey, violet and reddish brown colors. The lower horizon is typically friable and disintegrates into angular or platy fragments on the surface. The contact between the lower horizon and the upper siltstone horizon (W2b) is a gradational, through a 4m to 6m thick yellow-brown clay bed.
The upper siltstone horizon (W2b) represents one of the most characteristic marker beds in the entire area. In some areas, it forms the lowest, relatively narrow step of the north eastern escarpment, while in other areas it forms flat, rocky outcrops comprising beds up to 20cm -30 cm thick. The upper siltstone horizon is yellow-brown in color and generally has a high calcium carbonate content; sometimes grading into a silty limestone or marl.
The thickness is varied between 1,0m to 3m.

- ***The upper Unit (W3a, W3b, W3c)***

The Upper Unit of the Wasia Formation forms the central, and very prominent, morphological step of the north eastern escarpment above the Middle Wasia siltstone and below the vast, flat rocky plateau of the Aruma Limestone. It is divided into lower clay (W3a), a middle limestone (W3b) and an upper variegated clay (W3c) horizon respectively.
The lower clay horizon (W3a), which attains a thickness of between 4,0m and 5,0m, is comprised predominantly of green-grey, relatively homogenous clay that may have been deposited in a shallow basin environment. Mottled clay may, however, also be present over the lower portion of the unit, representing continental conditions. The transition to the upper, limestone horizon (W3b) is gradual, through approximately 1 m thick yellow marl bed.
The limestone horizon (W3b) may has a thickness of some 3,0m to 4,0m, while in some places and 1,0m or may be replaced by a 0,5m to1,5m thick yellow marl horizon in other places. The limestone is well-bedded (30cm to 40cm thick) and has a characteristic yellow-brown color and cryptocystalline texture. Over the south eastern portion of the central morphological plateau, it is covered by a 10cm to 20 cm thick, black hematite crust, representing the onset of the next continental cycle.
The upper horizon of the Upper Unit of the Wasia Formation (W3c) is comprised predominantly of organic rich, dark grey to black clay, and white, brown, yellow or violet variegated clay having a combined thickness of 4m to 20m. The upper horizon forms a steep slope below the overlying Aruma Limestone plateau. Its assignment to the Wasia Formation is tentative, as considering the transgressive cyclicity of the Upper Cretaceous sedimentary sequence, it could also form part of the Aruma Formation.

- **Aurma Formation**

The Aruma Limestone forms the uppermost plateau of the escarpment that borders the flat basin along the south western extension of the bauxite deposit. The Aruma Limestone Formation varied in thickness from 2,0m to 3, 0 m over in some places, and may attain a thickness of up to 4,0m to 5,0m in other places.
In some places of the plateau the lower part of the formation comprises a 1,0m to 1,5 m thick, white, nodular limestone bed, which may grade over the lower half meter into a marly limestone or marl bed. However, this marl bed may not be developed, and/or replaced by, hard, cryptocrystalline limestone in other part of the plateau.

The upper portion of the plateau comprises a massive, red-brown to brown, microcrystalline limestone, approximately 1,5m to 3,0m thick, which forms the main morphological feature, namely the rocky plateau.

3 Resource Estimation

3.1 Introduction

This study aimed to update the resources and calculate the reserves of Az Zabirah Bauxite in Central Zone.

The previous study was conducted by Hatch on 2004 for both Central and South zone, using Data mine software for resource estimation and no reserve calculation was done for the Central zone.

The table below describes the drilling data used by Hatch which contains two different campaigns:

Campaign	Date	Description
BRGM	1987-1993	500X500m
Riofinex	1979-1984	2000 to 4000 North- south (local grid) with 500m nominal spacing & Cross BH with 5 to 50m spacing

Table 1. Central Zone Data Programs Used By Hatch on 2004.

3.2 Hatch Resource Report

- **Mineral Resource**

The Global mineral resource estimated by Hatch on 2004 was 135.55 dry million tonnes at 51.45 TAA, 8.22 SiO_2 and SG of 2.01 within cut off 40% TAA.

Hatch resource estimation was classified according to JORC 1999, hence they reported two classes of resource for the central zone, Indicated & inferred.

The indicated resource which represents the area covered by 250m grid spacing although no 250m grid spacing was applied in the central zone but this area drilled by BRGM and Riofinex which generated closed spacing (≥250m), as well there was cross spacing 5-50m. However, the indicated resource was 15.55 Mt at 51.55 TAA, 8.17 SiO_2 and SG of 2.01, within cut of 40% TAA.

The inferred resource which represents the area covered by more than 250m grid spacing was 120 Mt at 51.36 TAA, 8.26 SiO_2 and SG of 2.01, within Cut of 40% TAA.

The Central zone was not considered in Hatch mine planning report on 2004 so no reserve was calculated.

3.3 The Current study

The objective of this study is to update and upgrade the resource for the central zone.

The work which was done using Surpac software included Variogram modeling, ordinary kriging, block modeling and resource and reserve reporting.

Three campaign's data was used in this study are listed in the table below:-

Campaign	Date	Boreholes Number	Grid & Spacing
Riofinex	1979-1984	157	2000 & 4000 NS X 500 WS & cross drilling with 5-50M spacing
BRGM	1987-1993	127	500 X 500
Ma'aden	2006 & 2007	365	250 X 250

Table 2. Central Zone Data Programs Used in the Current Study.

There were 37 Boreholes excluded from Riofinex and BRGM campaigns for the following reasons:

1. Some boreholes were excluded because it was located in same locations with other boreholes which were loaded and used in this study.
2. Some boreholes were excluded because it has no assay data or no logging and assay data.

3.3.1 Data Validation

In order to have realistic and accurate data to use in the resource and reserve study, the following investigation and modification was applied:

- Borehole plotted map was created to check the borehole coordinate and locations. (Figure:11)
- Loaded assays of the boreholes were checked and compared with the original laboratory assay sheets. (Figure 12)
- The lithology in the logging table was adjusted according to the assay result, taking on account TAA (total available alumina). (Table 3)
- Simple statistics were reported for the Al_2O_3, SiO_2 and Fe_2O_3 variables from the Original laboratory assay excel sheet and compared with simple statistics from Surpac software.

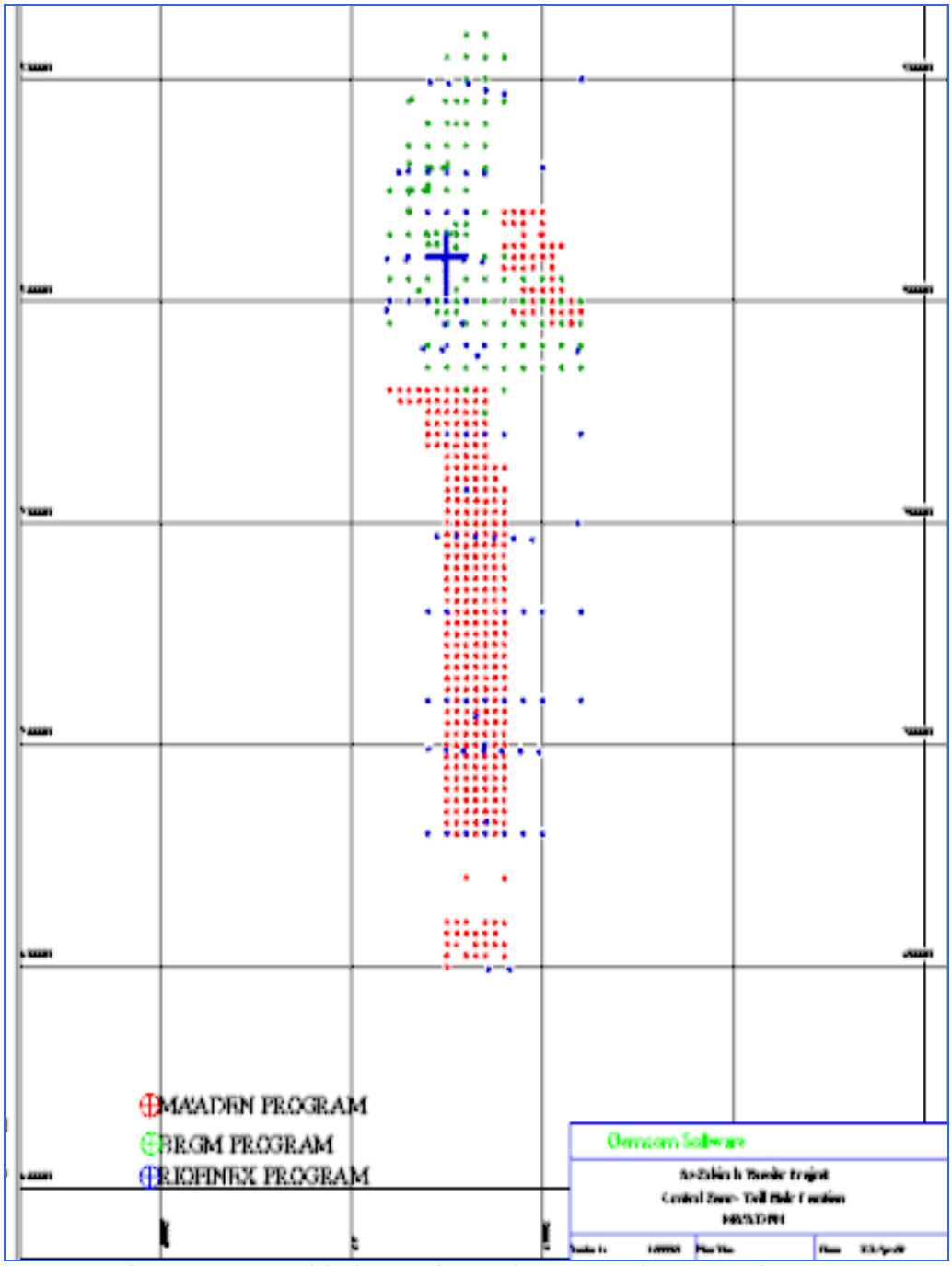


Figure 11. Az-Zabirah Bauxite Project-Central zone BH lay-out



Figure 12. The loaded boreholes with Al2O3 result in the right and SiO2 in the left side.

TAA Value	Logging	TAA Value	Logging
32	Ucz	32	Ucz
36	Bxz	36	Ucz
48	Bxz	48	Bxz
46	Lcz	46	Bxz
40	Lcz	40	Bxz
34	Lcz	34	Lcz
Before Validation		After Validation	

Table 3. Logging data Modification

- Topography was created to check and modify the boreholes elevations and its maximum depth (Az0009 & BC1086 elevations showed anomalies in the initial topography and been adjusted according the neighbourhood boreholes, and AZ0024 maximum depth was shown anomaly and adjusted to be match with logging and assay table). (Figure 13, 14 & 15)

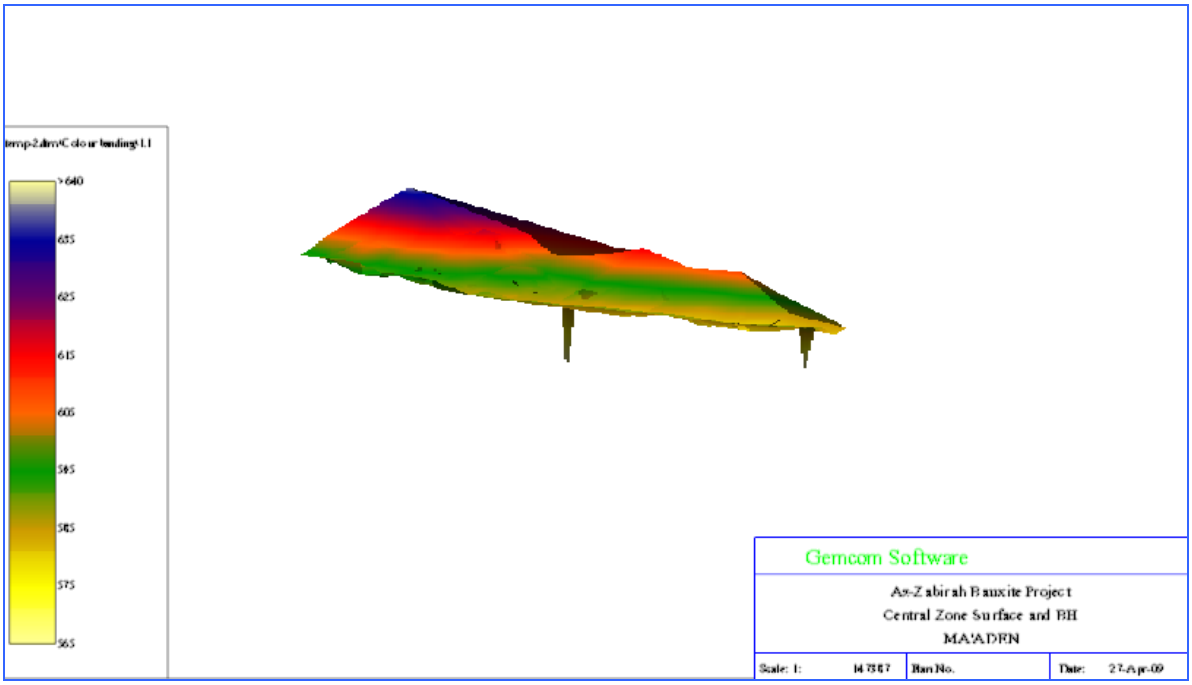


Figure 13. The Topography before modification

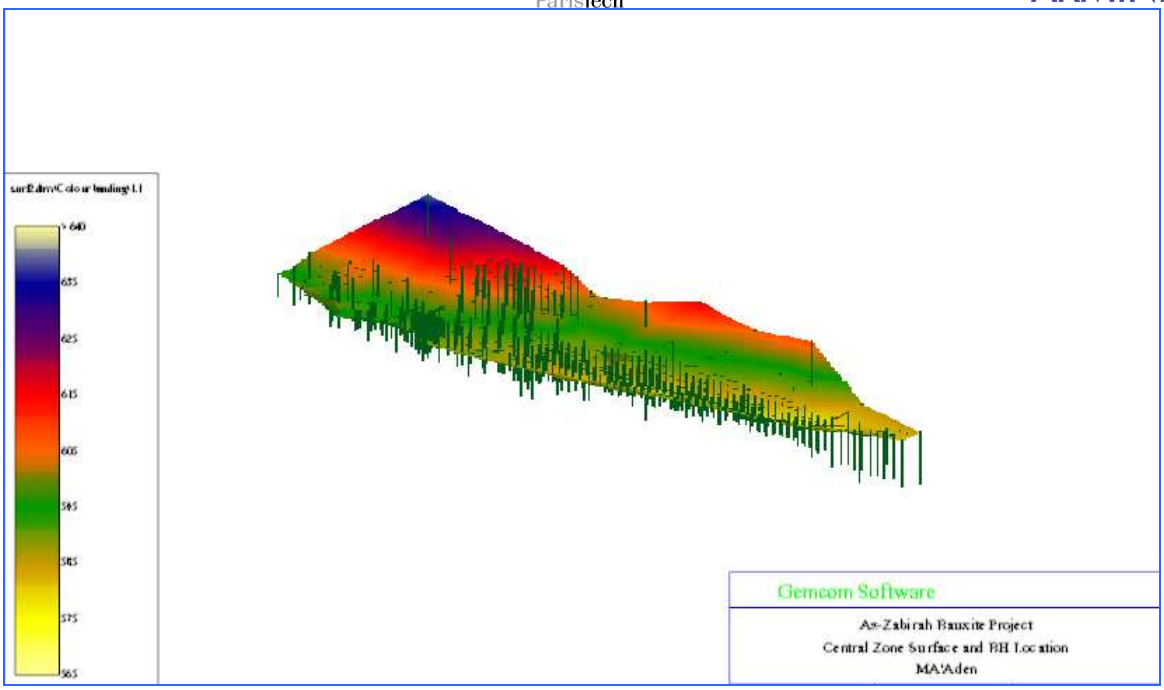


Figure 14. The Topography after modification.

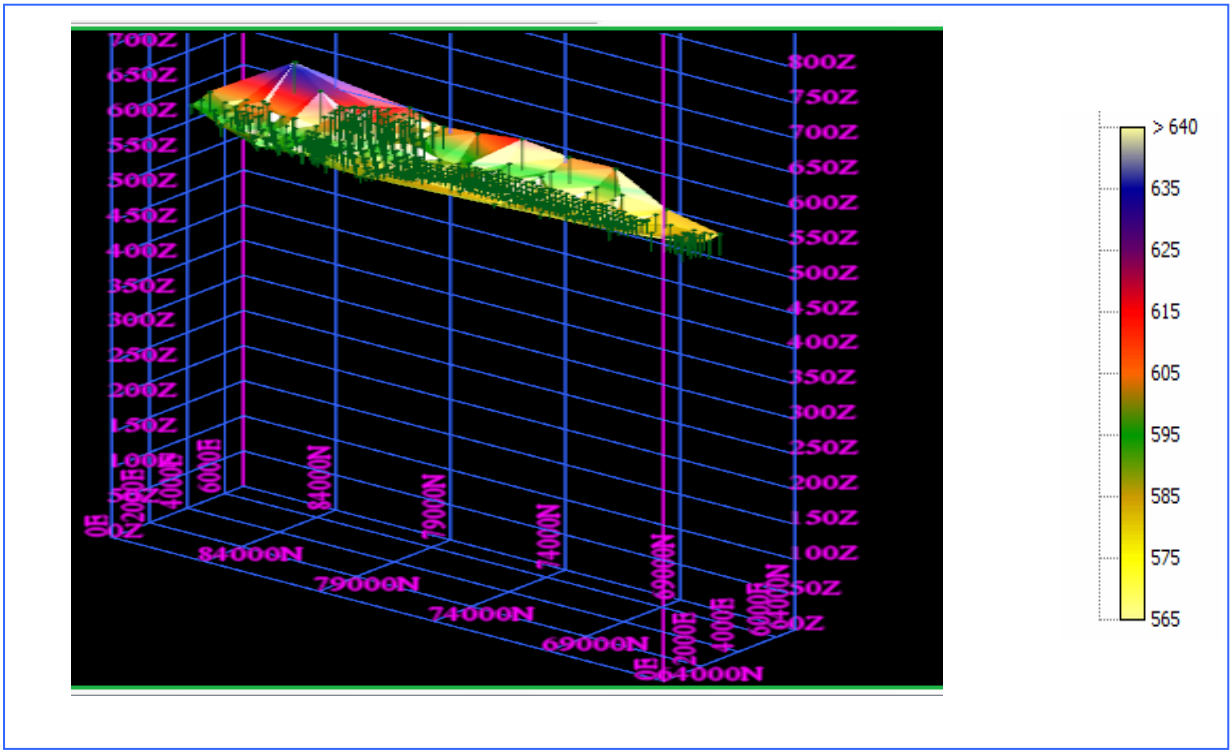


Figure 15. The final Topography.

- A contour Topography was created. (Figure 16)

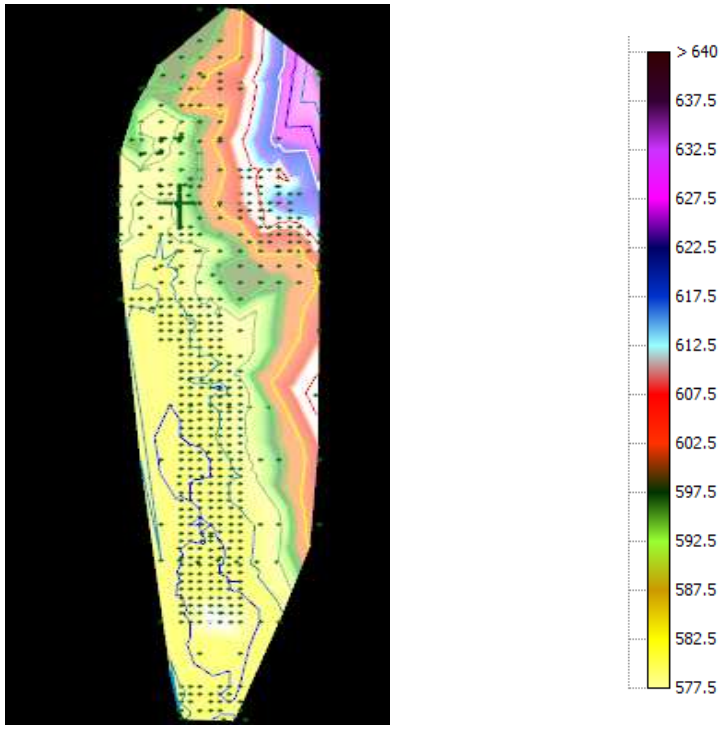


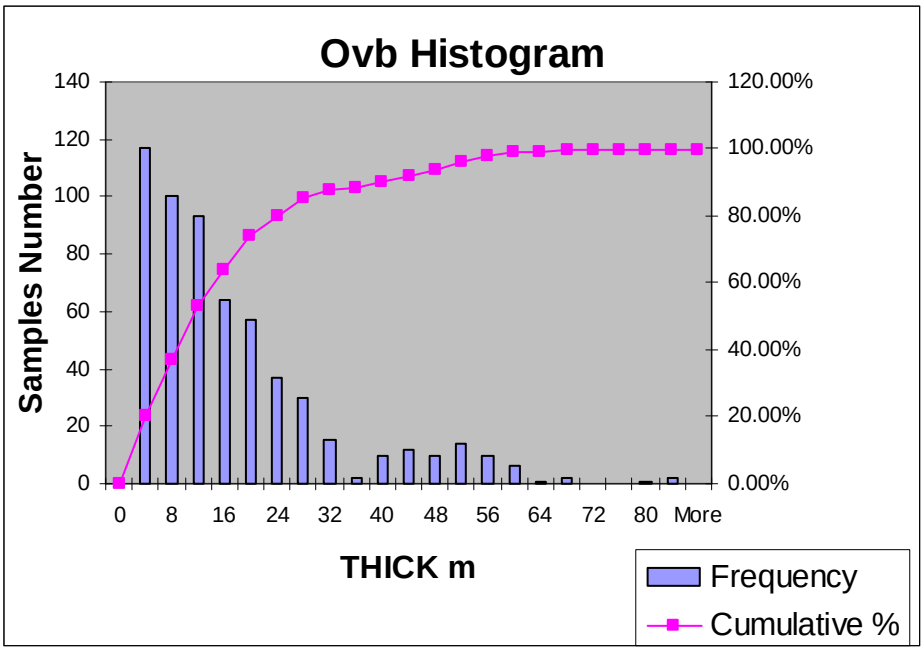
Figure 16. Contour topography with boreholes plot.

- The intercepts thickness were calculated by Microsoft Excel from the logging table for the current study.(Table: 4)

Layer	Thickness		
	Minimum	Maximum	Average
Ovb	0.00	81.05	15.94
Ucz	0.00	8.75	1.52
Bxz	0.00	10.70	2.40
Lcz	0.00	16.25	3.94
Pr	0.00	4.85	1.59

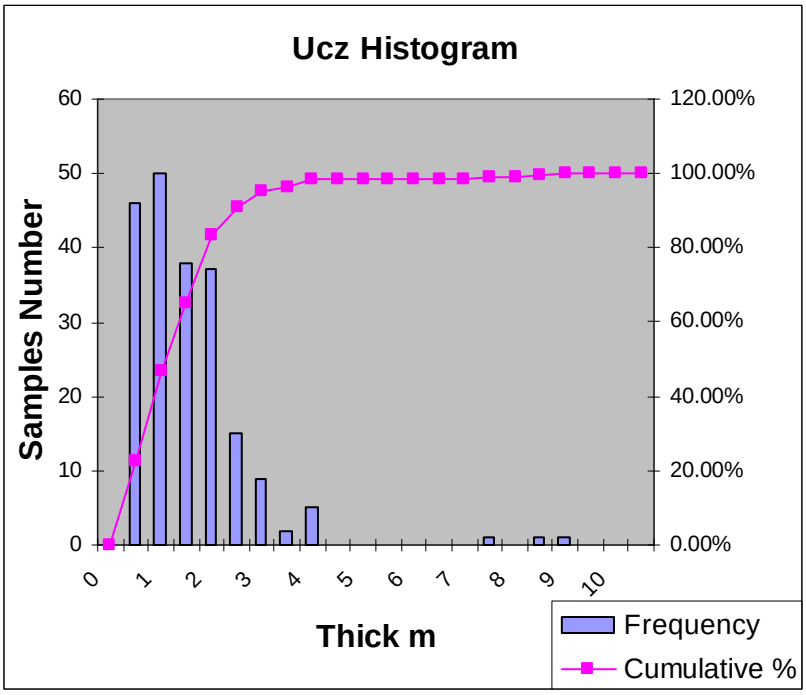
Table 4 Layer intercepts thickness summary

- Also simple statistic for the intercepts thickness was done using Microsoft Excel, the following histogram showing the statistic for each zone(intercept thickness):



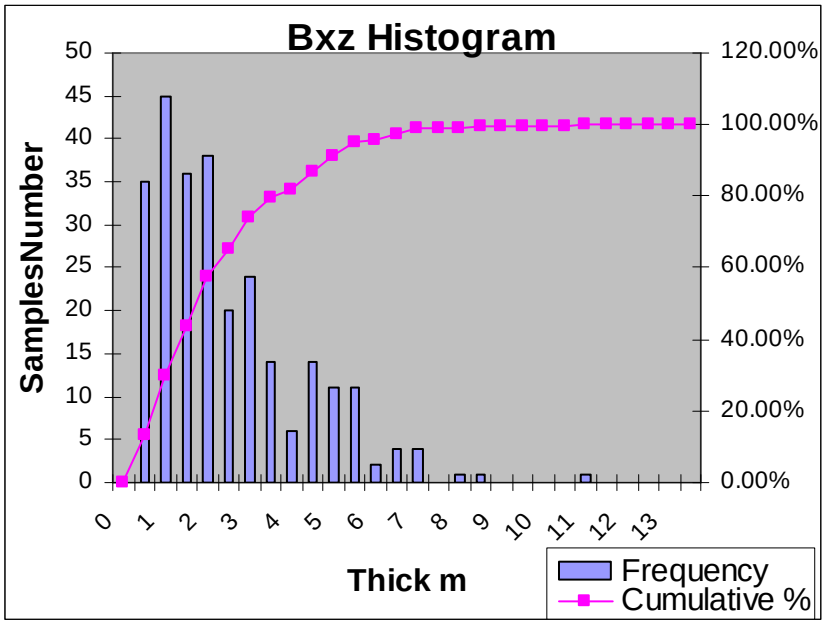
Overburden	
Mean	**15.93**
Standard Error	**0.615**
Median	**11**
Standard Deviation	**14.85**
Minimum	**0.3**
Maximum	**81.05**
Count	**583**

Figure 17. Ovb Histogram and simple statistic.



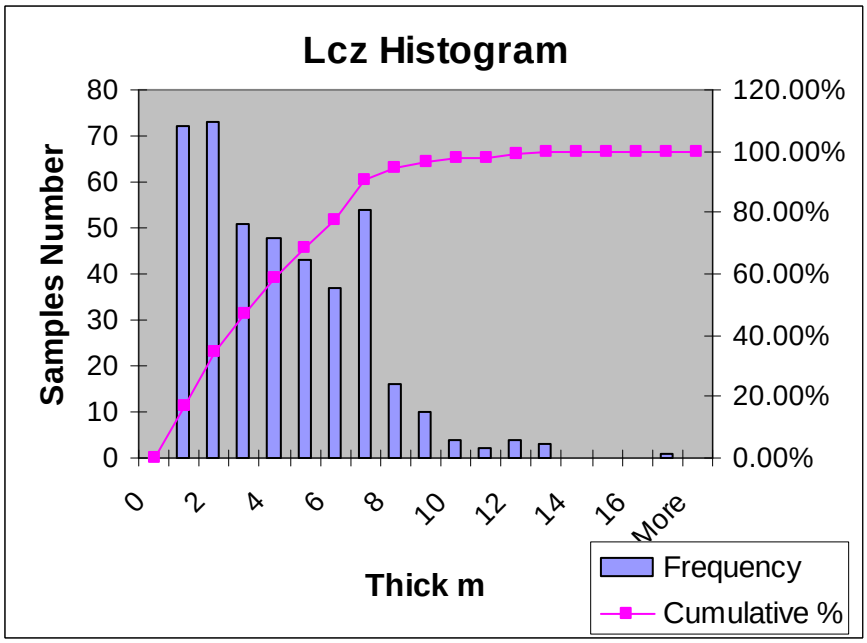
Upper Clay	
Mean	**1.51**
Standard Error	**0.081**
Median	**1.5**
Standard Deviation	**1.16**
Minimum	**0**
Maximum	**8.75**
Count	**205**

Figure 18. Ucz Histogram and simple statistic.



Bauxite	
Mean	**2.39**
Standard Error	**0.108**
Median	**2**
Standard Deviation	**1.76**
Minimum	**0**
Maximum	**10.7**
Count	**267**

Figure 19. Bxz Histogram and simple statistic.



Lower Clay	
Mean	**3.94**
Standard Error	**0.13**
Median	**3.5**
Standard Deviation	**2.76**
Minimum	**0**
Maximum	**16.25**
Count	**418**

Figure 20. Lcz Histogram and simple statistic.

3.3.2 Zone thickness

The following Figures displaying color shaded contour of the thickness of each layer, the contour color is varying from zone to zone according on the minimum and maximum thickness.

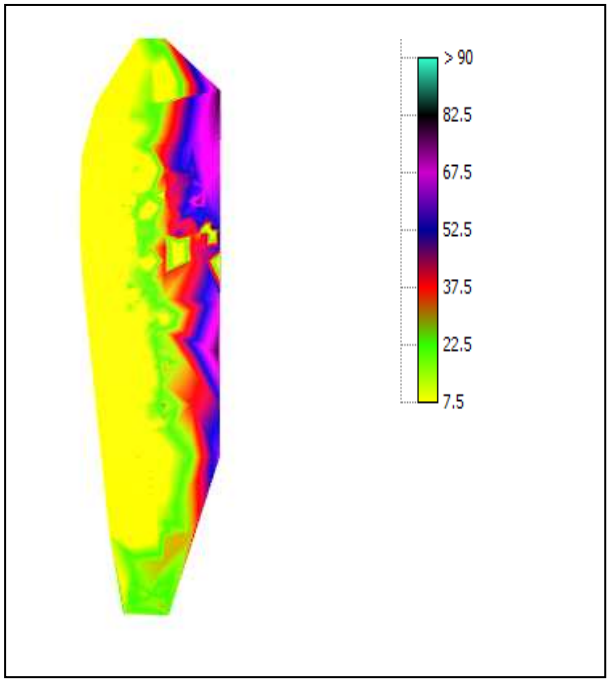


Figure 21. Ovb Thickness.

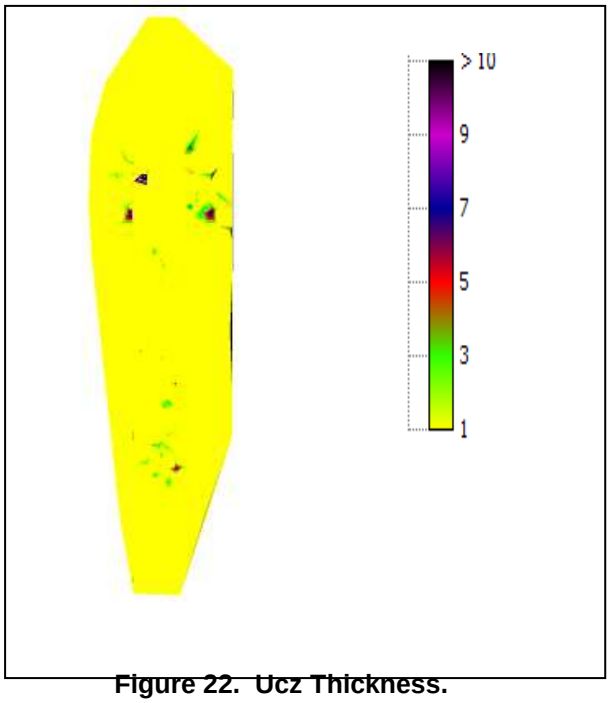


Figure 22. Ucz Thickness.

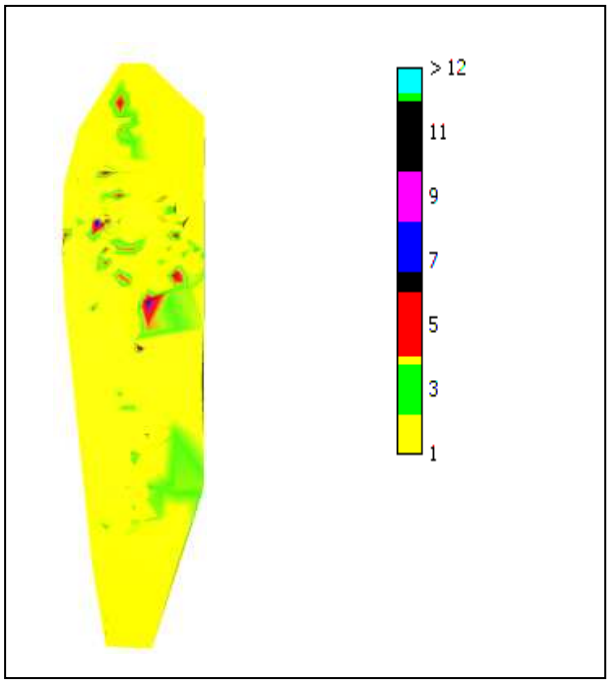


Figure 23. Bxz Thickness

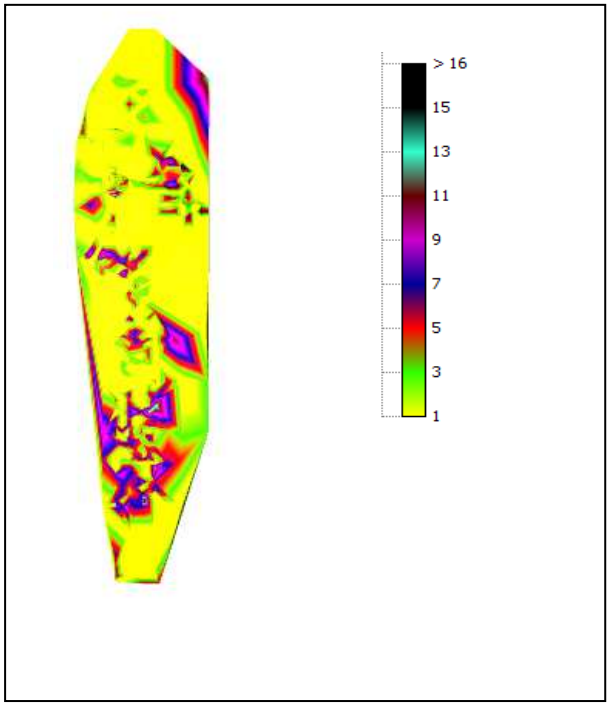


Figure 24. Lcz Thickness

3.3.3 Composite Down Hole

In order to regularize the interval's length for the entire borehole used in this study, a composite down hole based on length was performed using Surpac software.

The majority of the boreholes used in this study have a sample intervals of 0.5m, thus the composite length of 0.5m was applied on the composite down hole. (Table 5 & 6 illustrating the composite down hole)

Hole Number	Depth From	Depth To	Al2O3 Value
BC1790	0	1	37.97
BC1790	1	2	44.56
BC1790	2	3	50.49
BC1790	3	4	54.08
BC1790	4	4.5	53.53
BC1790	4.5	5	53.31
BC1790	5	5.5	53.52
BC1790	5.5	6	44.89
AZ0004	17.5	17.75	37.3
AZ0004	17.75	18	45.7
AZ0004	18	18.25	55.8
AZ0004	18.25	18.5	61.9

Table 5. Borehole's Intervals before down hole composite.

Hole Number	Depth From	Depth To	Al2O3 Value
BC1790	**0**	**0.5**	**37.97**
BC1790	**0.5**	**1**	**37.97**
BC1790	**1**	**1.5**	**44.56**
BC1790	**1.5**	**2**	**44.56**
BC1790	**2**	**2.5**	**50.49**
BC1790	**2.5**	**3**	**50.49**
BC1790	**3**	**3.5**	**54.08**
BC1790	**3.5**	**4**	**54.08**
BC1790	4	4.5	53.53
BC1790	4.5	5	53.31
BC1790	5	5.5	53.52
BC1790	5.5	6	44.89
AZ0004	**17.5**	**18**	**41.5**
AZ0004	**18**	**18.5**	**58.85**

Table 6. Borehole's Interval after down hole composite.

The Down hole composite was applied on each layer separately and also was applied on the whole data.

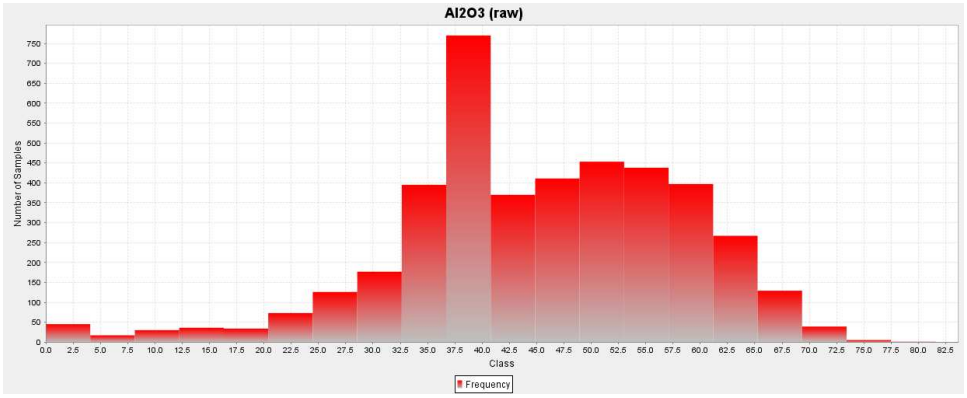
3.3.4 Simple Statistics

Simple statistic were reported for the all the boreholes which been used in this study to display the parametric and non- parametric statistics for the Al_2O_3, SiO_2 and Fe_2O_3 variables.

The statistics were reported for all zones together as well for each zone separated except the Ovb where no sufficient data in this Zone, the statistics were reported using the down hole composite files using Surpac software.

I. All Zones Statistics

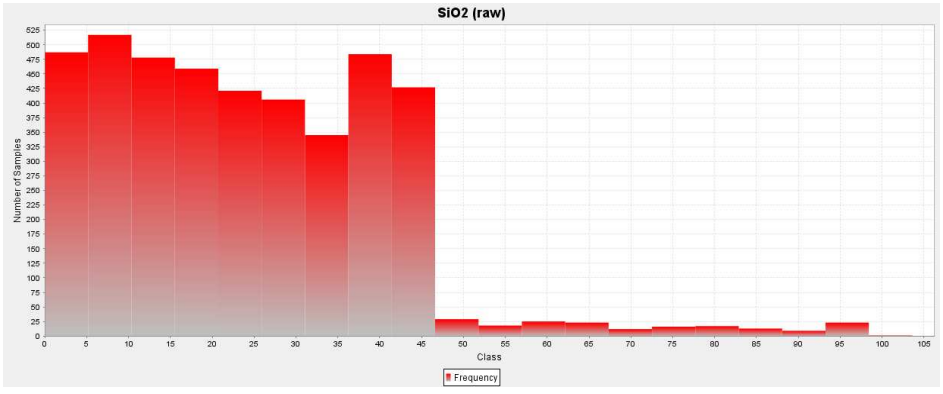
- **Al_2O_3 Statistics**



No of Sample	4213
Minimum	0.00
Maximum	77.49
Mean	45.14
Std. Dev	13.08

Figure 25. Al_2O_3 Histogram-All Zones

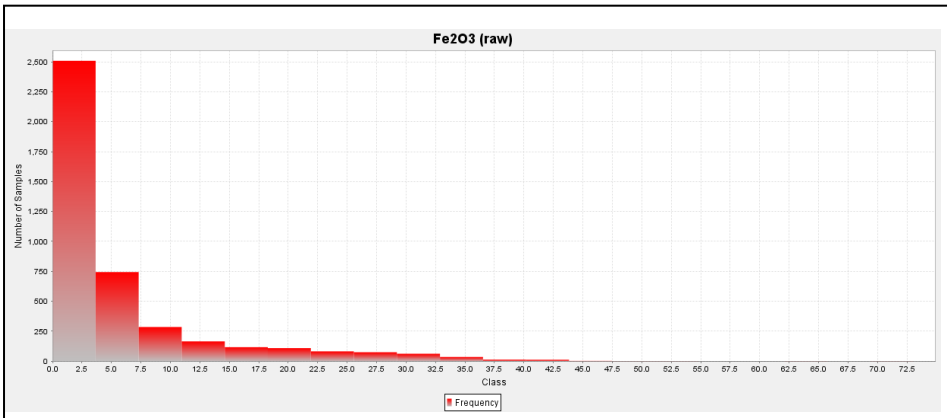
- **SIO_2 Statistics**



No of Sample	4210
Minimum	0.00
Maximum	98.42
Mean	24.56
Std. Dev	16.82

Figure 26. SiO_2 Histogram-All Zones

- **Fe_2O_3 Statistics**

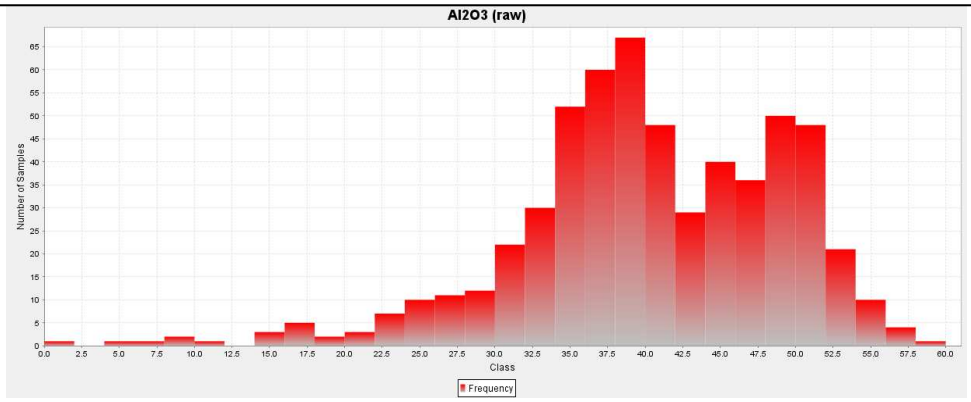


No of Sample	4213
Minimum	0.00
Maximum	69.4
Mean	6.16
Std. Dev	7.86

Figure 27. Fe_2O_3 Histogram-All Zones

II. Ucz Zones Statistics

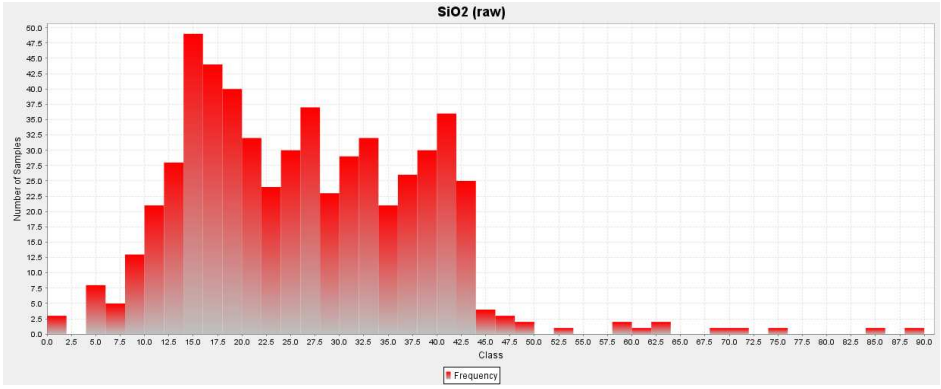
- **Al_2O_3 Statistics**



No of Sample	577
Minimum	0.00
Maximum	59.35
Mean	40.22
Std. Dev	8.93

Figure 28. Al_2O_3 Histogram-Ucz.

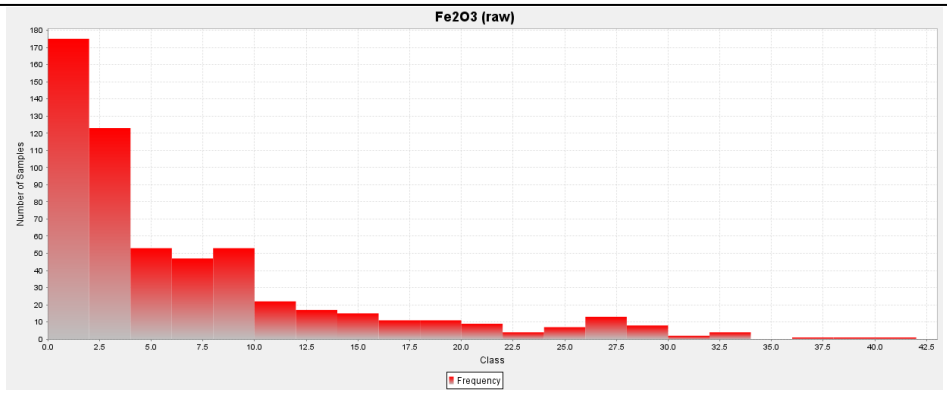
- **SIO_2 Statistics**



No of Sample	576
Minimum	0.00
Maximum	88.26
Mean	26.41
Std. Dev	12.15

Figure 29. SiO_2 Histogram-Ucz.

- **Fe_2O_3 Statistics**

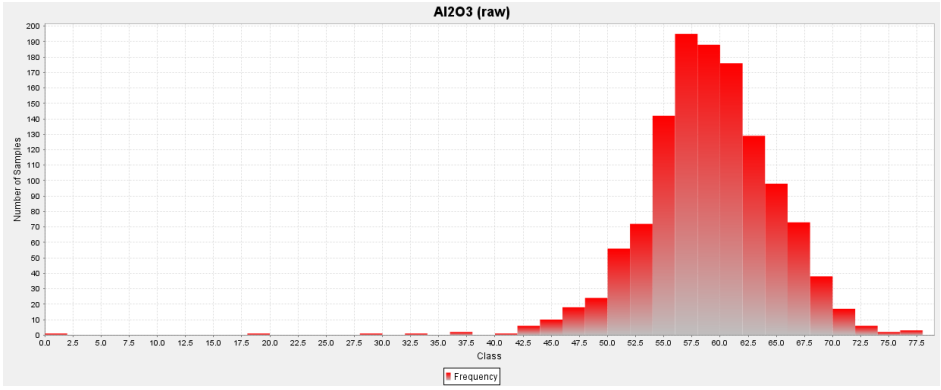


No of Sample	577
Minimum	0.00
Maximum	41.3
Mean	7.02
Std. Dev	7.72

Figure 30. Fe_2O_3 Histogram-Ucz.

III. Bxz Zones Statistics

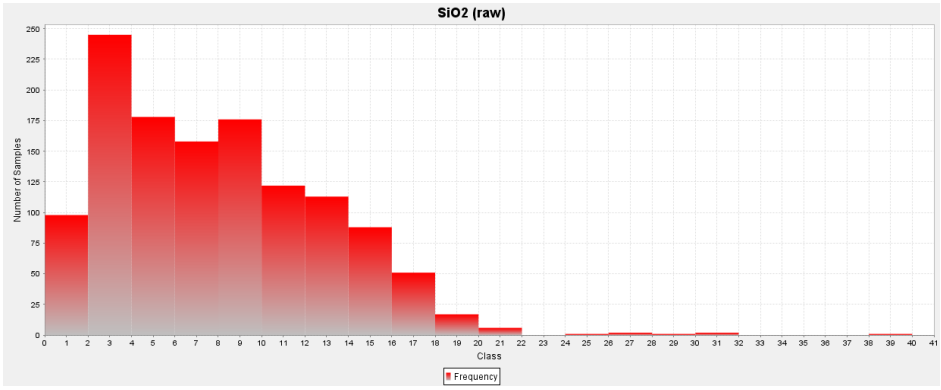
- **Al_2O_3 Statistics**



No of Sample	1260
Minimum	0.00
Maximum	77.49
Mean	59.04
Std. Dev	6.004

Figure 31. Al_2O_3 Histogram-Bxz.

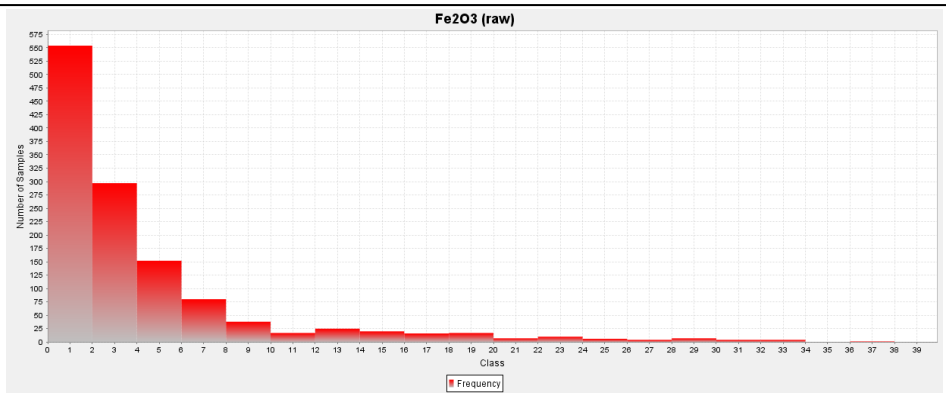
- **SIO_2 Statistics**



No of Sample	1259
Minimum	0.00
Maximum	38.69
Mean	7.99
Std. Dev	5.02

Figure 32. SiO_2 Histogram-Bxz.

- **Fe_2O_3 Statistics**

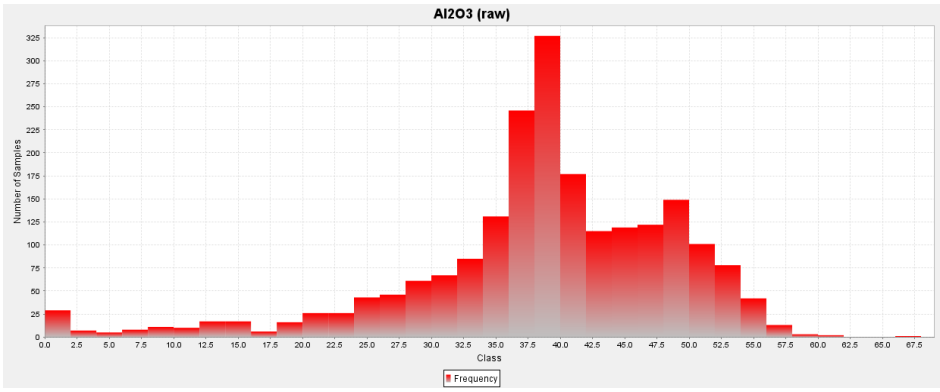


No of Sample	1259
Minimum	0.00
Maximum	36.05
Mean	4.48
Std. Dev	5.69

Figure 33. Fe_2O_3 Histogram-Bxz.

IV. Lcz Zones Statistics

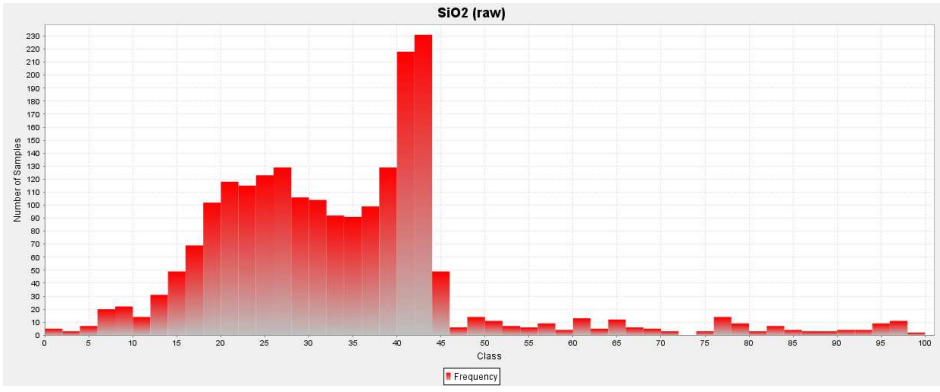
- **Al_2O_3 Statistics**



No of Sample	2106
Minimum	0.00
Maximum	66.5
Mean	38.49
Std. Dev	10.60

Figure 34. Al_2O_3 Histogram-Lcz.

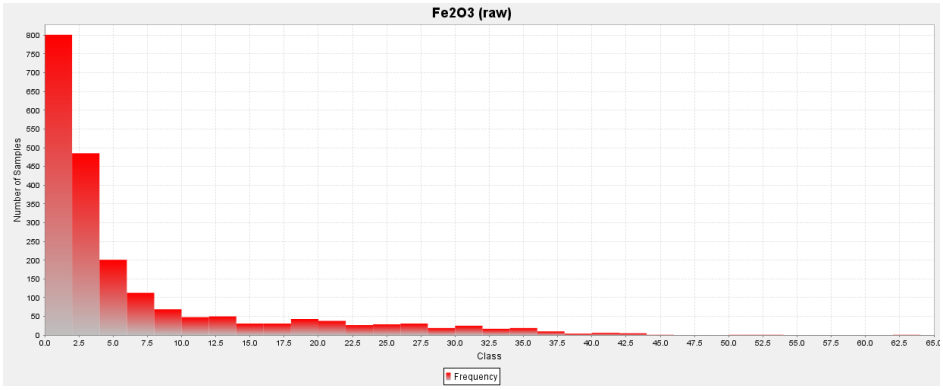
- **SIO_2 Statistics**



No of Sample	2103
Minimum	0.00
Maximum	98.42
Mean	33.83
Std. Dev	15.29

Figure 35. SiO_2 Histogram-Lcz.

- **Fe_2O_3 Statistics**



No of Sample	2106
Minimum	0.00
Maximum	62.5
Mean	6.83
Std. Dev	9.05

Figure 36. Fe_2O_3 Histogram-Lcz.

3.3.5 Al_2O_3 Vs SiO_2 Scatter diagram

A scatter diagram for Al_2O_3 Verses SiO_2 was performed using Surpac software to show the continuous association between them on the deposit and to illustrate the strength of the correlation between the variables through the slop of the line. (Figure 37)

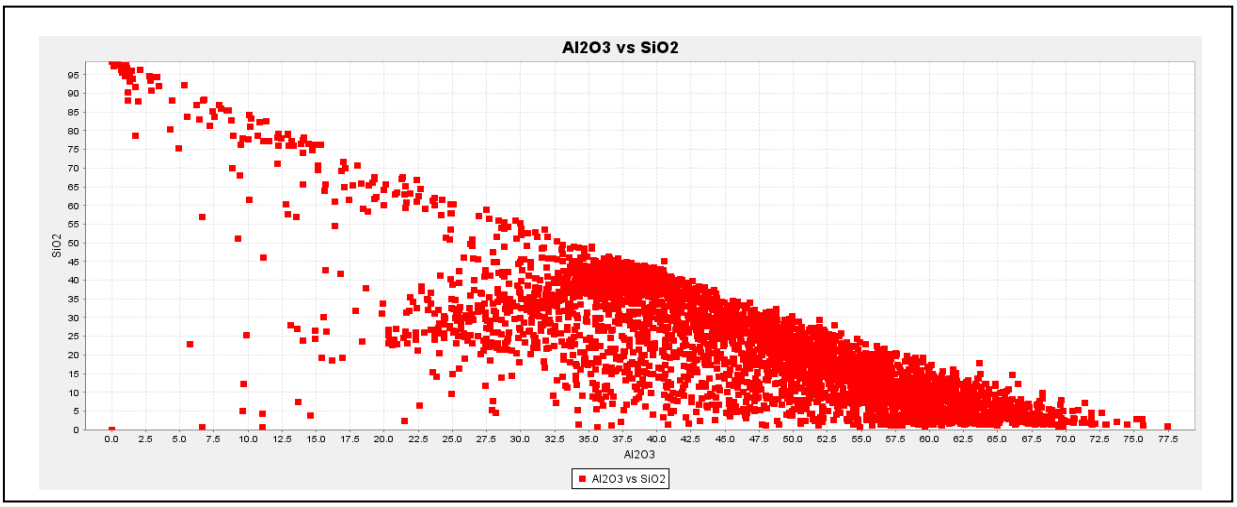


Figure 37. Al2O3 Vr SiO2 Scatter diagram-all Zones.

3.3.6 Variogram modeling

In order to use ordinary kriging estimation a series of variograms within the zones of Ucz, Bxz and Lcz, were accomplished using Surpac software.

The variograms accomplished was beginning by performing a series of primary variogram maps for each element in each zone, to evaluate the anisotropy of the data, or identify which direction has the longest continuity.

Each primary variogram map was performed in 16 different directions which represents 8 variograms.

Once the longest direction been identified as a major direction, a secondary variogram then been extracted as in perpendicular direction as semi major.

It was not possible to extract a variogram for the minor direction (Z direction) due to insufficient data in that direction which refers to the small thickness of each zone, thus an experimental variograms for each element in each zone were accomplished and that also was poor, therefore the miner directions were identified exactly as the semi-major.

The following are some variogram maps, major and semi-major variograms for Al_2O_3, SiO_2 and Fe_2O_3 variables within the Bxz, and the rest are in Appendix A.

- **Al2O3 Variograms**

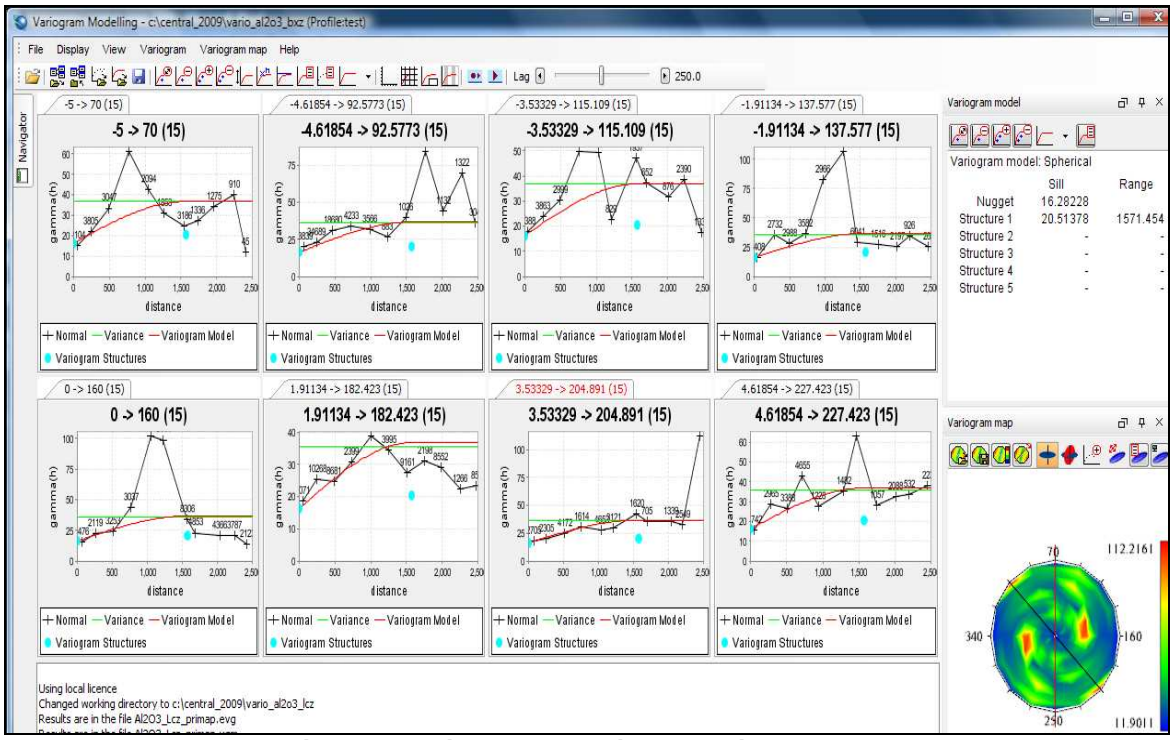


Figure 38. Al2O3_Bxz_ Primary Variogram Map

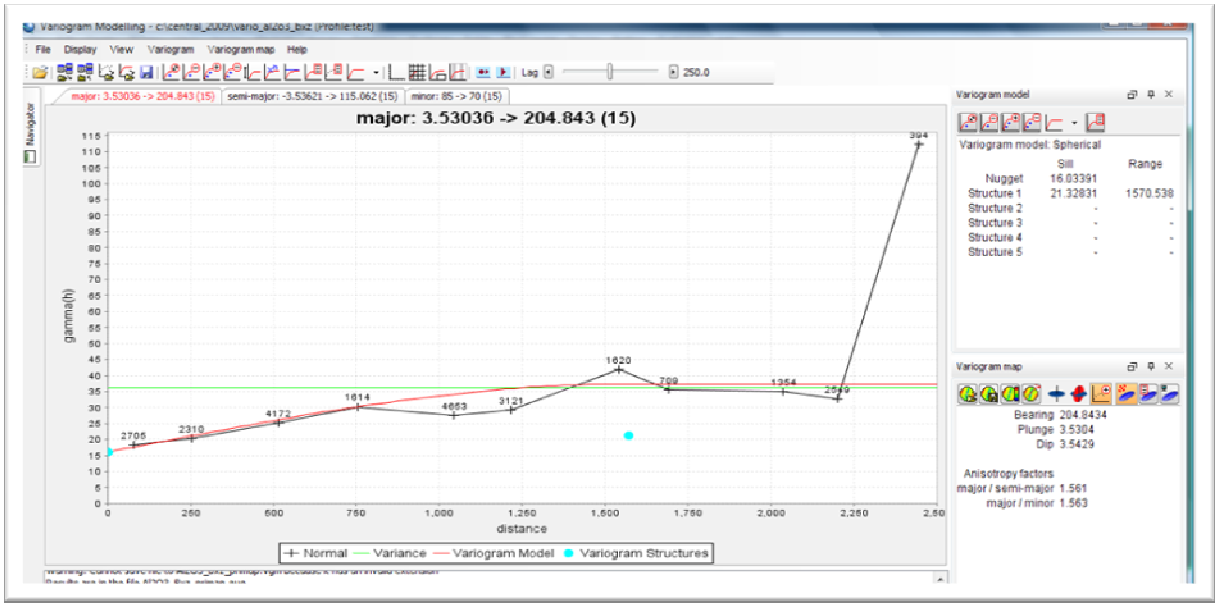


Figure 39. Al2O3_Bxz_Major Direction.

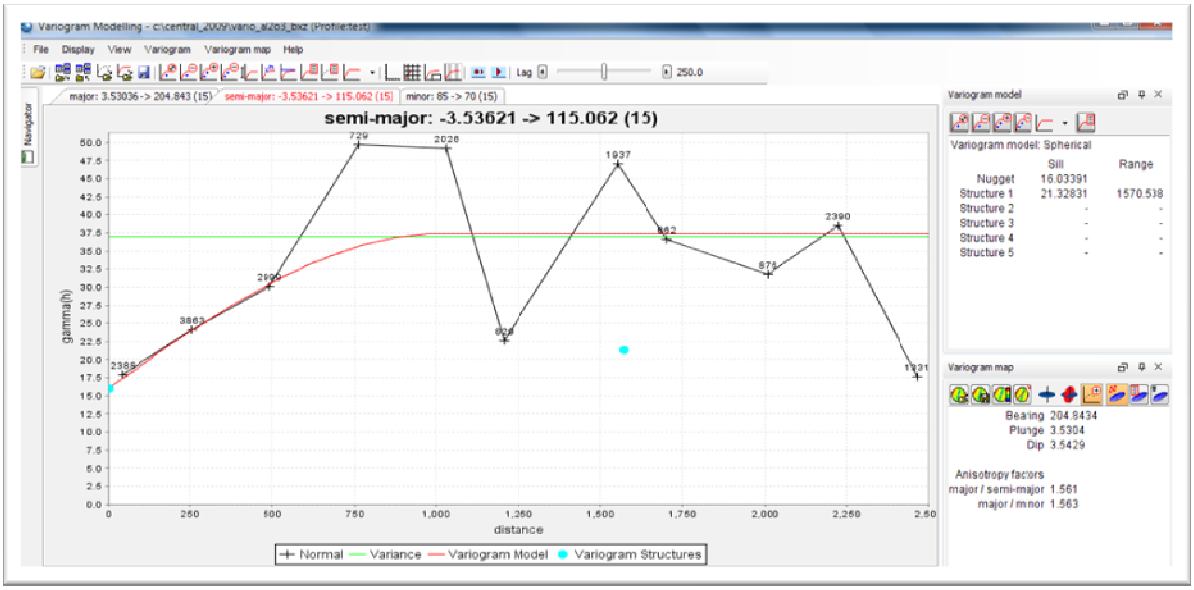


Figure 40. Al2O3_Bxz_Semi-Major Direction

- **SiO2 Varigrams**

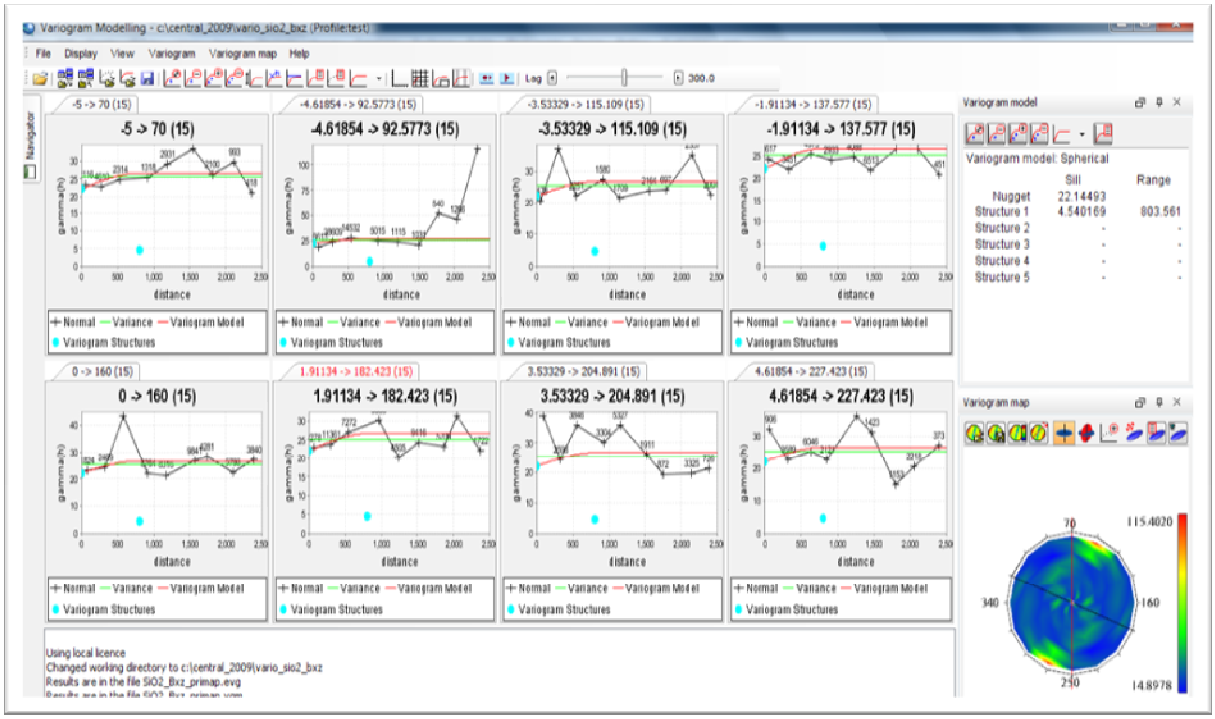


Figure 41. SiO2_Bxz_ Primary Variogram Map

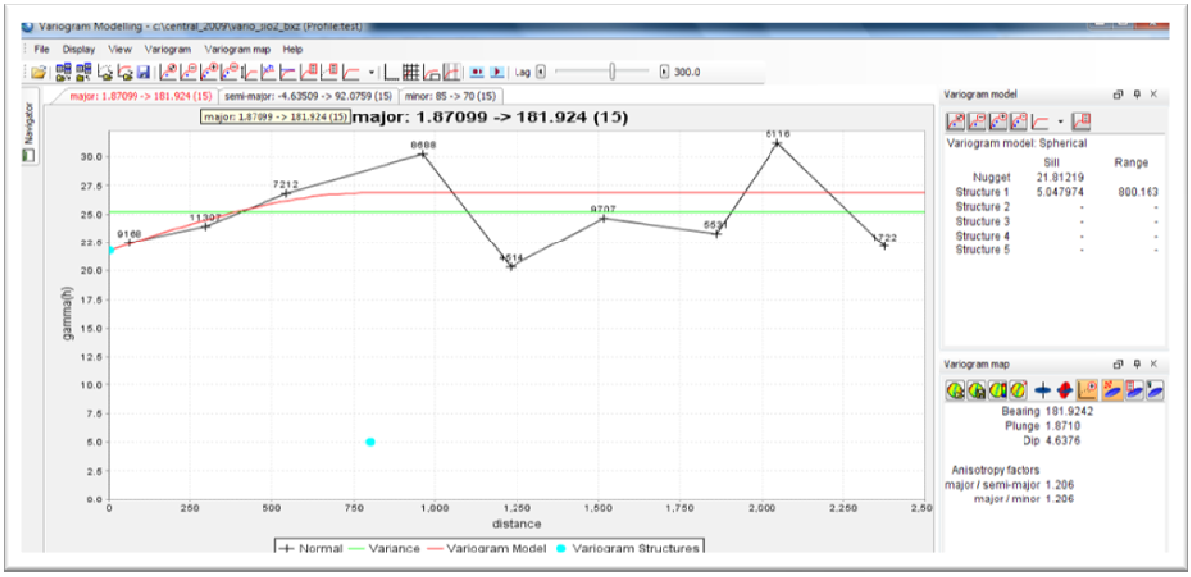


Figure 42. SiO2_Bxz_Major Direction

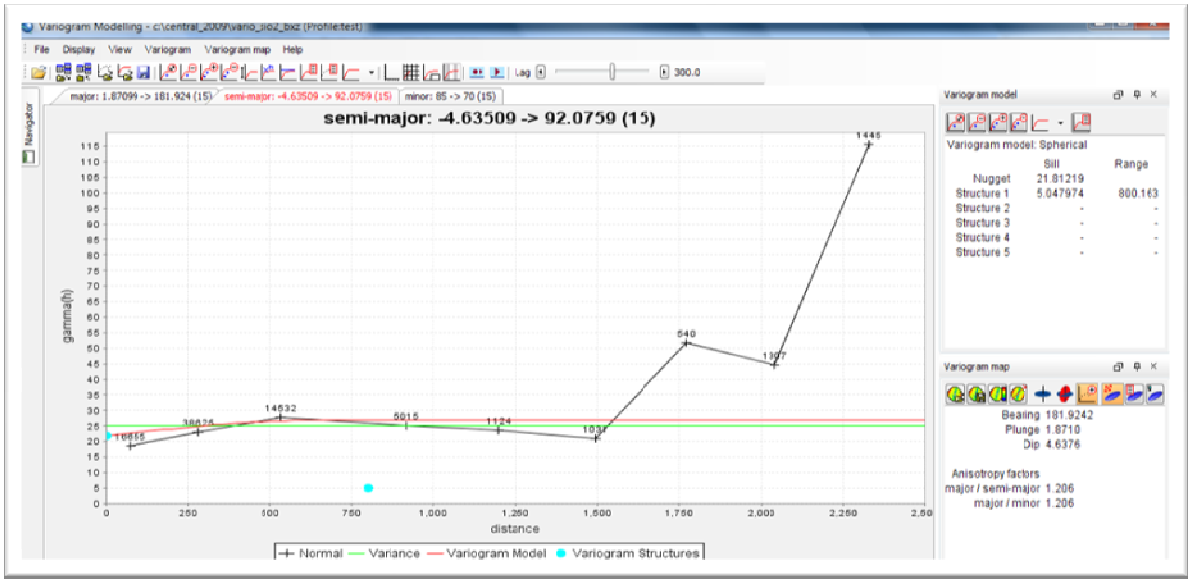


Figure 43. SiO2_Bxz_Semi-Major Direction

- **Fe2O3 Variograms**

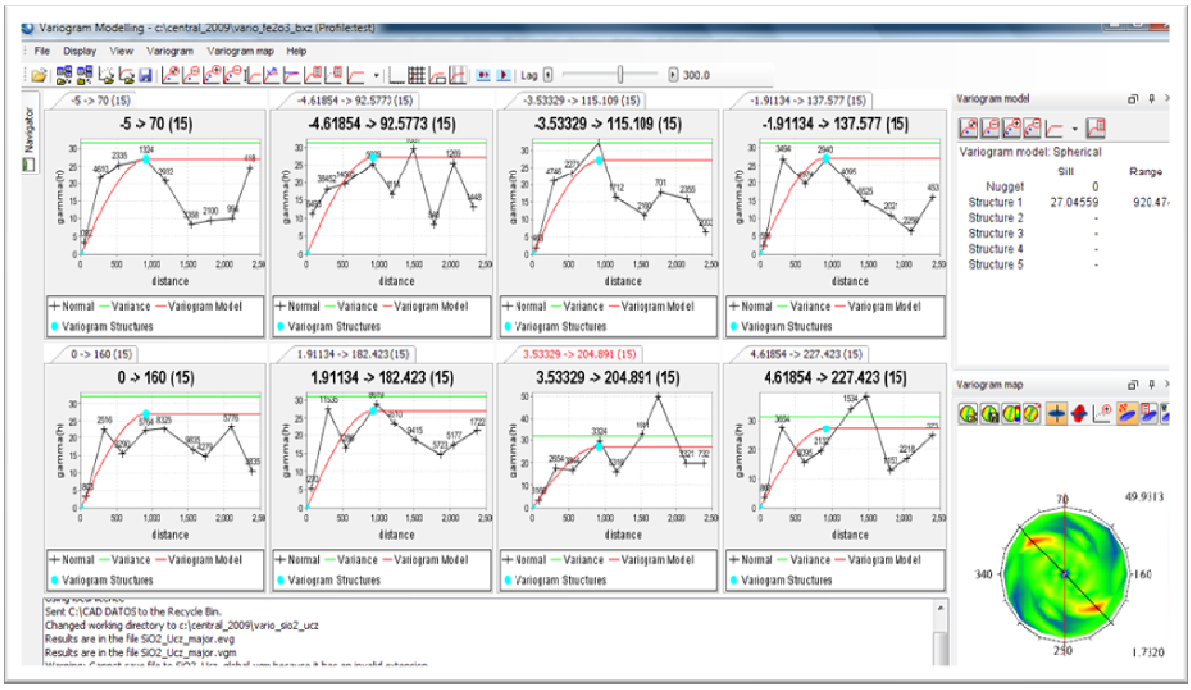


Figure 44. Fe2O3_Bxz_ Primary Variogram Map

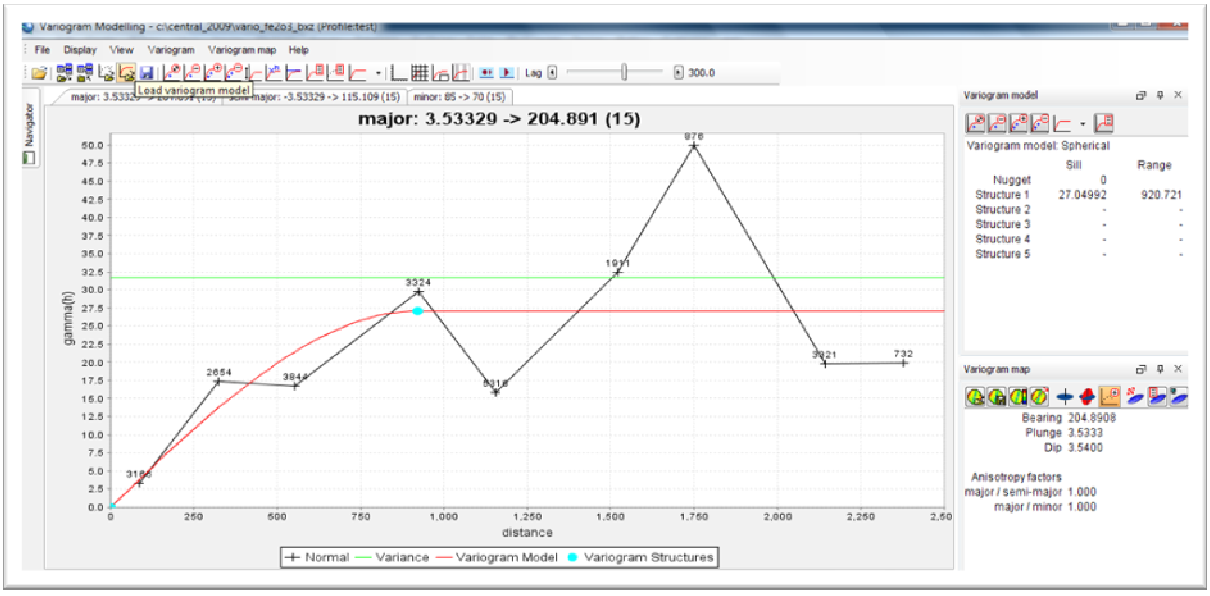


Figure 45. Fe2O3_Bxz_ Major Direction.



Figure 46. Fe2O3_Bxz_ Semi-Major Direction.

3.3.7 Block Modeling

A block model for the Central zone was created with the properties and attributes showing in the below tables within the geological model:

Block Model Geometry	Y	X	Z
Minimum Coordinates	64948	918	534.95
Maximum Coordinates	87048	6118	639.45
User Block Size	100	100	0.5
Total Blocks	182184		

Table 7. Block Model Geometry.

Attribute Name	Type	Background	Description
Al_2O_3	Float	-	
Sio_2	Float	-	
Fe_2O_3	Float	-	
Taa	Calculated	-	Iff(Al_2O_3 - SiO_2 <0,0, Al_2O_3 - SiO_2)
sg	Float	2.00	
Distance	Float	-	
Avg_distance	Float	-	
Num_sample	Float	-	
Krg_var	Float	-	
material	Calculated	-	Iff(taa>=40,"ore","waste")

Table 8. Block Model's Attributes.

The distance represents the anisotropic distance to the nearest sample, Avg_distance represents the average anisotropic distance to samples, Num_sampel represents the Number of samples used for estimation one block and the Krg_var represents the kriging variance.

3.3.8 Layers Surfaces

IN order to estimate the block model and in each layer separately, the following surfaces were created:

- Topo (Overburden Roof)
- Overburden Floor
- Upper Clay Zone Roof & Floor
- Bauxite Zone Roof and Floor
- Lower Clay zone Roof & Floor

(Figure 51 & 52) are the Bxz roof & floor:

These Surfaces were also used for resource reporting to report the tonnage and grade in each layer.

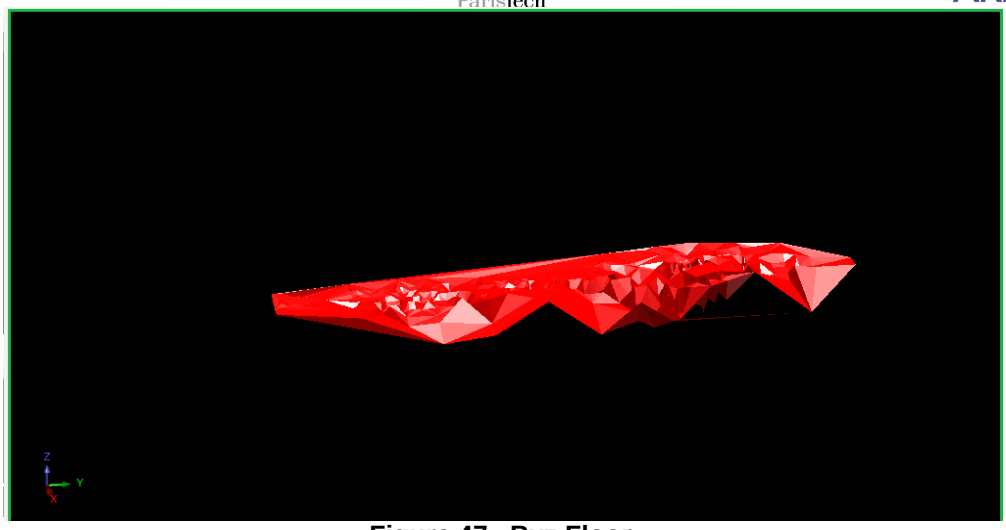


Figure 47. Bxz Floor.

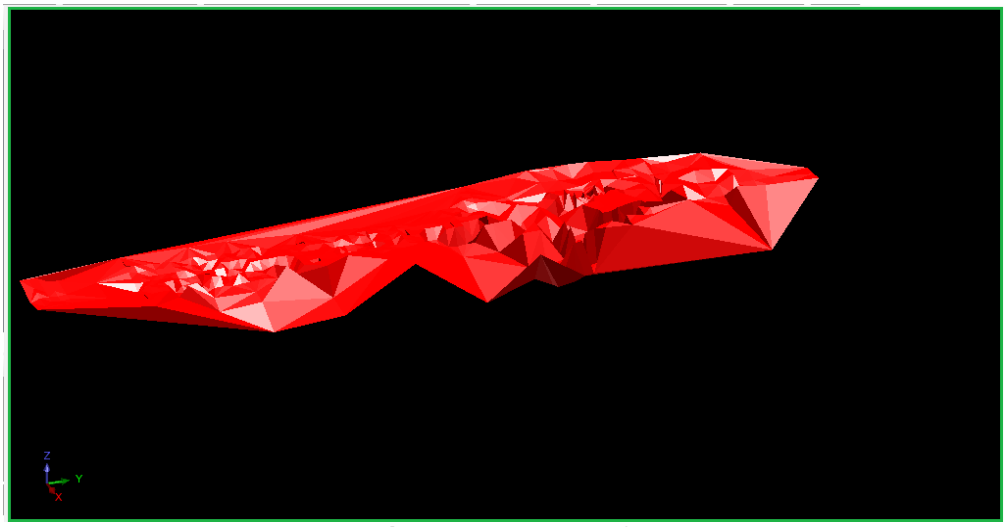


Figure 48. Bxz Roof.

Boreholes cross sections were also creating in order to check the layers surfaces. (Figure 53,54 & 55)

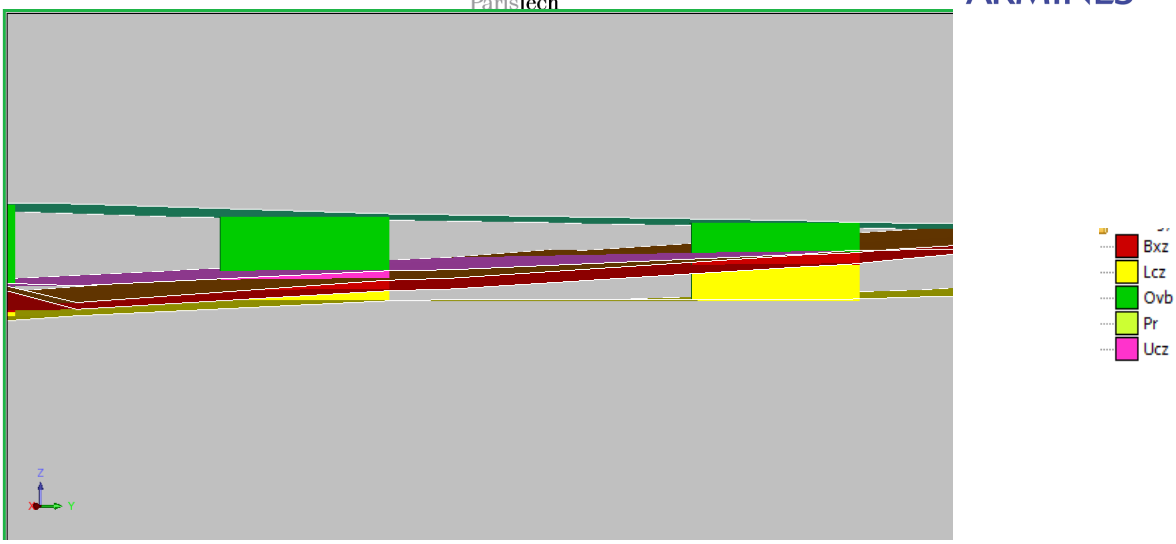


Figure 49. Drill holes Cross Section with Layers Surfaces.

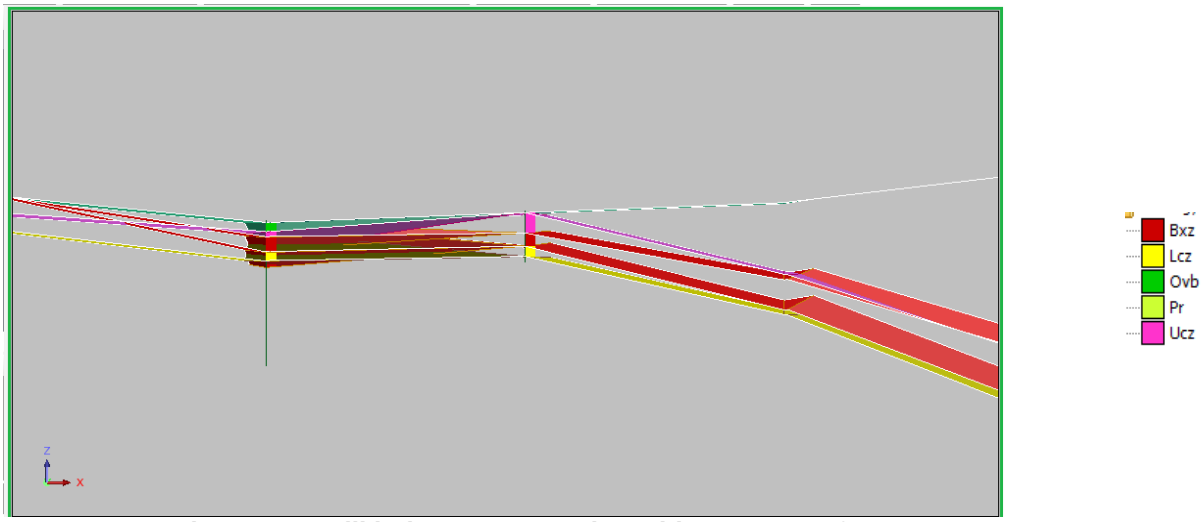


Figure 50. Drill holes Cross Section with Layers Surfaces.

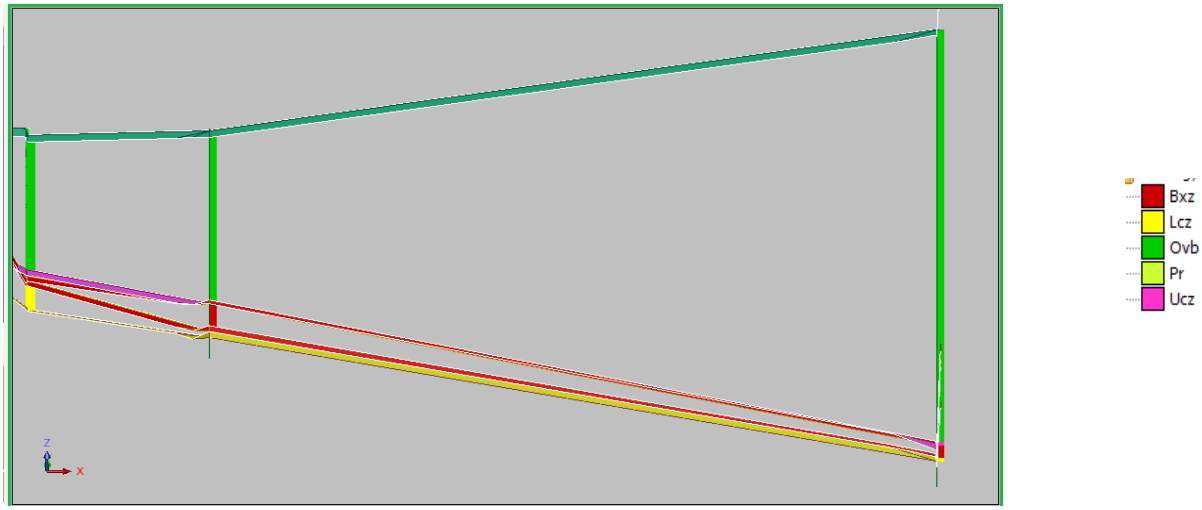


Figure 51. Drill holes Cross Section with Layers Surfaces.

3.3.9 Ordinary Kriging Estimation

The block model was estimated by surpac software using ordinary kriging method.
Three elements was estimated in the model, Al_2O_3, Sio_2 and Fe_2o_3 in three zones, Ucz, Bxz and Lcz. The estimation was based on the variograms modeling, summary of the kriging parameters are described in the table below:

Algorithm	Ordinary kriging
Maximum samples	15
Minimum samples	1
Search distance	As per the range obtained from the variograms (major & Minor)

Table 9. Kriging neighborhood parameters.

The below plot is ellipsoid model illustrating the estimation and search progressing:

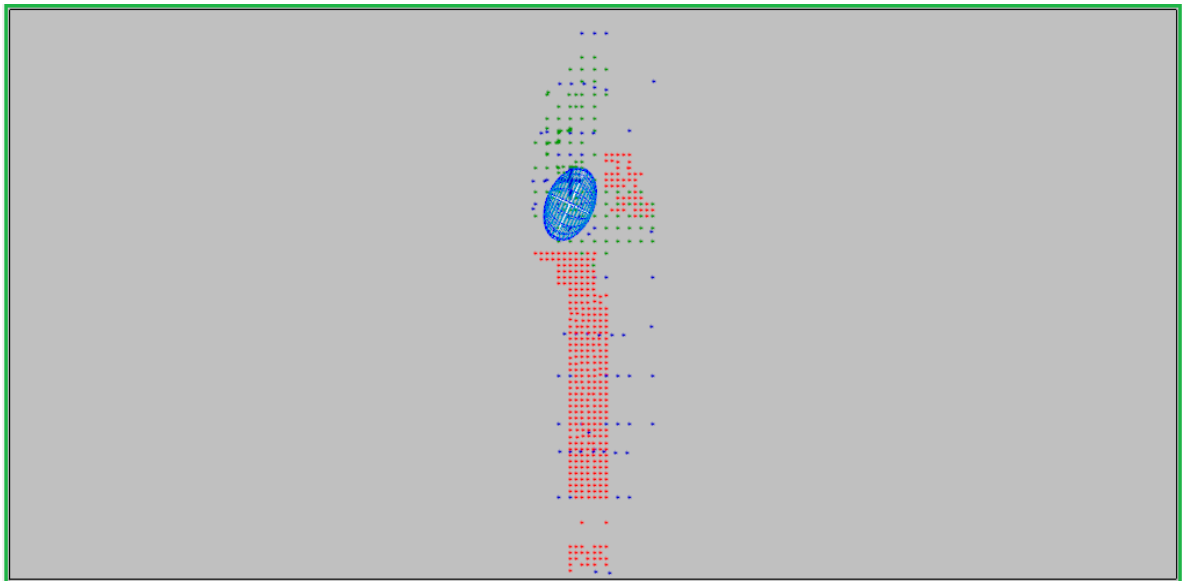


Figure 52. Ellipsoid Models.

The following are some plots for the estimated blocks in Bxz layer (using constraint says above Bxz floor and below Bxz roof) for Al_2O_3, SiO_2 and Fe_2O_3.

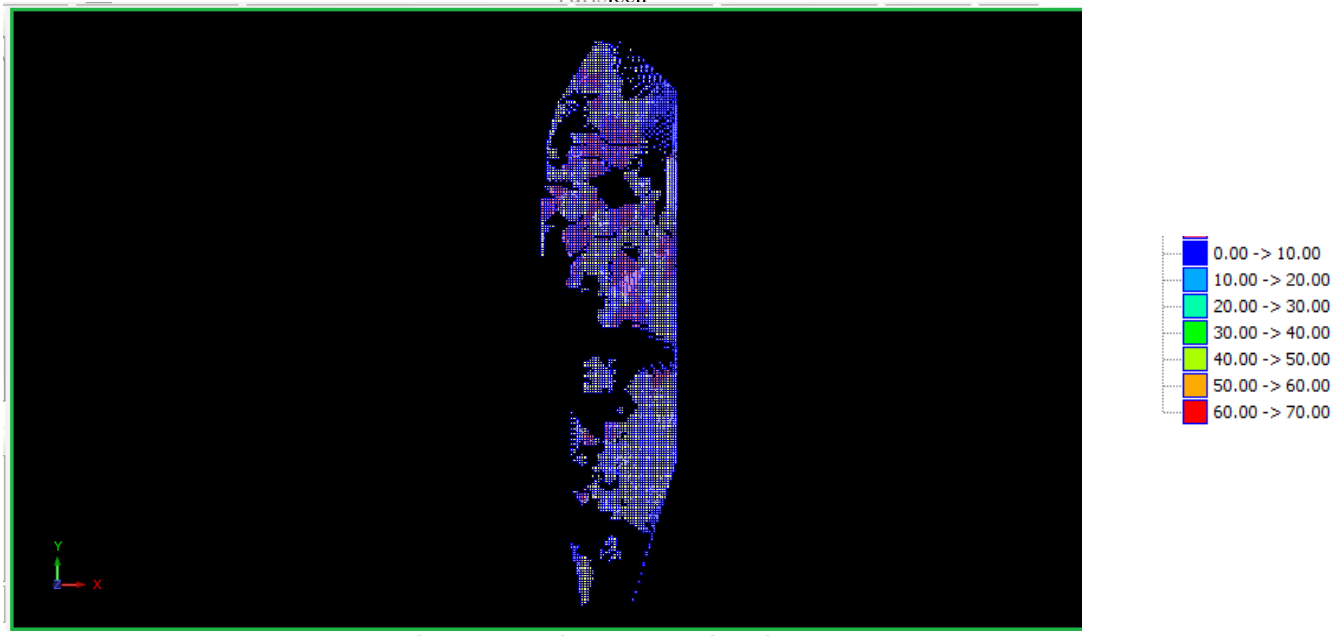


Figure 53. Al_2O_3-Bxz estimation.



Figure 54. Sio_2-Bxz estimation.

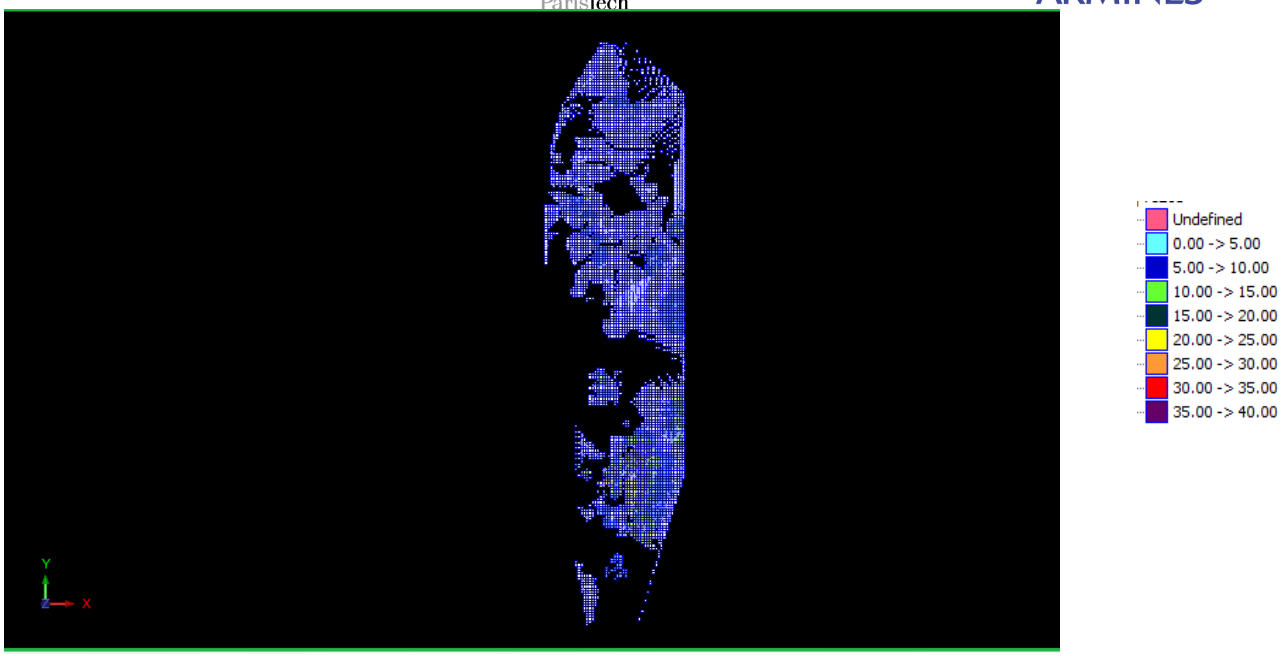


Figure 55. Fe_2O_3-Bxz estimation.

3.3.10 Resource Reporting

In order to report the resource the following steps was performed:

- Constraint the block model by the floor & roof of Ucz (for reporting within the Ucz), the floor & roof of Bxz (for reporting within the Bxz) and by the floor & roof of Lcz (for reporting within the Lcz).
- Define the boundary for the inferred and indicated of the resource. (Figure 51), the resource boundary was based on JORK code for resource categorization, and it was created by Hatch on 2004 (Table 10), the reason to use the same boundary is to make a comparison between the current study and Hatch study.
- A cut off grade was applied as constrain to report within blocks which have grade of taa ≥ 40%.

Resource Category	*Definition*
Indicated	Bauxite material covered by 250m drilling grid
Inferred	Remaining bauxite, lower and upper clay zone material covered by more than 250 m drilling grid.

Table 10. Resource Categories.

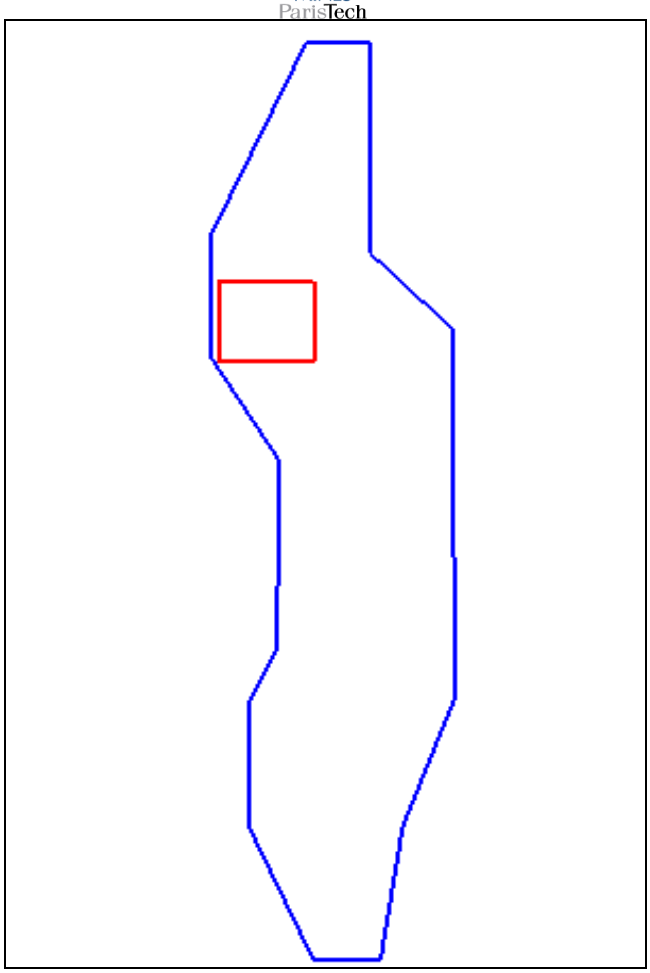


Figure 56. Resource Categories Boundary.

— Inferred
— Indicated

The table below shows comparison between the resource estimation for the current study and Hatch estimation.

Class	Study	Tonnes	Taa	Al_2O_3	Sio_2	Fe_2O_3
Indicated	Current. S	12710000	52.54	59.82	7.28	4.21
	Hatch. S	15500000	51.55	59.88	8.17	4.26
Inferred	Current. S	121690000	50.06	58.29	8.23	5.13
	Hatch. S	120000000	51.36	59.95	8.26	4.03
Total	Current. S	134400000	50.29	58.44	8.14	5.05
	Hatch. S	135500000	51.46	59.92	8.22	4.15

Table 11. Az Zabirah Central Zone- mineral resources reporting at 40% Taa Cutoff- current study Vs Hatch study.

The resource then was reported again based on the new boundary which created based in the new boreholes and drilling grid. (Figure 52)



Figure 57. The new resource boundary.

The read boundary is the Indicated area and the blue is the inferred area.

The resources were reported again within the new boundary and the results are shown in the below table:

Az Zabirah Central zone Mineral Resources at 40% Taa Cutoff					
Class	**Tonnes**	**Taa**	**Al_2O_3**	**Sio_2**	**Fe_2O_3**
Indicated	32330000	49.88	58.34	8.46	4.93
Inferred	103100000	50.40	58.45	8.05	5.07
Total	135430000	50.27	58.42	8.15	5.03

Table 12. Az Zabirah Central Zone- Final Mineral Resources.

The table below and figure 58, show the change in the tonnages and grades when applying different cutoff:

Az Zabirah Central zone Mineral Resources at different Taa Cutoff					
Taa Cutoff (%)	**Tonnes**	**Taa**	**Al_2O_3**	**Sio_2**	**Fe_2O_3**
40	135430000	50.27	58.42	8.15	5.03
35	138260000	50.01	58.20	8.19	5.00
30	144530000	49.23	57.61	8.37	4.95
25	168540000	46.07	55.98	9.90	5.13

Table 13. Az Zabirah Central Zone Resources at Different Taa Cutoff.

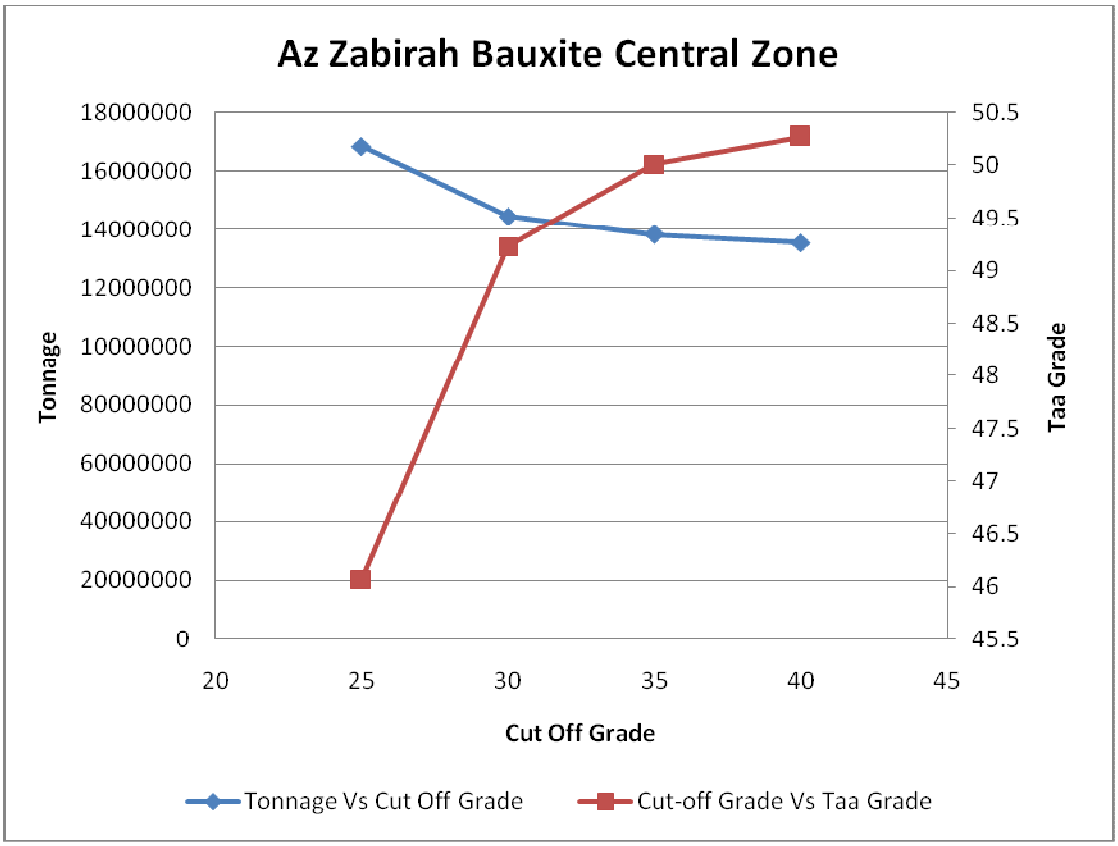


Figure 58. Grade Tonnage Curve.

3.3.11 Reserve Reporting

The Reserve was reported and considered only the Indicated resource of the current study.

The reserve calculation was performed through the following steps:

1. The Bxz roof was dropped down 0.25 m to allow mining loss.
2. The Lcz roof was dropped down 0.15 m to apply mining dilution.
3. The same Taa cutoff (>= 40%) which applied for resource estimation was applied also to calculate the reserve on the indicated area which was defined in the final resource for the current study.
4. No excluding for the boreholes which intersected by less than 1m of bauxite because they are only 47 boreholes (out of 267 total boreholes intersected of Bauxite) and they are distributed everywhere in the Deposit and not aggregated in

one area, as there are many of them located on the west of the deposit where the bauxite is outcropping. (Figure 59 & 60)

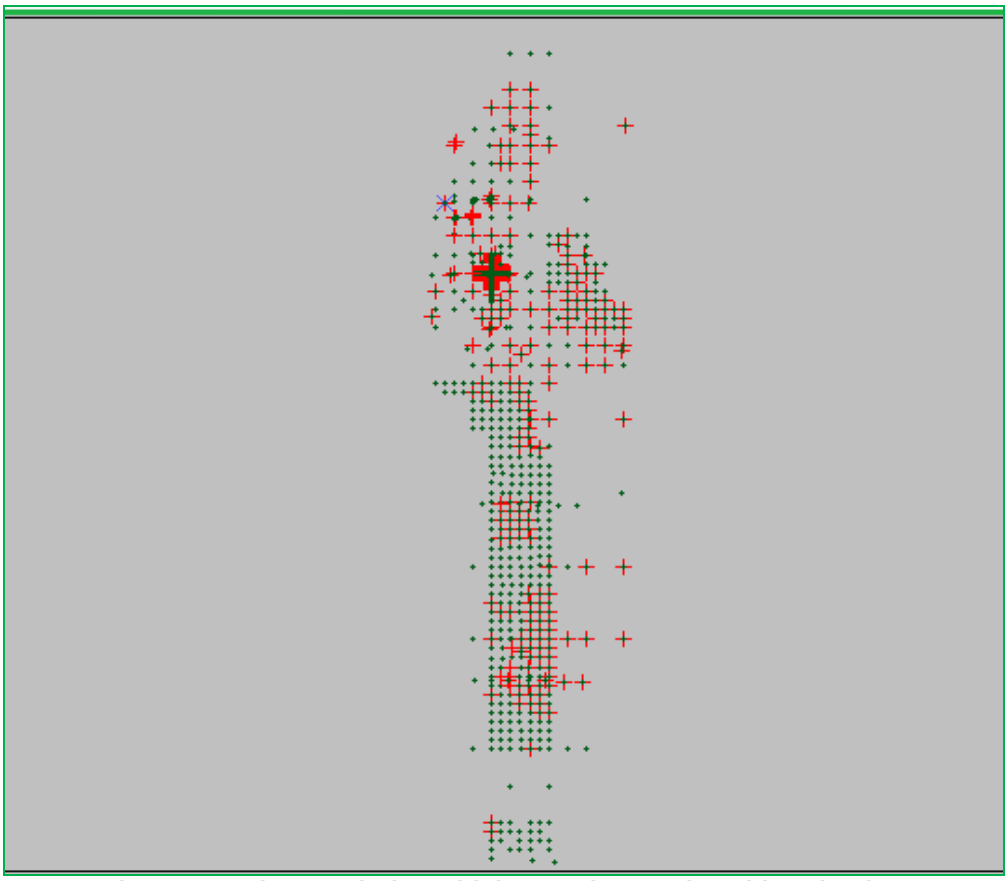


Figure 59. The Boreholes which contain Bauxite with red color.

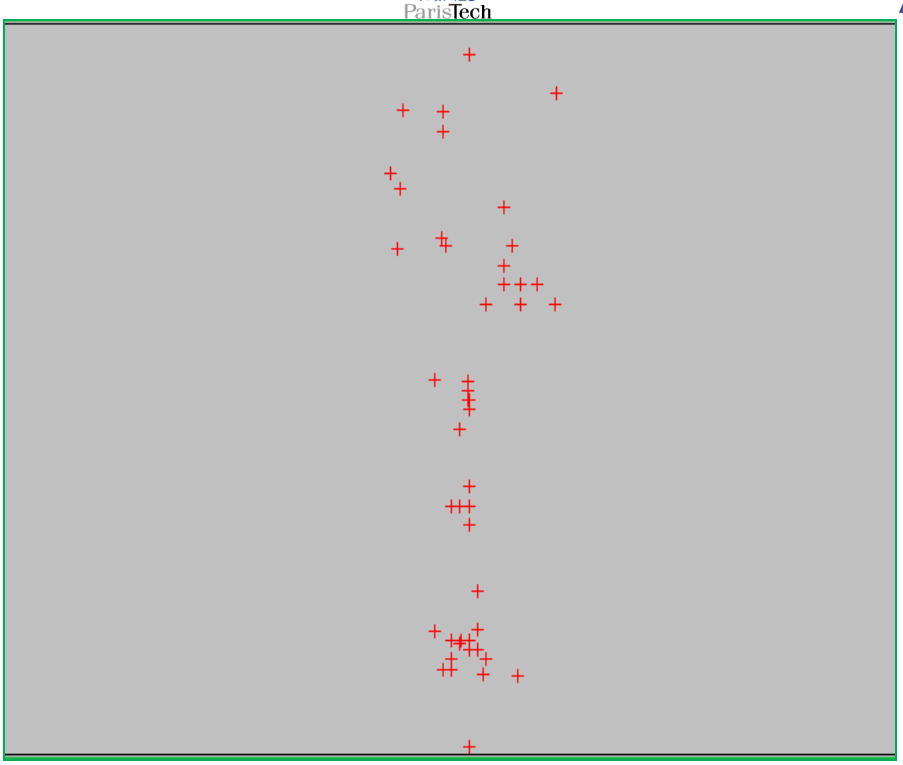


Figure 60. The Boreholes which have less than 1 m Thickness of Bauxite.

The table below is the probable mineable reserve report:

Az Zabirah Central zone Mining Reserve at 40% Taa Cutoff.					
Class	**Tonnes**	**Taa**	**Al_2O_3**	**Sio_2**	**Fe_2O_3**
probable	26010000	50.20	58.53	8.32	4.81

Table 14. Az Zabirah Central Zone Mining Reserve.

The table below is the waste materials of Ovb and Ucz were reported for Indicated (probal) area only.

Az Zabirah Central zone waste tonnage (Ucz and Ovb)	
Zone	Tonnage
Ovb	641438050
Ucz	23429250
total	664867300

Table 15. Waste tonnage Report- mining reserve (Ovb & Ucz).

As no optimization was done on this study there are many waste materials which not considered to be mined included in the waste reporting. (Table 16) (Figure 61) Therefore, a new string boundary was created inside the reserve area around only the boreholes intersected by Bauxite, (Figure 62) and then the waste was re-calculated and reported again.

Therefore, it would be recommended to do an optimisation for the central zone reserve in the future.

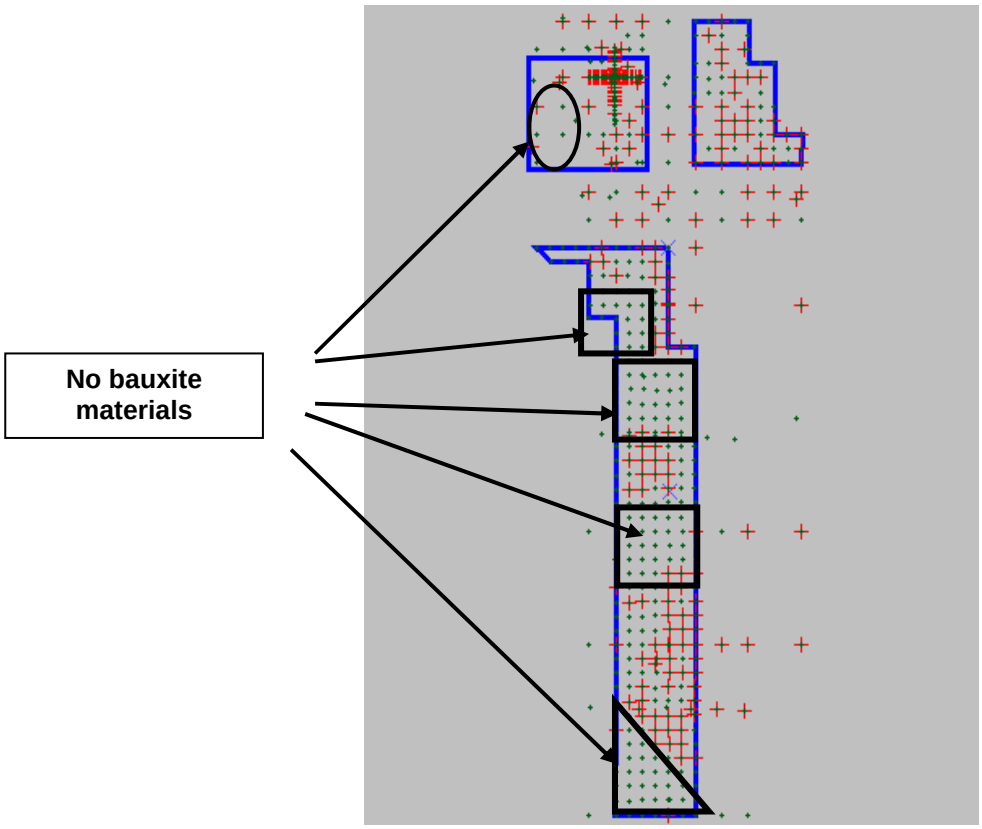


Figure 61. The reserve area (Blue polygons) contains huge areas where bauxite (red dots) doesn't exist (Black polygons)

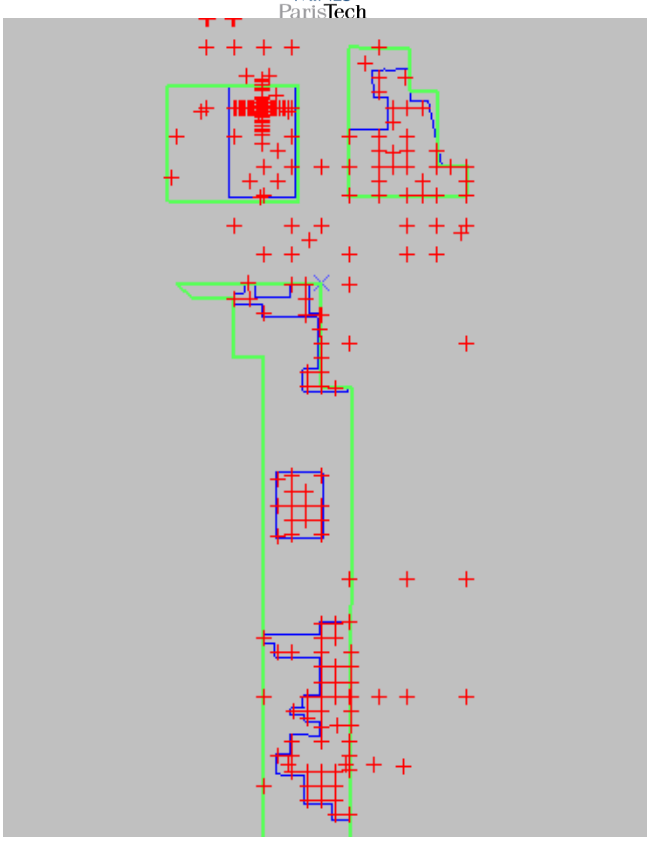


Figure 62. The new waste boundary around only the bauxite Boreholes (blue polygons) inside the reserve area (green polygons).

Az Zabirah Central zone- waste tonnage (Ucz and Ovb)	
Zone	Tonnage
Ovb	340003400
Ucz	18378750
total	358382150

Table 16. The latest waste tonnage in the Reserve area.

4 Mining

4.1 Mining Method

As Az Zabirah bauxite deposit is almost flat dipping approximately 5°to the north ease, a conventional open cut strip mining is proposed utilizing O&K loading units and Caterpillar haulage and ancillary mining equipments.

The key mining activities include the following as proposed by GHD (subcontractor with the EPCM):

- Land clearing, topsoil removal and storage for later use.

- Dune sand removal. Dozed to form buttress support for blasting.
- Drilling of hard bands in the overburden (OVB), in the Iron Cap (ICP) and in the economic Bauxite horizon (BXZ).
- Geophysical logging of drill holes, to obtain better understanding of deposit.
- Blasting of hard bands in the overburden (OVB), in the Iron Cap (ICP) and in the economic Bauxite horizon (BXZ), using discrete deck charges in the different materials. Material will only be blasted where the increase in costs (drill and blast) would be offset by increase loading productivity, otherwise material will be free dug.
- Overburden stripping and formation of mining benches.
- Formation of initial external waste dumps, progressive in pit dumping of waste, filling mined out voids and dump rehabilitation in stages.
- Establishment of access ramps to various mine benches.
- Bauxite mining and transport to the Bauxite processing facility at the mine.
- Establishment of ROM Bauxite stockpiles for blending.
- Operational control of mining with regard to equipment deployment, grade control and mine safety.

The major mining activities are described as follow:

4.1.1 Dune Sand Removal

- It is proposed that a Caterpillar D11T dozer be used to rip and doze the duricrust, then push the Aeolian surface sand and underlying sandstone/ siltstone over edge of the highwall into the existing pit void to form buttress support for blasting of overburden and the ore body.
- Overburden will be used to confine the Bauxite ore and allow fragmentation without excessive movement or dilution.

With any amount of material pushed over the highwall increasing the overburden haulage requirement, the following points need to be highlighted:

- Buttress support requirement is to be minimized.
- Waste haulage requirement (t.kms & lift) is to be minimized.
- Blasting process (includes buttress support, and blast hole burden and spacing) to be refine in initial years of mine operation whilst the impact of buttress support on costs will be lower due to lower initial strip ratios. (Figure 63)

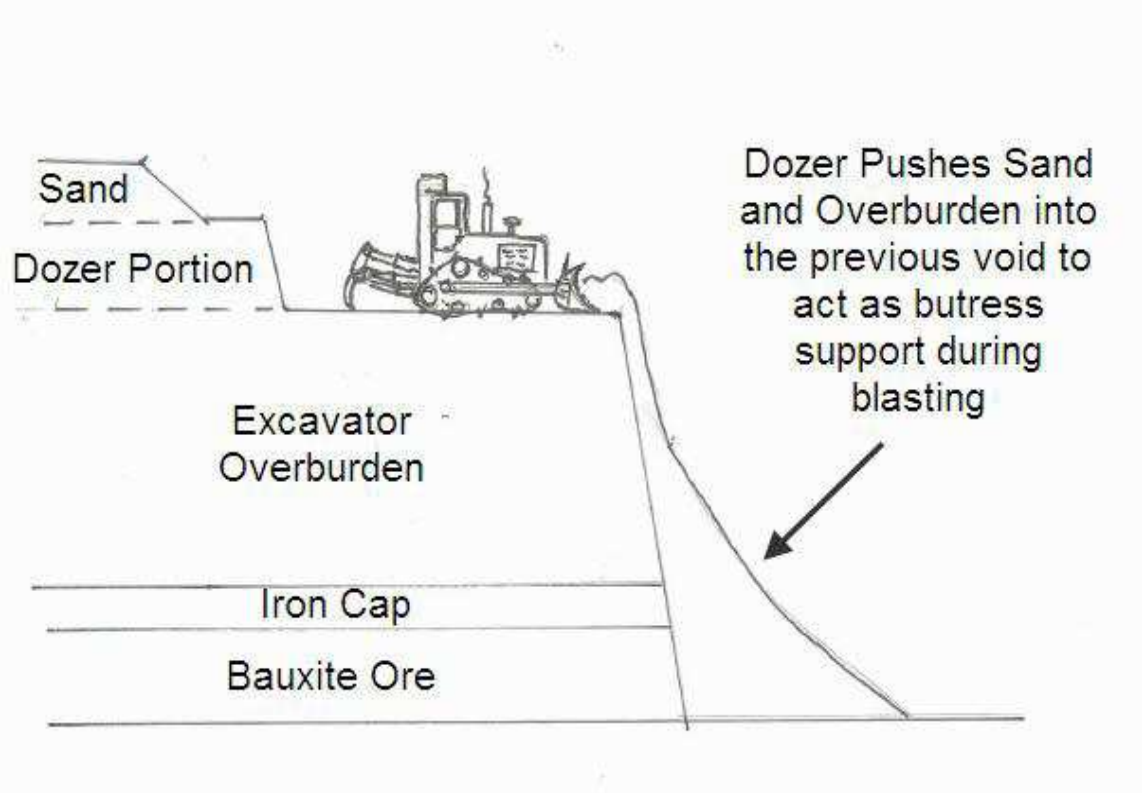


Figure 63. Overburden Removal Section.

4.1.2 Production Drilling

It is proposed to drill through the more competent overburden, any Iron Cap (if it is exist) and then through the Bauxite ore with a single setup. This will allow for discrete charges to be placed as a deck loading of production blast holes. (Figure 64)

The Iron Cap immediately above the orebody identified in the trial pit area does not observe entirely across the proposed mining area in the Central zone.

4.1.3 Geophysical Logging

It is believed that geophysical logging of blast holes would provide a better understanding of stratigraphy than other grade control methods, and define the top and bottom of the orebody across the resource. In particular the following information can be derived by geophysical logging:

- Boundary between Iron Cap and Bauxite ore. Not picked up by coarse exploration sampling (0.5m).
- Grade control of aluminium, iron and silica in the Bauxite ore.
- Insitu moisture % of the ore body. (Figure 65 shows further details).

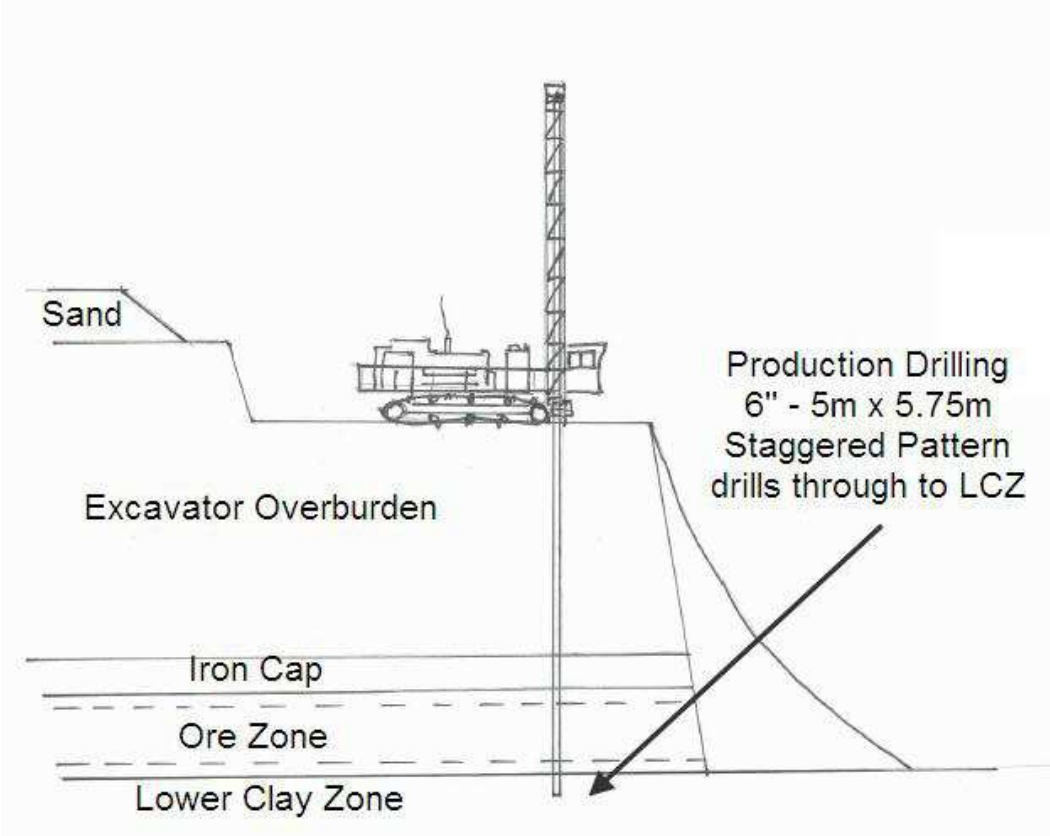


Figure 64. Production Drilling Section.

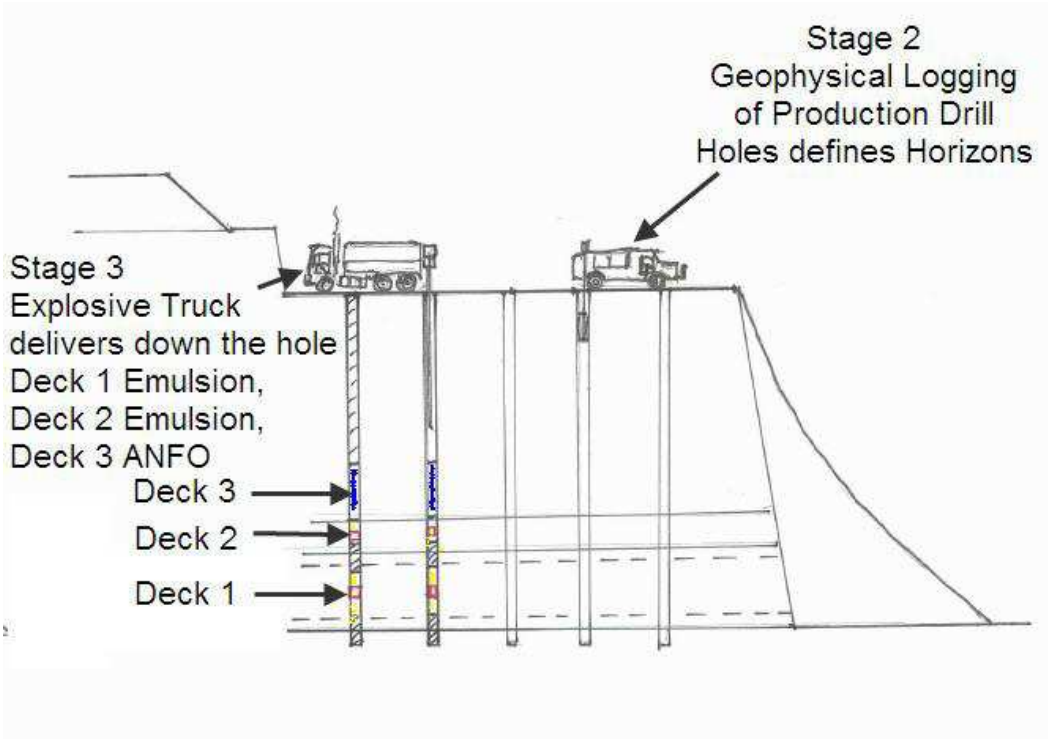


Figure 65. Geophysical Logging & Blast holes Charging Section.

4.1.4 Blasting

It is proposed to discretely blast the remnant overburden, Ironstone capping and Bauxite ore with discretely placed explosive charges, to provide suitable fracture of the overlying material while only slightly displacing the ore body. The Bauxite ore will be confined with buttress support along the exposed free face and above its insitu location, by overburden material, to keep it in place during blasting.
It is proposed to place discrete pocket charges of high density bulk explosive in the stratigraphy identified by geophysical probe and fire them by electronic initiation to reduce the Maximum Instantaneous Charge (MIC) to 1 deck.
This will provide adequate fragmentation of overburden, Ironstone capping and Bauxite ore while minimizing orebody movement and supporting high productivity high capacity excavation equipment. (Figure 66)

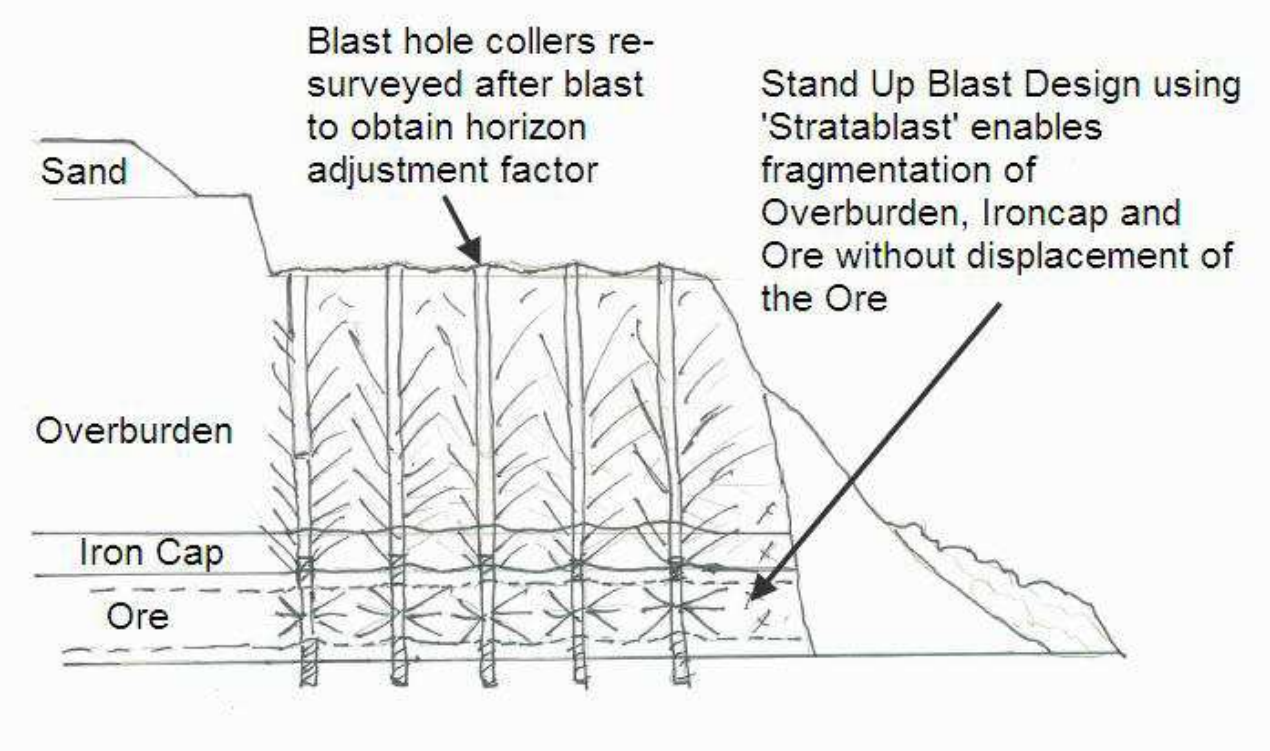


Figure 66. Blasting Section.

4.1.5 Overburden Removal

It is proposed to remove the competent overburden material above the Bauxite ore (PBZ) layer by an O&K RH 120 or RH 200 excavator.
Overburden will be removed by 100 t to 190 t haul trucks (i.e. Cat 777 to Cat 789) to out-of-pit waste dumps or used as buttress support in-pit against the ore face as required. Figure 67)
Overburden will be placed on in-pit waste dumps where possible in preference to hauling to out of pit dumps. Most overburden material, apart from that in the first two strips of

each pit, will be hauled to in-pit dumps. This is possible due to the strip mining layout of the operation.

4.1.6 Mining of Ore (PBZ)

It is proposed that the removal of Bauxite ore (PBZ) will be undertaken by an O&K RH 120 Hydraulic Shovel.
The triangular arrangement between boom and stick of this machine will enable it to cut to a defined horizontal floor, as designed by geophysics, spatial control systems and mine planning tools.

It is proposed that ore be transported by the same size trucks used on overburden removal (Cat 777 to Cat 789) to the ROM pad, then to the blending stockpile or to the ROM dump hopper for crushing. Figure 67)

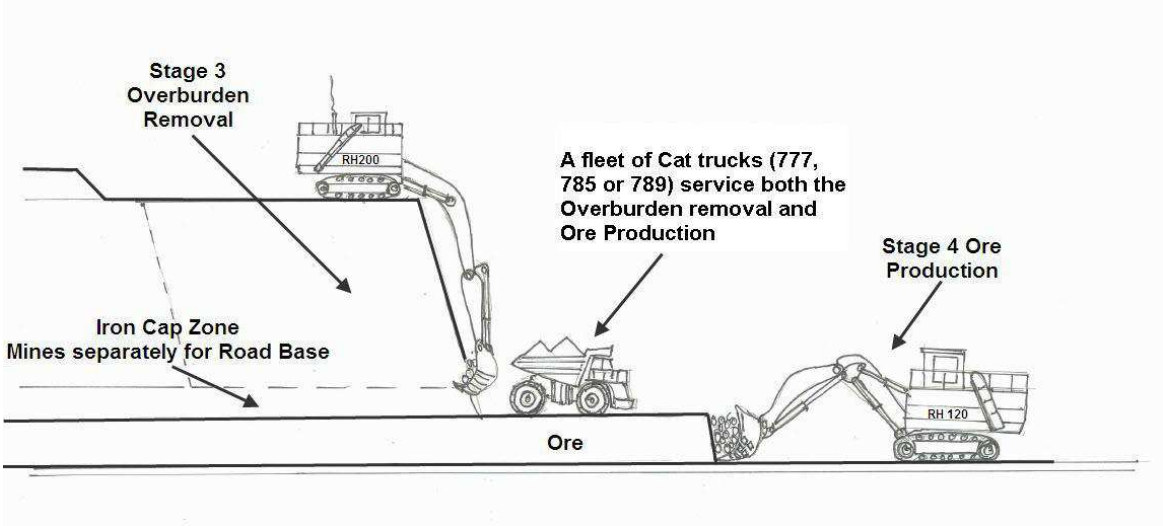


Figure 67. Ore & Waste Mining Section.

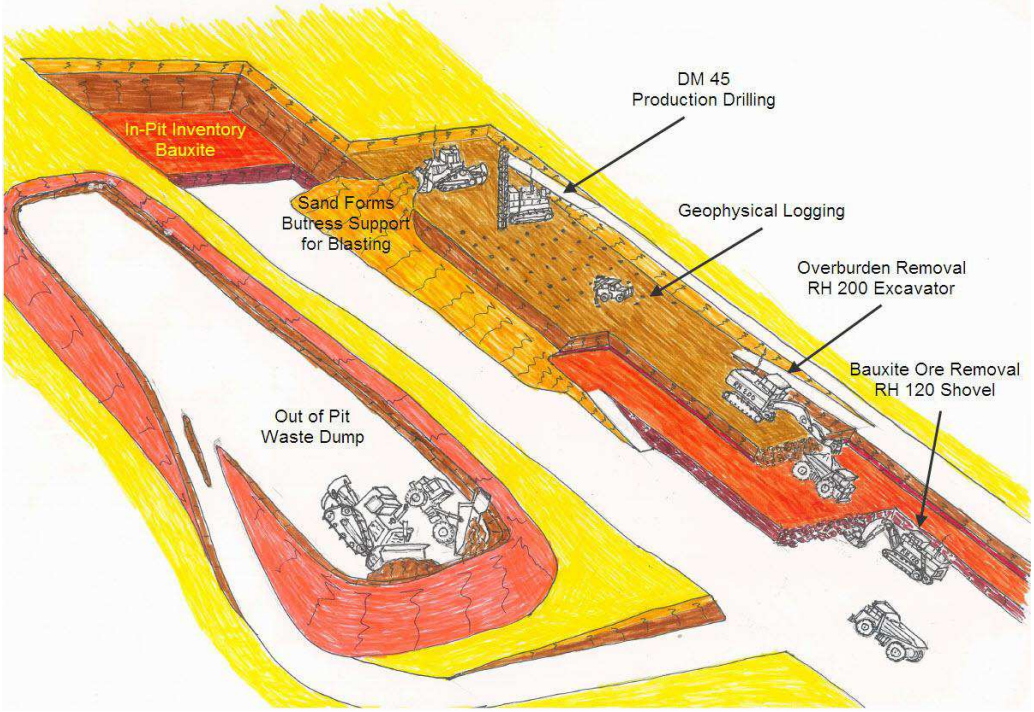


Figure 68. Overall View of Mining Activates.

4.1.7 Roads and Ramps

Haul roads will be constructed from the suitable type of materials excavated from the pit during the pre-strip operation, it will maintained by single 16m motor grader. In additional to maintaining the roads the grader will also be used for cleaning truck spillage from the roads, for general bench cleaning after blasting operation and for maintaining the truck turning areas on waste dump.
Haul roads widths are to be up to 27m, depending on truck class selected (3.5 times the width of truck), with ramp gradients no greater than 10%.

4.1.8 Dust suppression

Dust generated by truck movements on the mining benches, haul routes and waste strips will be suppressed by 773B water cart.

4.1.9 Contract Mining

At this study, it is planned that all mining activities are to be undertaken by mining contractors.
These contract mining activities include:

- Overburden removal
- Bauxite mining
- Drilling
- Blasting and Explosive Supply

4.2 Production rate and Equipments

The mine will be designed to produce ROM Bauxite such that the TAA content is sufficient to adhere to the 1.8 Mtpa creep schedule, where Alumina production ramps up to 2.09 Mtpa. This will require production between 4.6 and 4.9 Mtpa of dry ROM Bauxite. Therefore, the wet ROM Bauxite production rate from the mine will nominally need to be between the ranges of 5.1 to 5.4 Mtpa.

As proposed by GHD, an O&K RH200 sized excavator configuration is used for the waste handling and an O&K 120-E sized machine in shovel configuration for the ore handling. The waste and ore is hauled by CAT 789 class Off-Road Trucks. (Table 17)

Machine	Capacity
O&K RH200 backhoe	28.0 cu.m
O&K RH120 Shovels	16.5 cu.m
CAT 789 class off-road truck	177 tonnes

Table 17. Production Equipments.

Ancillary equipment is required for drilling and blasting, equipment maintenance and servicing, road maintenance, stockpiling, pre-stripping and other duties. Table 18 gives a list of the machinery required for Az Zabirah and the quantities required for full production.

Machine	Size / Class	Quantity
Front End Loader	992K	2
Tracked Dozer	D11	1
Grader	16 M	1
Blast hole Drilling	DM45	1
Grade Control Drill	Explorac R50 RC	1
Crane	25 tonne	1
Crane	15 tonne	1
Tyre handler	to suit above Equipment	1
Forklift	Stock Handler	1
Service Truck	773B Spec.	1
Fuel Truck	773B Spec.	1
Watercart	773B Spec.	1
Explosives Truck	15 tonne	1
Fitters Truck	Flatbed	1
Light Vehicles	Land Cruiser	6
Personnel Carrier	Bus	6
Ambulance	-	6
Lighting Plant	Mobile	10
Generator	200kVa	1

Table 18. Support Equipment Requirement.

The below table is summarizing the operating hours:

Calendar time	**365**	*Days*
Non- Scheduled Time		
1 day per week	52	days
Public Holidays	10	days
Sub Total	**62**	**days**
Scheduled Time		
Days per year	303	Days
Shift per day	3	Shifts
Hour per shift	8	Hours
Hour per year	7272	Hours
Av Maintenance Time	90	%
Available operating hours	6544.8	Hours
Operating days	**273**	**Days**

Table 19. Mining Operating Hours.

4.3 Mine Design

4.3.1 Slop Angle and Slop height

As no geotechnical study was done for the central zone, the same parameter will be used based on the geotechnical study on the South zone.

The table below describes the geotechnical parameters for 50m deep open pit:

Parameters	Value
Height of bench	5.0m
Total pit slop height	50.0m
Berm width	2.5m
Batter Angle	85 degrees
Catch berm width	8.0m
Height between catch berms	25.0m
Overall slop angle	56 degrees
Angle of Repose	34 degrees
Swell Factor	40 %

Table 20. Geotechnical parameters for 50m deep open pit.

4.3.2 Dump Design

The specifications for the haul dump design are as following:

1. Offset 50m from haul road alignment.
2. 20m degrees overall.
3. 100m maximum from face.
4. Average 850m single distance.
5. Swell factor of 1.2.

4.4 Mine Processing

The function of the Mine Processing Facilities is to accept ROM ore and process the ore to a product that is suitable for transport and ball mill feed.
The process option proposed by Bechtel and selected by Ma'aden for the Feasibility Study Report consists of a three-stage crushing plant with the tertiary crusher operating in open circuit with a screen. Figure 69 is a schematic diagram of the crushing circuit. To mitigate the adverse effects of fine material during rail transport, the ore will be transported after the secondary crushing step to the tertiary crusher which will be located at the refinery site.

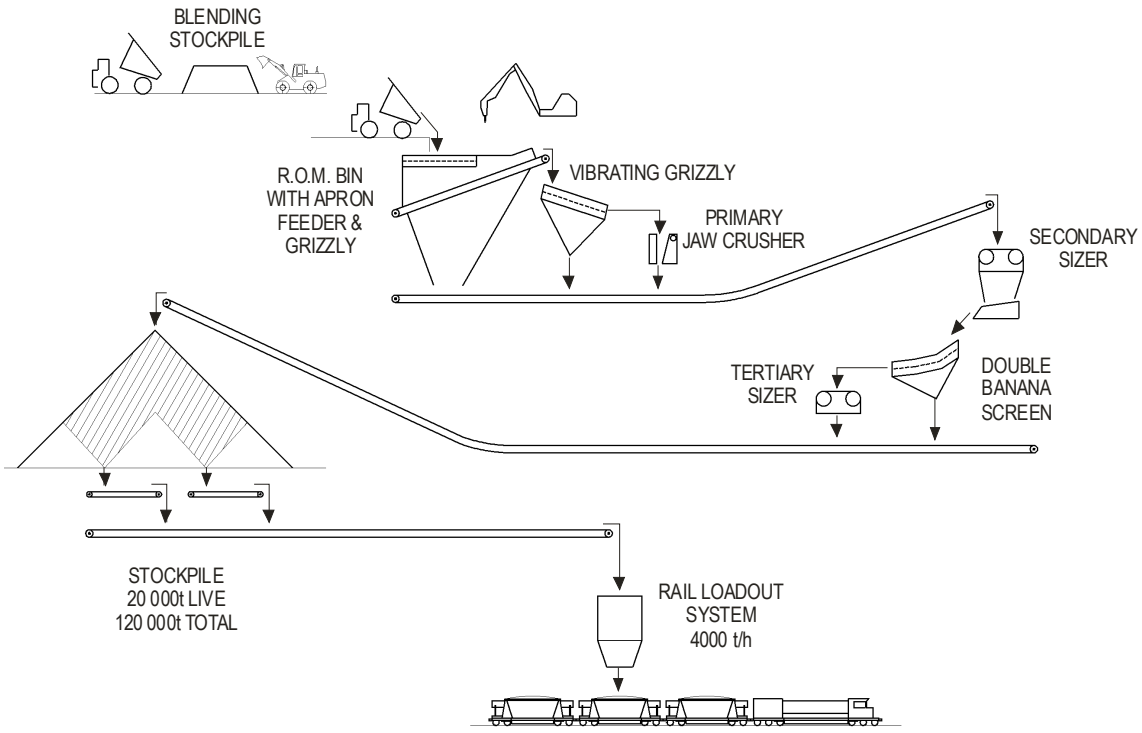


Figure 69. Mine Processing Facility Flow Sheet.

The sizing criteria for the products are summarized in the table below:

	Feed Size F95 mm	Product Size P95 mm
Primary Crusher	750	250
Secondary Crusher	250	70
Tertiary Crusher	70	15

Table 21. Mine Crusher Feed and product Size.

A vibrating grizzly is located above the feed to the primary crusher, limiting the lump size to the primary crusher to 800 by 800 by 1,000 millimeters. A rock breaker is provided to handle oversize ROM material.
The proposed Mine Processing Facilities design calls for operation 24 hours per day, 6 days per week, same as mine operating hours.

4.5 Mine Closure and Rehabilitation

To the extent possible, the operators would dump the mine material in the previously mined areas. And after the previously mined areas have completely filled, the surface would be countered the previously stockpiled topsoil would be distributed over the countered surface.

The Environment Impact assessment study, assert that the topsoil placed over the contoured fill created from the mine waste would revegetate naturally.

5 Project Cost

5.1 Capital Cost

This study is considers that the Central zone mine would be an extension of the south zone mine which would is planned to be producing on 2012.

The study depends on contract mining which means the contractor will carry out the Overburden removal, bauxite mining, drilling, blasting, loading and hauling.

Therefore, No mining equipments were taking in account in this project cost and no crushing plant, no rail construction cost, no mine village cost and no permanent building was talking in account.

The study considered that all capable equipments and crushers will be obtained from the south zone mine after mine closure.

Contingencies will be added (approximately 2% from the initial cost) for incapable equipment replacement and shift the crusher and other things from the south.

The table below shows the summary of the capital cost which was taking from the Last update of the Feasibility study:

Code	Specification		Grand Total	Observation
M001	Mine Development		17,287,717.00	
M310	ROM Dump Station		1,366,951.00	
M320	Crushing Plant		1,219,049.00	Without crusher
M330	Product Storage		1,686,598.00	
M410	Access Road		12,146,681.00	
M420	Site Development		7,351,292.00	
M440	Drainage System		489,362.00	
M500	Minesite Facilities	LS	6,106,777.00	Electricity from south
M540	Admin building(cabinet)	LS	224,000.00	Lump Sum
M610	Water supply	LS	50,000.00	Piping existing water wells
M660	Fire Protaction		721,561.00	
M990	Contingency	LS	1, 000,000.00	
Total			**49,649,988.00**	

Table 22. Project Estimated Capital Cost.

5.2 Operating cost

As mentioned previously that this study is considered that all mining activates will be carrying out by contract and the owner will be carrying the processing and transportation. The below table is summary of the operating Cost, which includes the contractor cost (Mining operation) and the Company cost.

Description	Mining Contract $/t
Mining Operation	11.19
Plant Operation	0.45
Manpower	1.45
Mine village & Infrastructure	0.54
Rehandling stocks	0.01
rail charges	8.74
Total	22.38

Table 23. Summary of Total Operating Cost- Contractor and owner.

6 Economic Evaluation

The aim of Ma'aden is to develop Az Zabirah mine (South and central zone) to build an integrate Aluminum project which include beside the mine power plant, port, refinery and smelter within an annual production of 720000 tpa of Aluminum.

Therefore, Ma'aden will not sell Bauxite ore and it will send it to the proposed refinery at Ras az Zawer, but in order to estimate the profitability of Az Zabirah bauxite Central zone a complete economic study was practiced. The study was based on the minable reserve which includes only the indicated area and was done in this study without performing an

optimization. It is recommended to convert the inferred area to be indicated and optimized the reserve in the future.

6.1 Bauxite Price

In order to do the economic evaluation a selling price was used as an average price (27.8) from 1991 to 2009 (Figure 70)

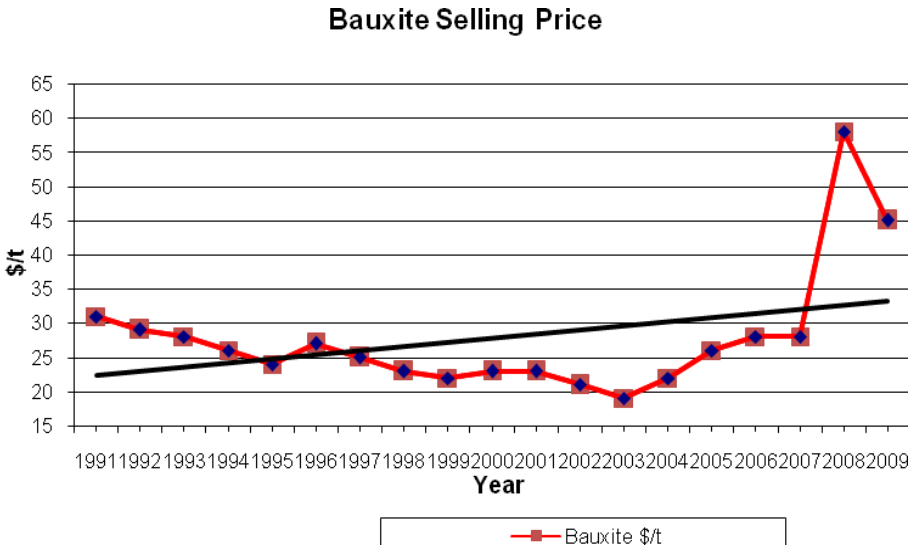


Figure 70. Bauxite Selling Price- 1991 to 2009.

The above prices were obtained from bauxite trend to USA (2007) and estimated Chinese bauxite imports (2008). (Figures 71 & 72)

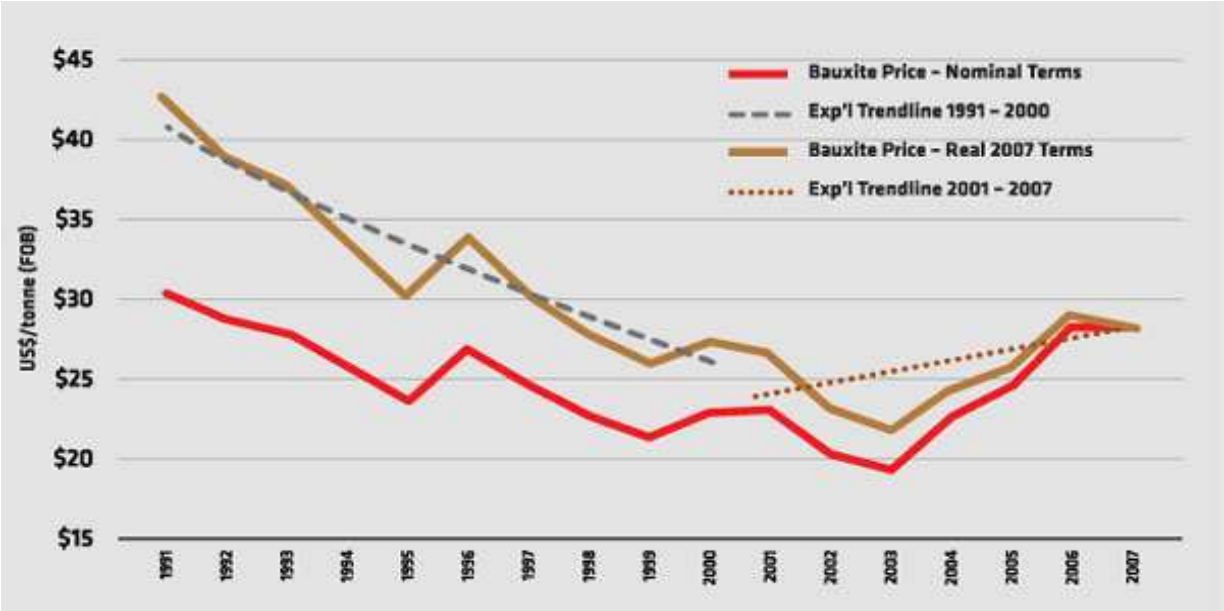


Figure 71. Bauxite Price Trends to United States (FOB 2007 Real Terms).

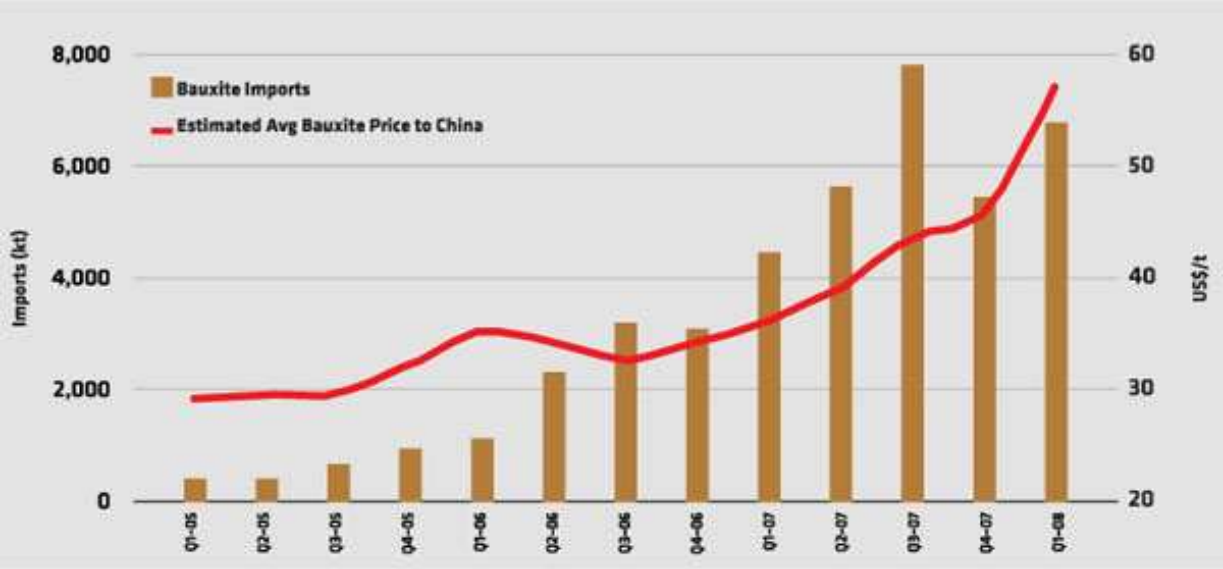


Figure 72. Estimated Chinese Bauxite Imports

6.2 General Study (Intrinsic)

The intrinsic study is a study without including taxes and the total investment is from the equity without loan. An actualization factor was used of 12%.

Table 24 summarized the intrinsic study and details are in Appendix B.

Investment (M$)	Opex(M$)	revenue(M$)	Selling Price ($/t)	NPV (M$)	IRR %	PBP
49.65	582.10	723.08	27.8	43.41	40.06	3

Table 24. The Intrinsic Study Result

6.3 Study with Taxes

Two taxes was added to the expenses in this study, Zakat tax (2.5% from the annual income) and royalty (0.8$/t). Table 25 summarized the result and details in Appendix B.

Investment (M$)	Opex(M$)	revenue(M$)	Selling Price ($/t)	NPV (M$)	IRR %	PBP
49.65	582.10	723.08	27.8	28.8	31.46	4

Table 25. Study with Taxes Result

The IRR in this study is interesting and indicates that this project is profitable and it would be possible to get a loan for financing.

6.4 Study with Loan

In this study an assumption of 60% of the total initial investment will be borrowing from a local bank as loan with 5% interest rate. Table 26 shows the summary of this study and the details in Appendix B.

Investment (M$)	Opex(M$)	revenue(M$)	Selling Price ($/t)	NPV (M$)	IRR %	PBP
49.65	582.10	723.08	27.8	46.5	55.96	2.45

Table 26. Study with Loan Result.

The IRR in the study with loan is better than without and it would be better to get the benefit from the loan for financing the project.

6.5 Complete Study

This study is encompassed the three study, intrinsic, with taxes and study with loan. The table below shows the summary of this result and details calculation in Appendix B.

Investment (M$)	Opex(M$)	revenue(M$)	Selling Price ($/t)	NPV (M$)	IRR %	PBP
49.65	582.10	723.08	27.8	31.94	43.99	3

Table 27. The Complete Study Result.

The complete study indicates that the project is attractive as extending of south Zone.

6.6 Economical Diagrams

Economical Diagrams were accomplished for the different studies in order to show the payback period of the cumulative cash flow versus the discounted cash flow. And other diagrams were accomplished to show the discount rates versus NPV. (Figure 73 & 74) show these Diagrams for the complete study and rest study diagrams are in Appendix B.

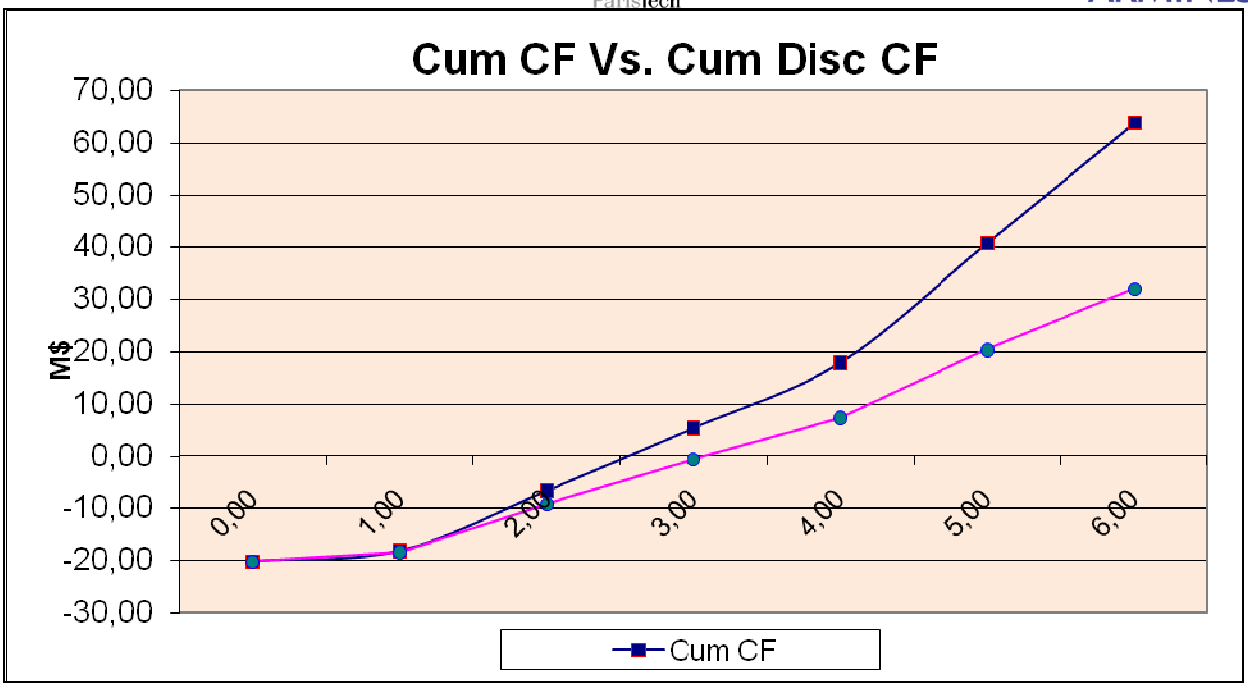


Figure 73. Cumulative Cash Flow Vs. Cumulative Discounted Cash Flow.

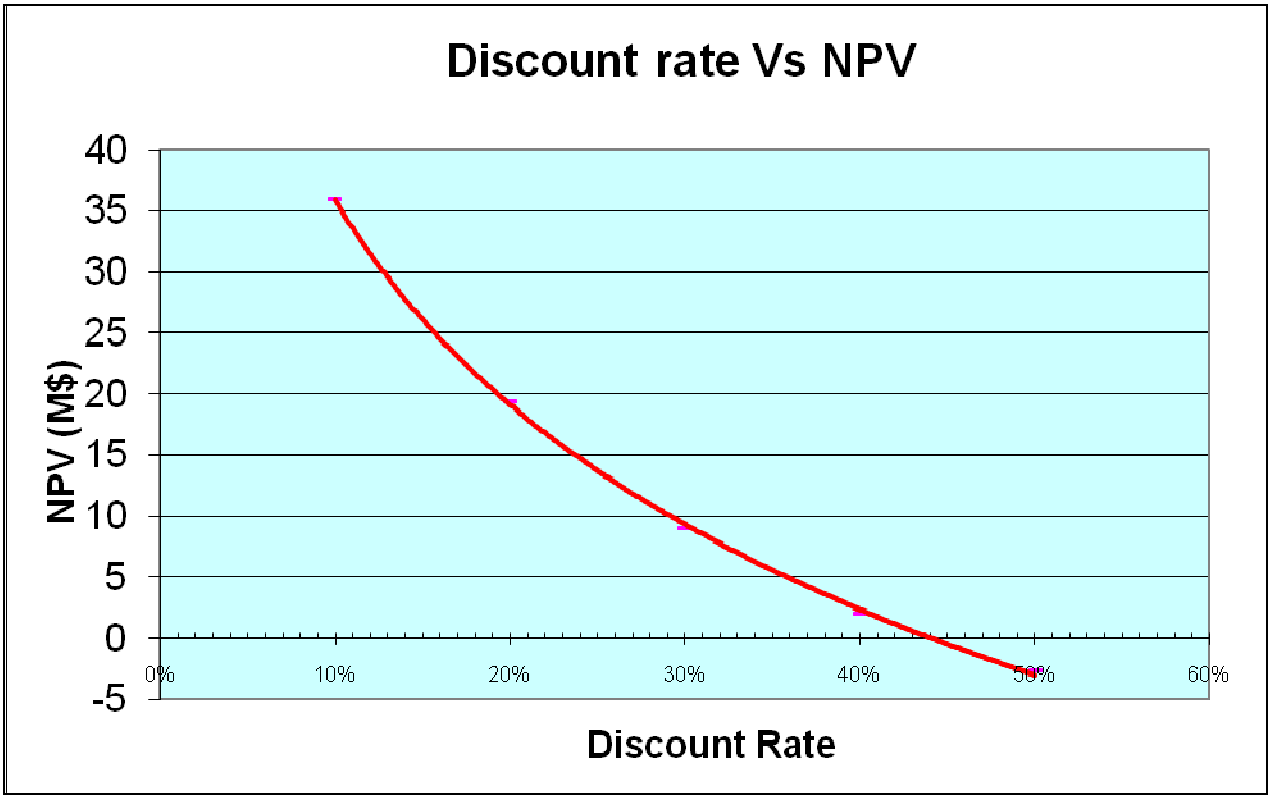


Figure 74. Discount Rates Vs. NPVs.

6.7 Other Economical Factors

Other economical parameters were also performed such as Capitalistic intensity, Margin, Break even and cash break even. (Table 28)

Capitalistic Intensity	Margin	Break even Price	Cash break even Price
0.35%	19%	25.29	23.38

Table 28. Other Economical Parameters.

6.8 Sensitivity Study

The sensitivity study was performing in order to show the effect of the parameters on the project either in positive or negative way. Five elements were test in this study which are, selling price, production rate, operation cost, Income tax and royalty

The study showed was performed for IRR and NPV and variation range from 50% to 150% was applied on each element. (Figure 75 & 76)

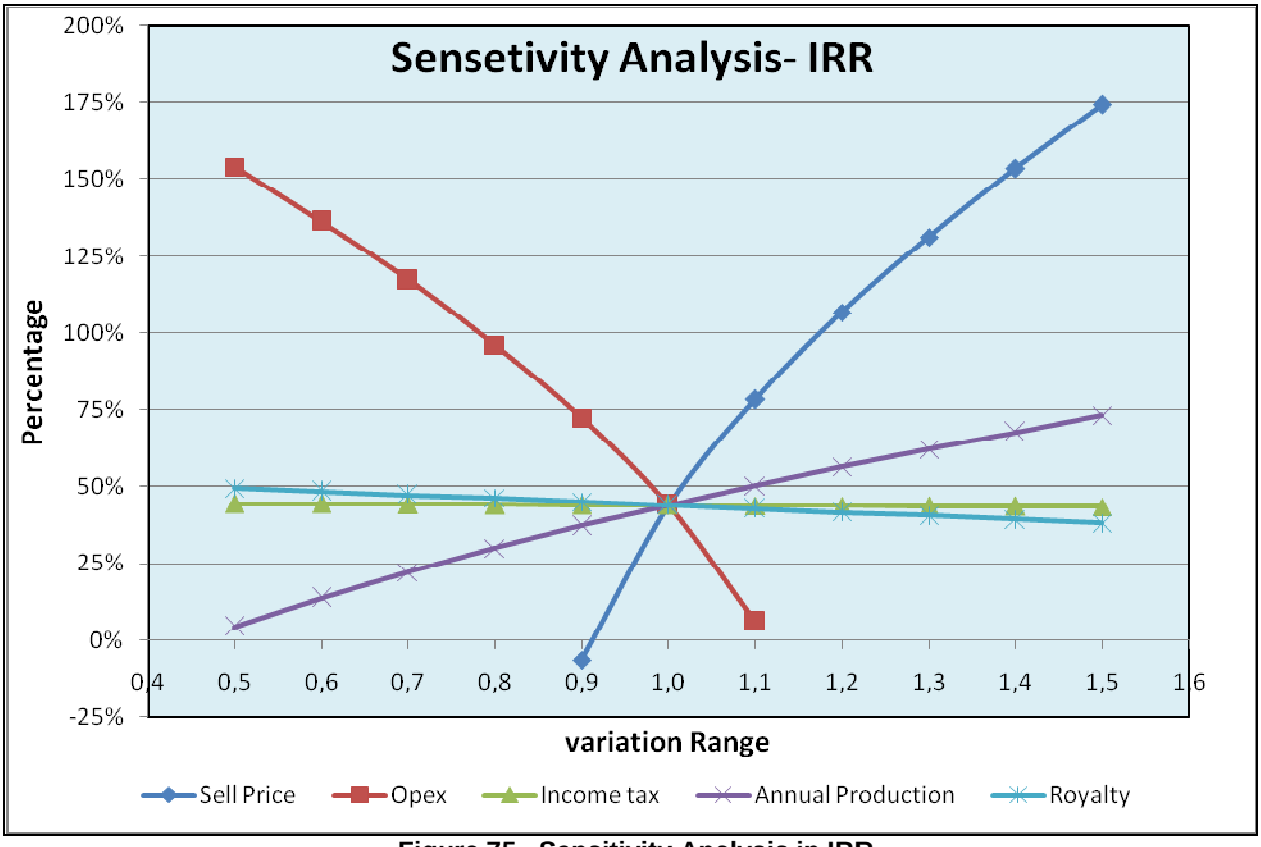


Figure 75. Sensitivity Analysis in IRR.

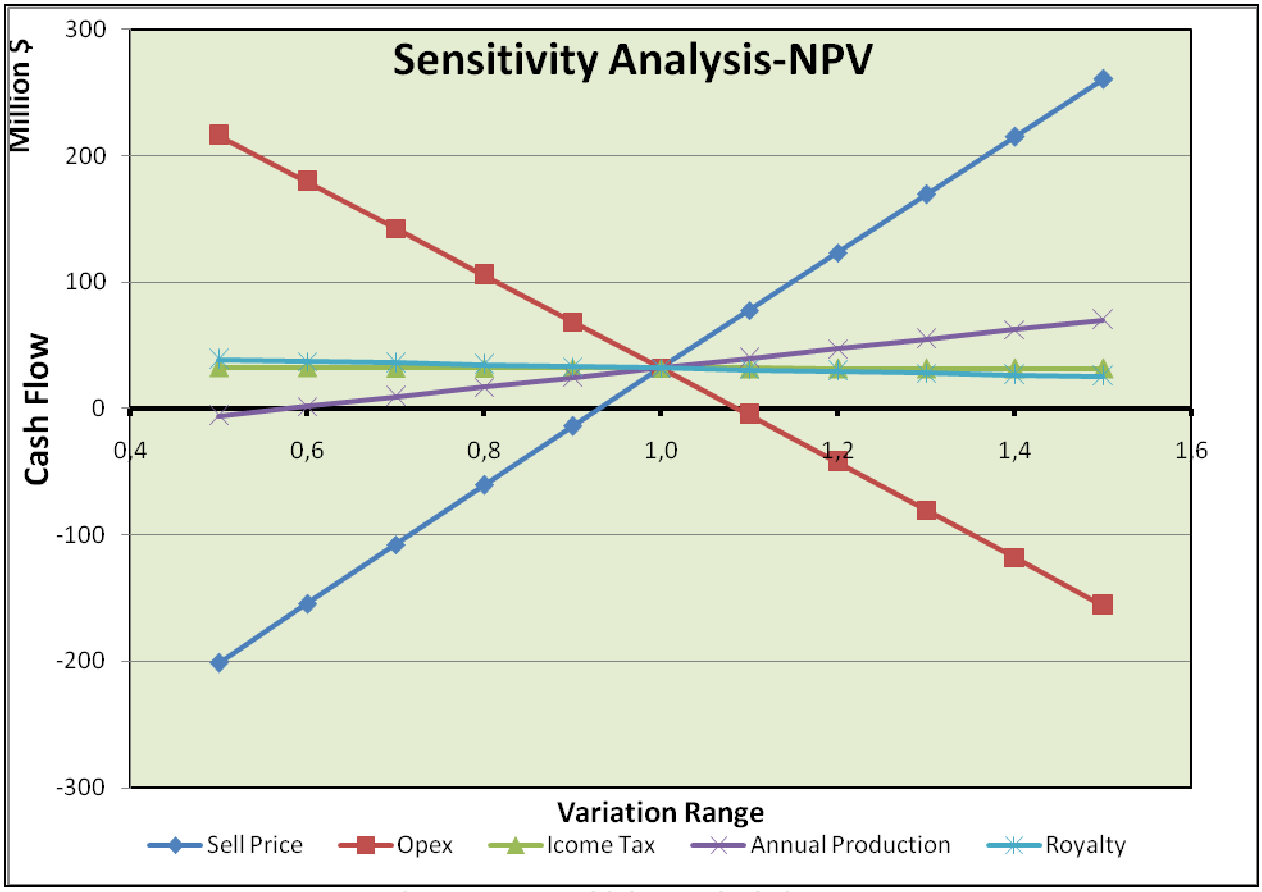


Figure 76. Sensitivity Analysis in NPV.

The previous charts show that the selling price and operating cost are critical elements, where 10% reduction on selling price or at 10% increment on operating cost we have Negative cash flow and break even on the same reduction of selling price. The next sensitive element is the production rate which gives break even at 40% reduction, and the income tax and royalty are not sensitive.

The below figure show the NPV with different discount rate.

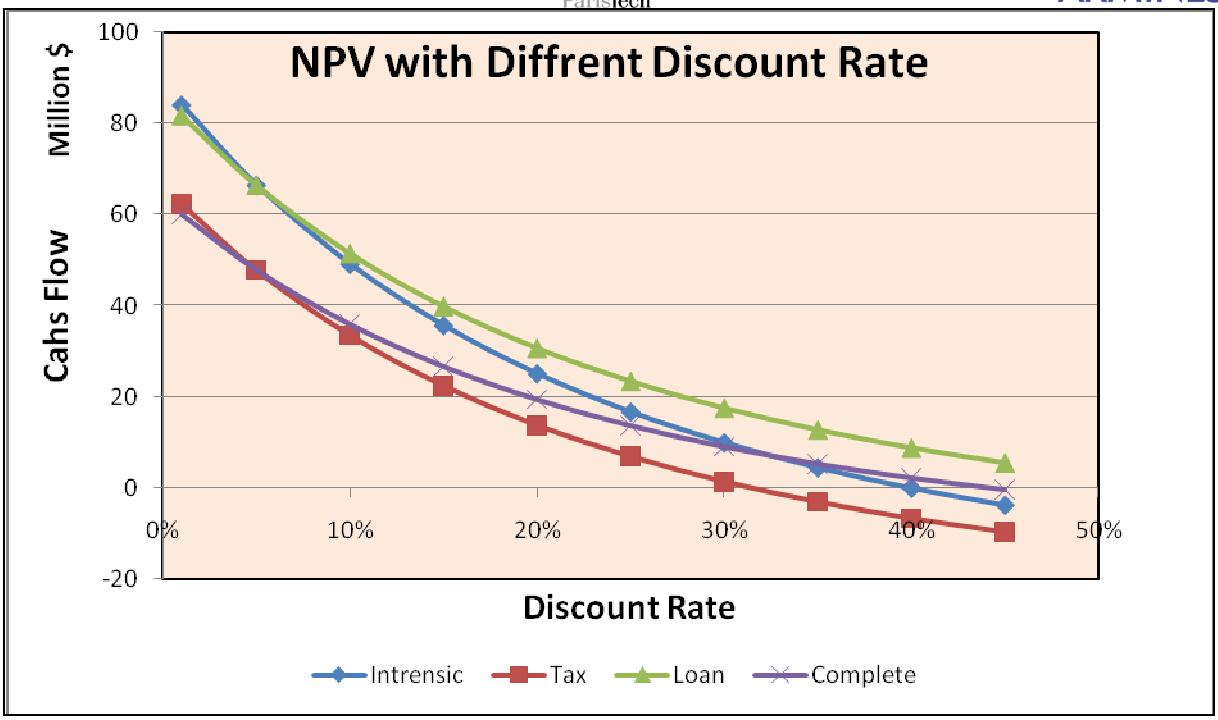


Figure 77. NPV at diffrent discount rate.

7 Conclusion and Recommendation

- It’s preferable to do the resource estimation using Miex software which is special for seams modeling although Surpac is good software but is most use for massive deposit.
- The drilling plant for the Central zone should be completed in order to convert the inferred resource to an indicated and increase the reserve and the mine life.
- It’s not recommended to drill boreholes more than 50m, where the waste ratio is very high (13.7).
- An optimization should be performed for the current reserve study in order to identify the optimum pits and reduced the waste ratio.
- The economic study proved that the mine as project is risky without refinery and smelter where the price and operating cost is highly sensitive.

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