UNIVERSIDADE D COIMBRA

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MODELLING AND RESOURCES ESTIMATION FOR THE BAUCAU LIMESTONE AT THE BLOCK I MINE1 AND MINE2, BAUCAU MUNICIPALITY-TIMOR-LESTE

Dissertação no âmbito do Mestrado em Geociências, Ramo Recursos Geológicos Orientada pelo Professor Doutor Nelson Edgar Viegas Rodrigues e Doutor João Alberto Correia Marques e apresentada ao Departamento de Ciências da Terra da Faculdade de Ciências e Tecnologia da Universidade de Coimbra

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Abstract

The study area is located in the Baucau Municipality, East Timor. Baucau Municipality borders with Lautem Municipality in the east, with Manatutu Municipality in the west, with Viqueque Municipality in the south and with the strait of Wetar in the north, it is approximately 120 km east of Dili, capital of Democratic Republic of Timor Leste. The mineral licenses areas consist of Block I-1, Block I-2 and Block II.

For the Baucau Limestone at concession area in block I-Mine1 and Mine2, the modelling and resources estimation is a critical tool for the development of that concession area. Thus, limestone is one of the important raw materials needed for producing cement while gypsum, silica and clay are needed as a complimentary materials. Cement is one of the important materials necessary for for the development of the nation especially for Timor-Leste in the present and in the future. There average grades of CaO vary from 42 to 53% at block I-Mine1 and from 54 to 55% for block I-Mine2. The lithologies found in the concession area are diverse such as top soil, coral reef limestone, sandy limestone, chalky or soft limestone and clay. The modelling permitted to calculate maximum of the percentages of the chemical composition that consist of Al_2O_3, CaO, Cl, Fe_2O_3, MgO and K_2O. There are various average models namely Al_2O_3 model, CaO model, SiO_2 model and Fe_2O_3 model. Index hydraulicity, silica module, aluminum ferric module and lime saturation module. The estimated resources at block I-Mine1 and Mine2 follow the recommendations of the JORC Code reporting standardization.

Key words: Baucau limestone, cement, modelling, resources estimation, open pit optimization.

Resumo

A área em estudo localiza-se no municipio de Baucau, Timor-Leste. O Municipio de Baucau confina com o municipio de Lautem a este, com o Manatutu a oeste, com o de Viqueque a sul e com o estreito de Wetar a norte. Fica a aproximadamente 120km a este de Dili, a capital da República de Timor Leste. As áreas concessionadas são referidas por Bloco I-1, Bloco I-2, e Bloco II.

Para o calcário de Baucau na área de concessão no bloco I-Mina1 e Mina2, a modelação e a estimativa de recursos são ferramentas críticas para o desenvolvimento desta área de concessão. Assim, o calcário é uma das matérias-primas importantes para a produção de cimento, sendo também necessário gesso, sílica e argila como materiais complementares. O cimento é um dos materiais importantes para o desenvolvimento como nação, especialmente para Timor-Leste no presente e no futuro. Os teores médios de CaO variam entre 42-53% no bloco I-Mina1 e entre 54-55% no bloco I-Mina2. As litologias encontradas na área de concessão são diversas, como solo superior, calcário recifal, calcário arenoso, calcário macio e argila. A modelação permitiu calcular valores máximo das porcentagens da composição química (Al_2O_3, CaO, Cl, Fe_2O_3, MgO e K_2O). Existem vários modelos médios, nomeadamente o modelo Al2O3, modelo CaO, modelo SiO2 e modelo Fe2O3. Indice de hidraulicidade, módulo de sílica, modulo férrico de aluminio e módulo de saturação de cal. A estimativa de recursos no bloco I-Mina1 e Mina2 seguiu as recomendações do Código JORC.

Palavras-chave: Calcário de Baucau, producão de cimento, modelação, cálculo de recursos, otimização de céu-aberto.

Abbreviations

MPRM	: Ministerio do Petroleo e Recursos Minerais
TL Cement	: Timor Leste Cement
M	: Meter
ADD	: Additional
BH	: Boreholes
Amsl	: Aboute mean sea level
XRF	: X-Ray Fluorescene
Al_2O_3	: Aluminium trioxide
CaO	: Calcium Oxide
Cl	: Chlorine
Fe_2O_3	: Iron trioxide
K_2O	: Dipotassium Oxide
MgO	: Magnesium Oxide
Mn	: Manganese
SiO_2	: Silica Dioxide
Na_2O	: Sodium Oxide
P_2O_5	: Phosphorous Oxide
SO_3	: Sulphur Trioxide
MnO_2	: Magnesium Dioxide
TiO_2	: Titanium Dioxide
LOI	: Loss On Ignition
JORC	: Joint Ore Reserves Committee

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Chapter 1
Introduction

1.1 Background of Study

As a new country, Timor-Leste requires construction in his territory. Thus cement is an important part of materials needed for the physical development of the country. Regarding the raw materials needed to produce cement especially in what concerns limestone deposits, based on geological data Timor Leste is majority occupied by industrial rocks (like limestone). Therefore the Cement Company (TL Cement) cooperated with the Timor-Leste Government and after the permission of the Ministry of Petroleum and Mineral Resources **(MPRM)** started a feasibility study in 2014 which finished by the end of that year. The TL Cement company has its head-office in Perth, Western Australia and a project office in Dili Timor-Leste. The cement company is contemplating to put a clinker and cement manufacturing plant in the Baucau Municipality, Timor-Leste. TL Cement company is in the process of installing a 5.000 tons per day clinkerization unit at Baucau Municipality of the Democratic Republic of Timor Leste and it has been granted a mineral license for prospecting over an area of 38.4 sq km spreading across three blocks. TL Cement company collaborated with Holtec Consulting Private Limited **(HOLTEC)** from India and is preparing a mining plan for their captive limestone mine to supply limestone for their proposed cement plant. Holtec Consulting Private Limited is an ISO-certified consulting company, primarily positioned to service the entire range of consulting needs of the global cement industry. Its portfolio spans services in all disciplines of Engineering, Business Consulting, Geology and Mining, Project and Construction Management, Environmental Management, Performance Enhancement and Logistics. Regarding TL Cement company, the production target is 1.65 million tons per annum of Portland cement clinker (Worley Person Consulting) but it is dependent on the market.

Portland cement is the basic ingredient of concrete. Concrete is formed when Portland cement creates a paste with water that binds with sand rock to harden. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients. Common materials used to manufacture cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand, and iron ore. These ingredients, when heated at high temperatures form a rock-like substance known as clinker. Clinker is then ground to a fine powder, along with gypsum and other substances to produce useable cement. Clinker, if stored in dry conditions, can be kept for several months without appreciable loss of quality. Because of this and because it can easily be handled by ordinary mineral handling equipment, clinker is traded international in large quantities. The proposed project will provide cement clinker for both domestic use and international sale.

1.2 Objectives

Based on the data available, the main objectives are:

1. **Primary objective**

   To understand modelling and distribution of limestone based on borehole data processed with the software RockWorks (V17) and Surfer (V16).

2. **Secondary objective**

   To estimate the resources at the concession area and to estimate the life of Block I (Mine 1 and Mine 2) as a function of the expected current production based on the borehole data available.

1.3 Methodologies

1.3.1 Previous Work

Audley-Charles (1968) reported that Baucau Limestone deposited after underlying formation folded. The underlying formation is the Viqueque formation, which comprises of chalky and grey clay stone. The surface of the Baucau plateau is covered by coral-reef limestone of the Baucau Formation.

Mentzner (1977) classified the physiographic units based on morphological characteristics into four zones that compose the Baucau Plateau, the east and west escarpment, the marine terraces zone and the coastal zone.

1.3.2 Data Collection

Several methods for data collection were that applied such as secondary data collection and field investigation. The secondary data were collected from the previous studies through different expertise, data from the feasibility study (drilling activity) and laboratory analysis data for each borehole.

Field investigation has been made directly in the field in order to acquire geological data and morphological data at the concession area and surrounding area of Baucau Municipality.

1.3.3 Data Processing and Interpretation

For data processing and interpretation, we used various data to implement modelling and for resource estimation that consisted of borehole data, geological data and morphology data. The data processing will focus on boreholes data. The step of data processing and interpretation will be demonstrated in chapter 4 and chapter 5 by using RockWorks software (v17). The resource estimation followed the international reporting templatees namely the JORC Code.

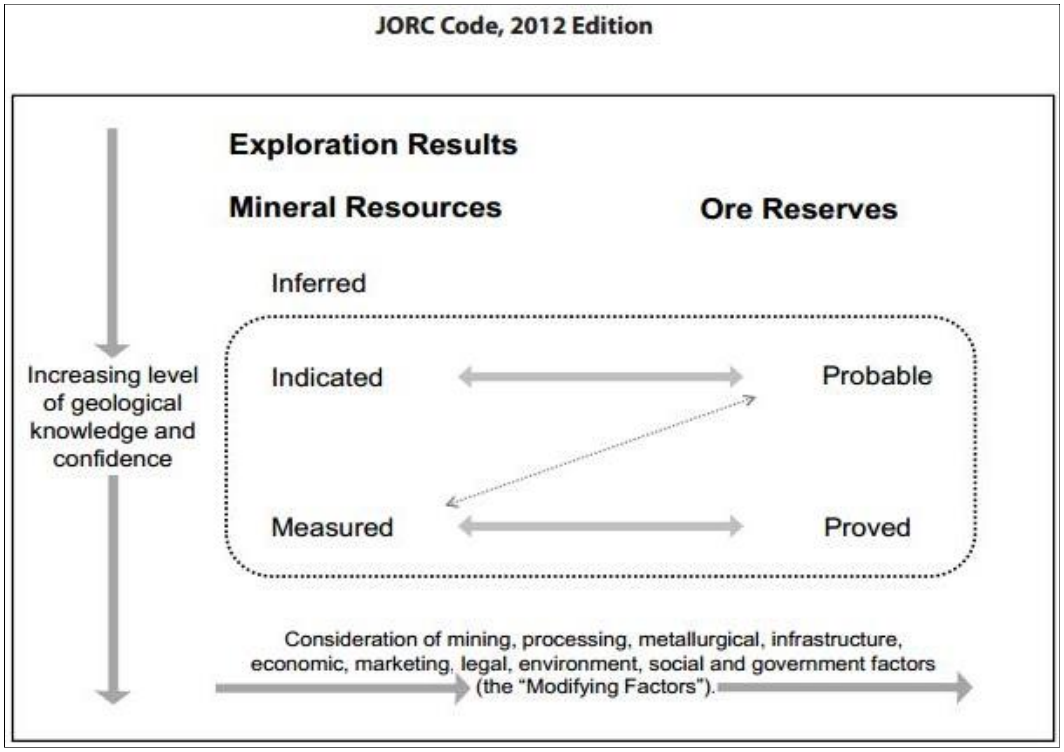

Figure 1.1 The general relationship between exploration results, mineral resources and ore reserves

1.4 Research Limitations

Eventhough using various data in the study, every study has limitation. This master dissertation had the following limitations:

1. More boreholes were needed for the Block I (Mine2) and Block II.
2. Lack of laboratory analysis for five (5) boreholes.

Chapter 2
Cement

2.1 Definition

Cement is a product obtained from chemical reactions between silica, aluminum and limestone at temperatures in the range of 1000-1500^o C. When it is powdered and mixed with water, it has the characteristic of hardening outside or inside it. Portland cement was invented by the French engineer Louis Vicat (1786-1861) in 1817, when he chose cement from the mixture of clay with finely ground limestone, and afterwards this mixture was heated up to about 1000^o C, which was insufficient for the formation of silicate tricalcic, an essential component of cement, which gives this material its high mechanical strength.

Then in 1824, the English Aspdin obtained good quality of cement after heating the clay mixture with limestone to a temperature of 1400^{o}C. The designation of cement Portland derives from the similarity with Portland stone, commercial stone mass quarried the English island of Portland. Portland cement can be defined as a clinker obtained from clinker spray that results from calcination to partial melting of a mixture of calcareous and clayey raw materials, consisting essentially of calcium silicates with the ability to hydrate.

Portland cement is produced from a controlled mixture of limestone and clay to which other mineral raw materials are added in smaller proportions, rich in silica, alumina and iron. The milled mixture is subjected to calcination at temperatures between 1400^{o}C and 1500^{o}C. The mixture is homogenized and dispersed, both dry and with water then connected to rotary kiln where reactions are produced, aided by the fusion of about 20% of the material to new compounds (aluminates and ferrates). Due to partial melting, the reaction products, upon cooling, agglomerate into granules to produce a product called clinker.

The temperature of firing is very important. In fact, while ordinary lime is obtained between 700-900^{o}C, hydraulic lime requires 1000-1100^{o}C and cement 1400-1500^{o}C. Under heat the clay-limestone mixture loses CO2 (carbonate) and water (clay). The fundamental components of anhydrous clay (silica and alumina) react with limestone oxide (derived from limestone) giving calcium and silicate aluminates. In the temperature range of 1400-1500^{o}C, Al_2O_3 and CaO react almost totally, so that the high quality cements do not have free lime but several limestone silicates and aluminates, such as: 3CaO. SiO_2,3CaO. Al_2O_3 generally crystallized. The following figure shows the cement production process.

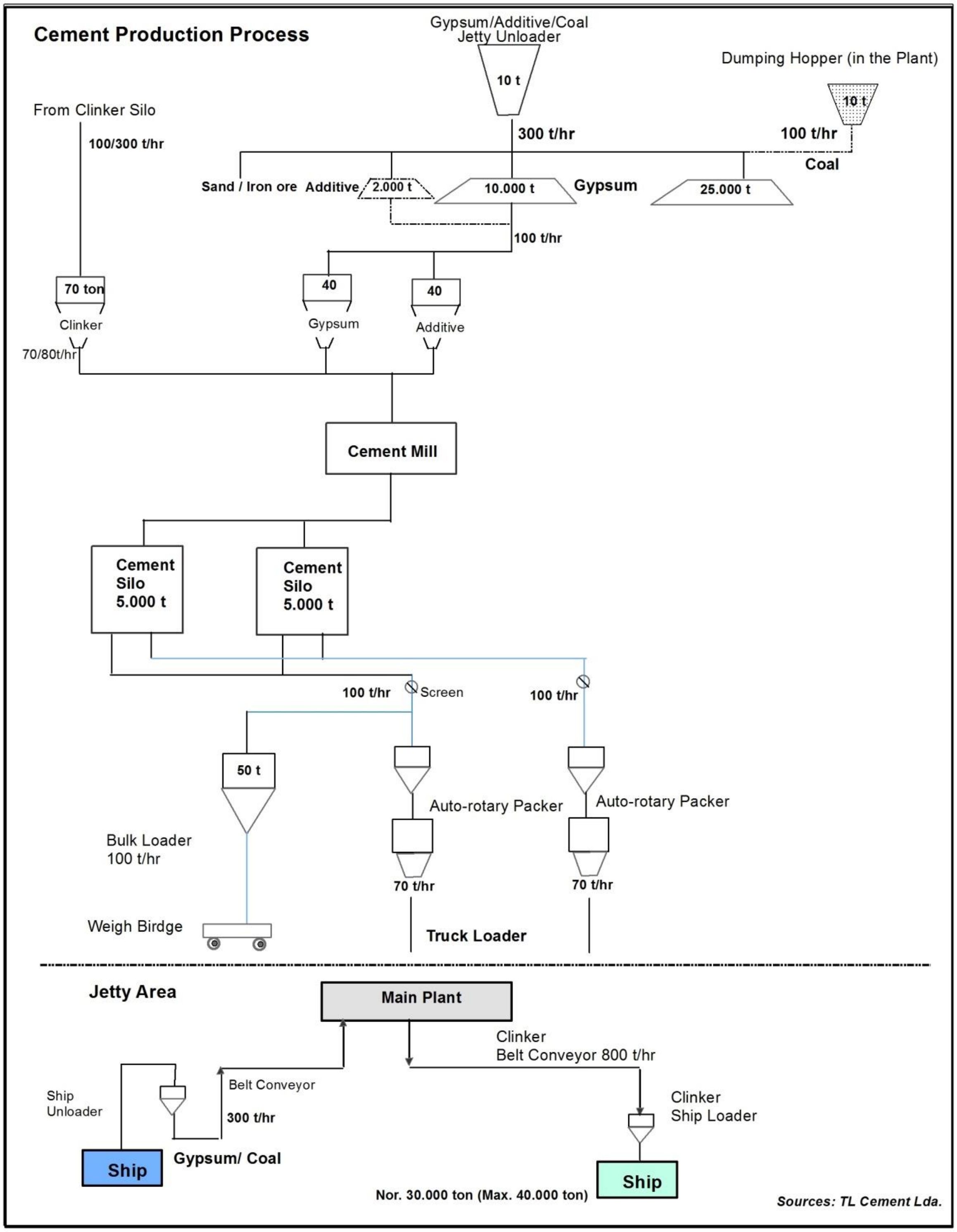

Figure 2.1 The conceptual view of cement process production (TL Cement, 2015)

2.2 Composition

Clinker is a synthetic product consisting in particular of impure tricalcium silicate $3CaO.SiO_2$ and dicalcic silicate ß (ß-$2CaO.SiO_2$) together with lower amounts of impure tricalcium aluminate

($3CaO.Al2O_3$) and a solid ferrite solution, FeO. The crystalline phases in clinker are similar to those occurring in the Portland cement area in the SiO_2-Al_2O_3-Ca phase diagram. Clinker is in granular form, with particles ranging in diameter from 3-20mm, having 20-30% of glass phase and a hard product, then due to it's iron content it is dark in color. When clinker is ground and water is added it hardens very fast and so plaster ($CaSO_4.2H_2O$) is added in a proportion of 3-5% which acts as a pre-retainer. In the end ground clinker plus gypsum or plaster is what is called commercial Portland cement.

The approximate composition of a clinker compound can be calculated by the nozzle formula which in case Al_2O_3/Fe_2O_3 is greater than or equal to 0.64 provides (Frohnsdorf, 1990, *apud* Velho *et al.*, 1998):

$\% \ 3CaO.SiO_2 = 4{,}071(\% \ CaO) – 7{,}600(\%SiO_2) – 5{,}718(Al_2O_3) – 1{,}430(\%Fe_2O_3) - 2852(\%SO_3)$

$\% \ 2CaO.SiO_2 = 2{,}876 \ (\%SiO_2) - O{,}7544(\%3CaO.SiO_2)$

$\%3CaO.Al_2O_3 = 2{,}650 \ (Al_2O_3) - 1{,}692$

$\%4CaO.Al_2O_3.Fe_2O_3 = 3{,}043(\%Fe_2O_3)$.

The clinker after spraying and contact with water, gives rise to hydrated compounds, constituted microcrystals that entangle each other, acquiring mechanical resistance and giving rise to a solid conglomerate. This phenomenon is called prey, the result of hydration that transforms a powdery product into a solid product through the following reaction (Dunn, 1990, *apud* Velho *et al.*, 1998):

$2(3CaO.SiO_2) + 9H_2O \rightarrow 2(CaO.SiO_2.2.5H_2O) + 4Ca(OH)2$

$3CaO.Al_2O_3 + 12H_2O \rightarrow Ca_3(Al_2O_3)2.12H_2O$.

The complexity of the system of simultaneous and consecutive reactions that takes place during the cement hydration phase is illustrated, ettringite, formed in the early phase of the hydration process and transformed into hydrated tetracalcium monosulfate aluminate after the plaster reacted so that the sulfate concentration in the aqueous phase decreases.

2.3 Material Percentages Values

The main products are CaO-SiO_2-H_2O and Ca $(OH)_2$. CaO/SiO_2 ratio generally ranges from 0,2-1,5. The hydrated calcium silicate structure is similar to that of a clay having a specific surface values of about $1.5x10^5$ m2 kg^{-1}. Besides the importance of temperature, the degree of hydraulicity or water hardening is very important factor, which depends on the relationship between the silicate component (deprived of combined water) and the limestone component (deprived of combined CaO). The index I= $(SiO_2+Al_2O_3+Fe_2O_3)/CaO$, hydraulic index, allows to classify both hydraulic lime and cement.

The numbers shown should only be interpreted as references above 40% of clay, the product obtained will acquire greater plasticity losing the ability to make prey with water. Currently, instead of the hydraulicity index, the hydraulic module, the inverse of the index, is used which is the relationship between lime (CaO) and the sum of silica, alumina and ferric oxide. The main raw material of cement is a source of lime (CaO), usually in the form of $CaCO_3$, which occurs in limestone, marbles and marl. Other sources of lime include oyster shells, in the most common form of aragonite, eolithic sands, silica and alumina rich raw slag required when the lime content of the primary raw material is too high. With the exception of white cement, iron is another of the cement raw materials.

Therefore, the raw materials used are mainly pure limestone and clay, mixed in certain proportions. Clay limestone is an excellent raw material as long as its clay content varies between 21-23% and contain fluxes, such as iron oxide, in such amounts as to allow the combination of lime and silica. In addition to the mentioned raw materials, a source of SO_3 is also important, which is mixed with clinker itself has SO_3, natural plaster or plaster-anhydrite mixture is preferred. Synthetic plaster may also be used as a by-product of power plants.

The applied raw materials usually contain impurities that must be controlled. Present in certain quantities, within certain limits, may be beneficial. The most common example is magnesium, which in small amounts, in the form of MgO acts as a base agent. Below 5% magnesium is considered innocuous, above this value it becomes harmful because certain compounds of magnesium, such as periclase, causing expansion and cement failure. In order to make 1 ton of Portland cement, including plaster, about 1300 kg of limestone, 330 kg of clay and 40 kg of plaster are required. It is important to note here that the cement manufacturing process is eminently chemical, only the manufacturer being interested in the chemical composition of the raw materials to be used. For the cement to have the desired characteristic it is necessary to be careful due to the high temperatures in the furnace, the limestone and clay mixture has a chemical composition within the guiding values in the following table.

Components	**Normal**	**Liz**	**Tejo**	**Secil**
SiO_2	19--25	22,62	19,98	21,11
Al_2O_3	5-9	5,07	7,22	5,64
CaO	60-64	66	64,76	65,88
MgO	1-4	2,2	1,61	1,34
Fe_2O_3	2-4	2,03	3,2	3,46
SO_3	1-2	1,73	1,06	1,43
Perda rubro/LOI	----	0,26	2,04	0,93

Table 2.1 Recommended compounding ranges for good Portland cement and composition of three Portuguese cements

2.4 Type of Cement

Portland cement is one of the most important and most common of cements produced. However, there are other types of cement such as grappiers cement (sourced from the most cooked parts of hydraulic lime kilns), aluminous cement, iron Portland cement (30% mixture of granulated blast furnace slag with 70% Portland cement), pozzolana cement and sand cement. There are several types of cement and their composition according to EN 197-1 and depend of uses.

Table 3.1.1: Types of cement and their composition according to EN 197-1

Main cement type	Designation	Cement type	Composition (parts by weight in %)[1]										
			Main components										Minor components
			Portland cement clinker	Slag	Silica dust	Pozzolans: Natural	Pozzolans: Artificial	Fly ashes: High silica	Fly ashes: High lime	Burnt shale	Limestone	Limestone	
			K	S	D[2]	P	Q	V	W	T	L[4]	LL[5]	
CEM I	Portland cement	CEM I	95–100	–	–	–	–	–	–	–	–	–	0–5
CEM II	Portland slag cement	CEM II/A-S	80–94	6–20	–	–	–	–	–	–	–	–	0–5
		CEM II/B-S	65–79	21–35	–	–	–	–	–	–	–	–	0–5
	Portland silica dust cement	CEM II/A-D	90–94	–	6–10	–	–	–	–	–	–	–	0–5
	Portland pozzolan cement	CEM II/A-P	80–94	–	–	6–20	–	–	–	–	–	–	0–5
		CEM II/B-P	65–79	–	–	21–35	–	–	–	–	–	–	0–5
		CEM II/A-Q	80–94	–	–	–	6–20	–	–	–	–	–	0–5
		CEM II/B-Q	65–79	–	–	–	21–35	–	–	–	–	–	0–5
	Portland fly ash cement	CEM II/A-V	80–94	–	–	–	–	6–20	–	–	–	–	0–5
		CEM II/B-V	65–79	–	–	–	–	21–35	–	–	–	–	0–5
		CEM II/A-W	80–94	–	–	–	–	–	6–20	–	–	–	0–5
		CEM II/B-W	65–79	–	–	–	–	–	21–35	–	–	–	0–5
	Portland shale cement	CEM II/A-T	80–94	–	–	–	–	–	–	6–20	–	–	0–5
		CEM II/B-T	65–79	–	–	–	–	–	–	21–35	–	–	0–5
	Portland limestone cement	CEM II/A-L	80–94	–	–	–	–	–	–	–	6–20	–	0–5
		CEM II/B-L	65–79	–	–	–	–	–	–	–	21–35	–	0–5
		CEM II/A-LL	80–94	–	–	–	–	–	–	–	–	6–20	0–5
		CEM II/B-LL	65–79	–	–	–	–	–	–	–	–	21–35	0–5
	Portland composite cement[3]	CEM II/A-M	80–94	6–20									0–5
		CEM II/B-M	65–79	21–35									0–5
CEM III	Blast furnace cement	CEM III/A	35–64	36–65	–	–	–	–	–	–	–	–	0–5
		CEM III/B	20–34	66–80	–	–	–	–	–	–	–	–	0–5
		CEM III/C	5–19	81–95	–	–	–	–	–	–	–	–	0–5
CEM IV	Pozzolan cement	CEM IV/A	65–89	–	11–35					–	–	–	0–5
		CEM IV/B	45–64	–	36–55					–	–	–	0–5
CEM V	Composite cement[3]	CEM V/A	40–64	18–30	–	18–30			–	–	–	–	0–5
		CEM V/B	20–39	31–50	–	31–50			–	–	–	–	0–5

Figure 2.2 The types of cement and their composition according to EN 197-1

Even though all cement Portland is basically the same, eight types of cement are manufactured to meet different physical and chemical requirements for specific applications that consist of:

- Type I is a general purpose Portland cement suitable for most uses,
- Type II is used for structures in water or soil containing moderates amounts of sulfate, or when it build up is a concern,
- Type III provides high strength at an early state, usually in a week or less,
- Type IV is a moderate's heat generated by hydration that is used for massive concrete structure such as dams,
- Type V is a cement resists chemical attack by soil and water high sulfate,
- Type IA, IIA and IIIA are cement used to make air-entrained concrete. They have the same properties as types I, II and III, except that they have small quantities of air-entrained materials combined with them.

White Portland cement is made from raw materials containing little or no iron even no manganese, the substances that give conventional cement its gray color.

Chapter 3
Geology of Study Area

3.1 Location and Accessibility

The study area is located in the Baucau Municipality, Timor-Leste. Baucau Municipality borders with Lautem Municipality in the east. With Manatutu Municipality in the east, with Viqueque Municipality in the south and with the strait of Wetar in the north, it is approximately 120 km east of Dili, capital of Democratic Republic of Timor Leste. The mineral licenses areas consist of Block I-1, Block I-2 and Block II.

The Baucau limestone deposit is accessible from Dili along the Dili – Baucau road through Hera-Manatuto-Laleia-Vemase. From Vemase, by following about 8 km on Dili Baucau road. The block I and II are easy to access by foot and even by car.

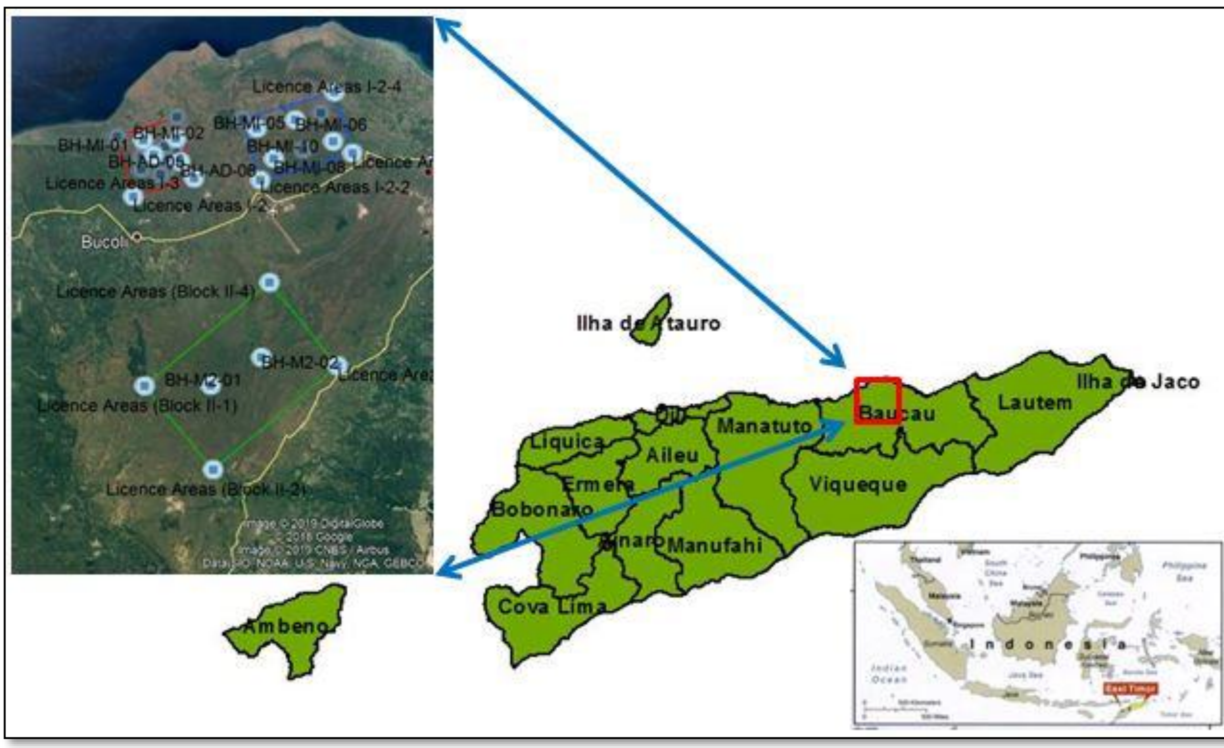

Figure 3. 1 The Location map of concession area at Baucau Municipality, Timor-Leste

3.2 Geology

3.2.1 Regional Geology

According to Audley-Charles (1968), the Baucau plateau is covered by the coral-reef limestone of the Baucau formation. This formation overlays by the Viqueque formation. The upper part of Viqueque formation is composed of marl and grey claystone. The age of the Baucau formation is Post-Pliocene and the Viqueque formation in upper Miocene. Both formations are overlying the Bobonaro scaly clay of Middle-Miocene age. The eastern and southern escarpment are covered by the Viqueque formation and the Bobonaro scaly-clay, along the south of the plateau, while the Baucau plateau and the northern marine terrace are occupied by coral-reef limestone of the Baucau formation.

Structurally, the Baucau limestone was deposited in a syncline of the Viqueque formation. The axis of the syncline is in northeast-southwest direction. The structure of the Viqueque formation was formed in the Mid-Miocene to Pliocene (Audley-Charles, 1968) which also affected the Bobonaro scaly-clay. This indicates that the Baucau limestone is deposited after the Viqueque formation and the Bobonaro scaly-clay was folded and faulted. Structural measurements (bedding, fold and fault) from west Timor to East Timor indicated the northwest-southwest direction shortening during the collision between the Australia continent and the Banda arc (Zobel, 2007). Harris (1991), reported that the maximum stress direction in the Timor is in the northwest-southwest direction. Therefore, it can be concluded that the folds of the Viqueque formation identified by Audley-Charles (1968) are in line with the direction of collision as proposed by Zobel (2007) and Harris (1991).

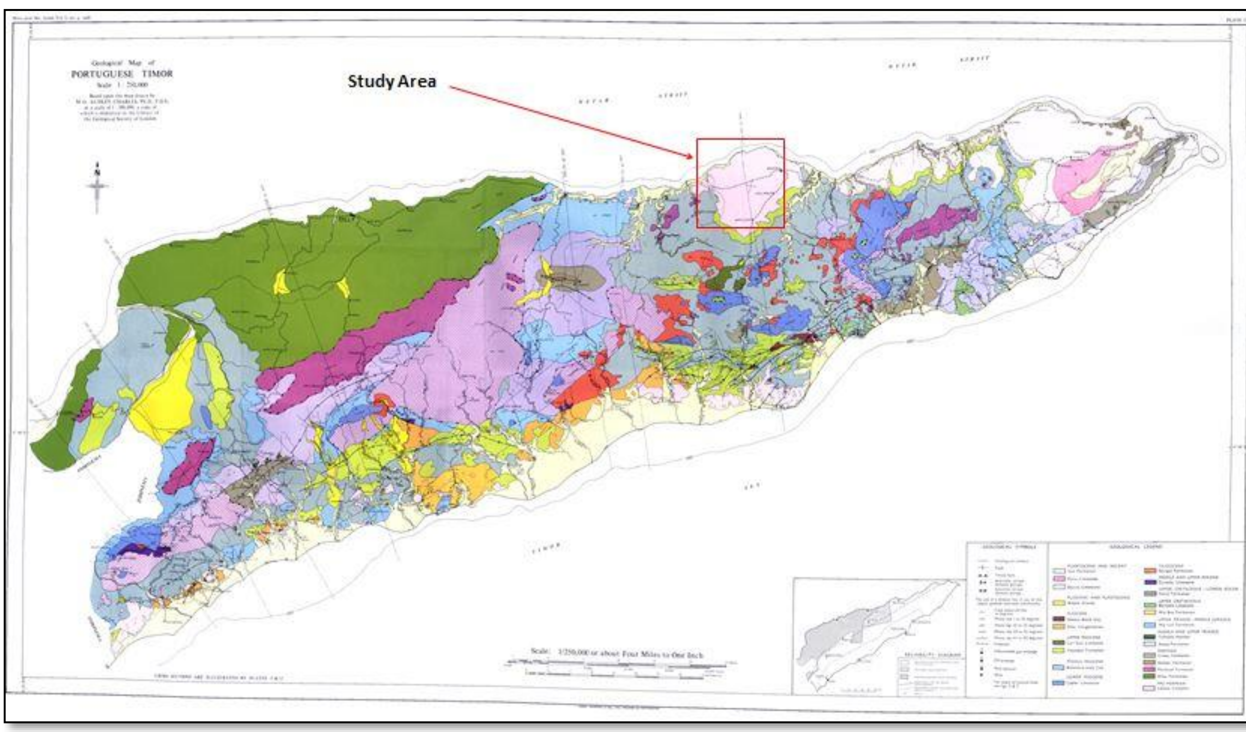

Figure 3. 2 Geological Map of Timor-Leste, Audley-Charles (1968)

3.2.2 Local Geology

The Baucau plateau is mostly covered by karst of the Baucau formation, while the eastern and western part are occupied by the Viqueque formation and the Bobonaro formation. The Suai formation is also present in the vicinity of the study area, however its distribution is only occupies in the northern part of the Baucau plateau. There are four (4) formations and deposit identified in the study area that consist of:

a. Baucau formation

The Baucau plateau is mostly covered by karst of the Baucau formation of Post Pliocene age. The coral reef limestone outcrops are identified by they are dominantly grey to dark color, though a few are brownish, reddish, yellow and sometimes pink in color. The limestone is cavernous, fossiliferous, hard and compact.

Figure 3.3 a. Coral Reef limestone, abandoned quarry, close to the road Waiono to Caisido, b. The real condition of the site.

b. Viqueque formation

The Viqueque formation is generally found in the southern part and both escarpments of the Baucau plateau. In the study area, this formation is mainly composed of marl and grey claystone which are upper Miocene to Pliocene in age. In the Venilale, especially in the area of Bercoli along the road to Viqueque Municipality, it is dominated by marl, chalky limestone and grey claystone.

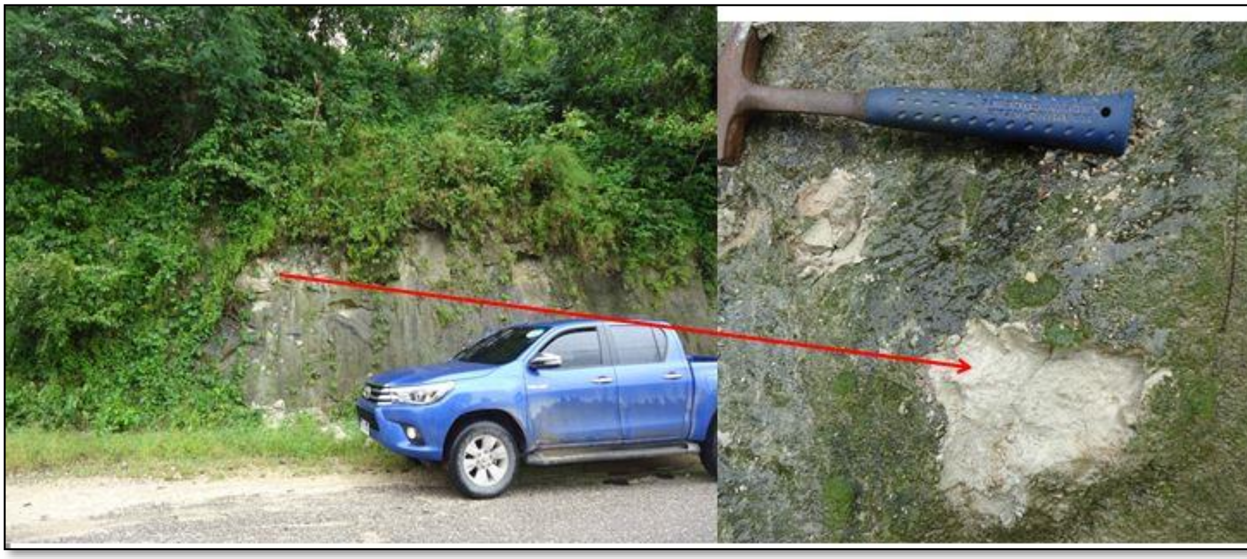

Figure 3.4 Viqueque Formation, Berekoli to Venilale main road

c. Bobonaro scaly clay

According to Audley-Charles (1968), the age of the Bobonaro scaly clay is Middle Eocene, and it resulted from the deposition of sub-marine grafity sliding product. Generally, the Bobonaro scaly clay shows reddish brown color, soft and loose, mainly composed of various type of rock fragments enclosed by a clay matrix.

Figure 3.5 Bobonaro scaly clay

d. Suai formation

The Suai formation (Loose sediment) is also occurs near the study area. However the distribution is only limited to the northern part of the Baucau plateau. This formation is formed by several materials that consist of gravels, quartz, chert, limestone, igneous rock, that are massive, and compact and it is Pleistocene to recent in age.

Figure 3.6 a. Suai Formation at Waiono beach north of the concenssion area, b. Some of outcrop that occur in the main road Vemase to Baucau.

3.2.3 Geology of Concession Area

Limestone is exposed on the surface with sporadic occurrences of soil in the area. The interpretation of local geology is based on the data generated during the exploration phase. The lithology units identified within the concession area are described below in their stratigraphic sequence from top to bottom:

Top Soil

Top soil is reddish brown in color and silty in nature. Its occurrence is only observed in relatively flat to gentle area. The thickness of top soil as encountered in boreholes varies from 0.50 cm to 1.0 m (Borehole MI-02).

Limestone

The limestone belongs to the Baucau formation and it is of greyish to brownish in color. The limestone is fossiliferous in nature, it has bio-clasts in the matrix, and it was deposited in a coral reef condition of marine environment. The thickness of limestone as encountered in boreholes varies from 3.7m to 91.5 m (Borehole ADD-08).

Conglomerate Limestone

Conglomeritic limestone is of pale white to brownish color having calcareous matrix. The thickness of conglomeritic limestone areas from 1.5 m to 14.5 m (borehole ADD-04).

Sandy Limestone

Sandy limestone is of pale greyish to brownish color having sandy appearance due to assemblage of sand pebbles within limestone. The thickness of sandy limestone varies from 4.0 m to 24.0 m (Borehole MI-01).

Clay

It is the lower most litho-unit present in the concession area. The clay is dark greyish to purple in color and fine grained in nature. The thickness of clay as encountered in the boreholes varies from 1.1 m to 41.8 m (ADD-06).

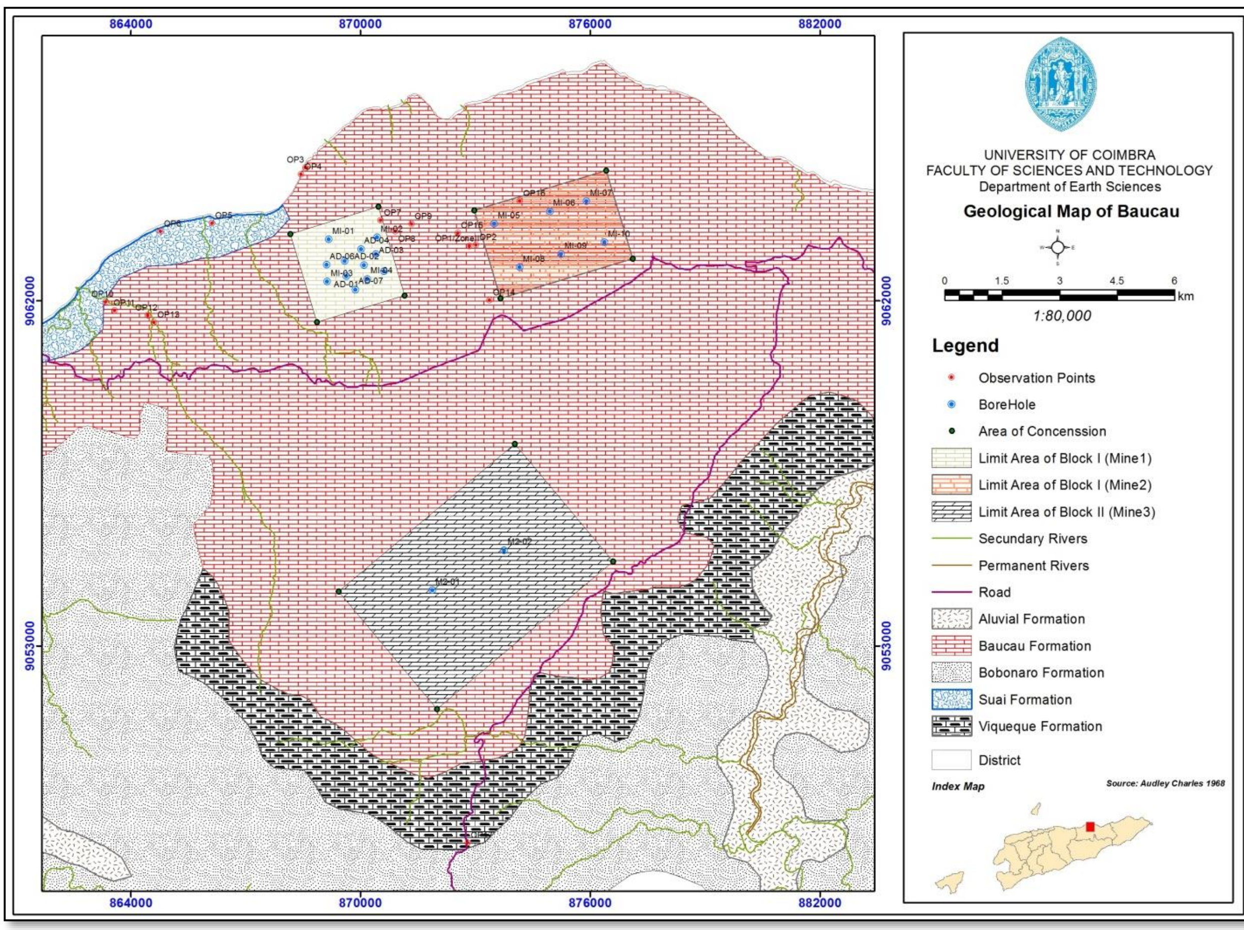

Figure 3.7 Geological map of study area and the sorounding area of Baucau Municipality.

3.3 Geomorphology

Physiographically, the area around Baucau limestone deposit forms an undulating terrain with a small hill and valley mainly consisting of limestone, marl and clay. The northwestern part of Block I-1 has an elevation of 25 m above mean sea level (AMSL) whereas the southeastern part has an elevation of about 390 m about mean sea level. In Block I-2 part has an elevation of within the 430 to 515 m about mean sea level. The Block II has maximum elevation of 680 meter about mean sea level and the minimum elevation is 500 m AMSL towards east of the concession area.

Regarding to Mentzner (1977), physiography of the Baucau Plateau can be classified into four (4) zones based on morphological characteristic and altitude, as follows:

1. **Zone I**

   Zone I is a coastal zone made up of alluvial material of the Post-Pliocene from Suai Formation. It is characterized by one or two sandy beach ridges, quite in contrast to the south coast.

2. **Zone II**

   Zone II is Marine Terraces zone, consisting of a series of up to twelve upheaved Pleistocene marine terraces which rise abruptly from the sea in a step-like fashion. These terraces of up 100 m high cliffs which at their base are often undetermined by wave-cut notches and which alternate with over 100 m wide abrasion platforms. These terraces tend to be correlated with successive shifts of the sea level due to the epeirogenetic uplift of Timor and to a lesser degree to the phases of glaciation in these latitudes.

3. **Zone III**

   Baucau Plateau, as an uplifted coral reef rising through a series of high terraced cliffs from sea level to 500 m and continues to rise gradually to over 700 m (Loilubu area) southwest of the plateau. Around the airport, the surface is rough and pitted caused by numerous solution cavities and residual low coral ridges because of weathering of underlying coral limestone. Baucau plateau forms a big triangle with it’s apex to the Venilale area, in the north part it abuts against marine terrace. In the west and east the area has an escarpment morphology.

4. **Zone IV**

   In the east and west part of Baucau Plateau, the Plateau flanked by two escarpments. Both escarpment drop from the top of the plateau down to the alluvial plain of the river Manoleden in the west and rive Seical in the east. The morphology of the escarpment is controlled by the underlying geological material. Where the coral limestone of the plateau is underlying by layers of Viqueque formation. The other coral limestone as rest upon Bobonaro scaly-clay is also reflected in the escarpment. The Viqueque formation reaches from 300 to 400 m down to the flood plain of the Seical river at around 50 to 100 m and less extensive in the western escarpment, where it covers a belt between 400 to 700 m near Loilubu Village.

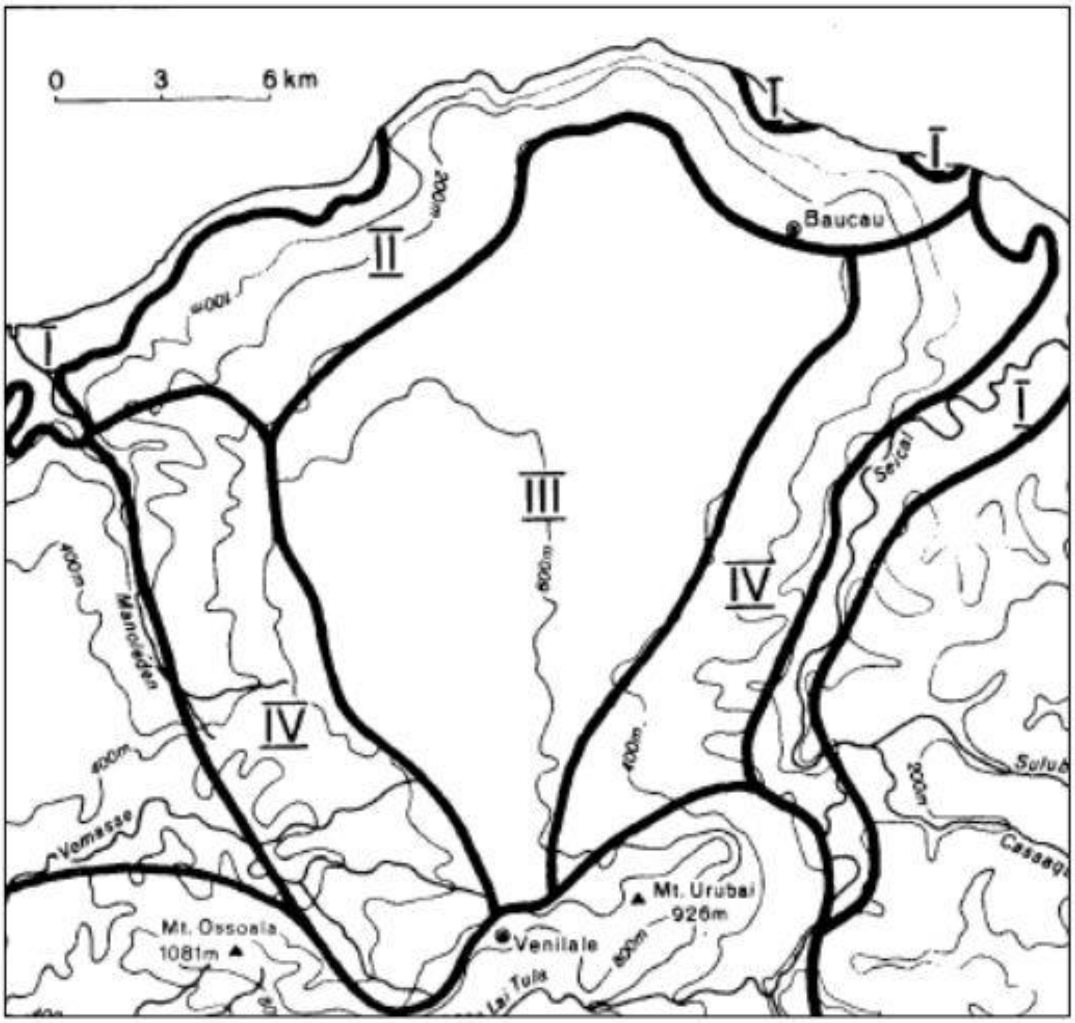

Figure 3.8 Geomorphology map of Baucau Plateau and Surrounding area (Mentzner,1977)

Chapter 4
Data and Boreholes

4.1 Block I-Mine1

There are 12 boreholes in this Block I-Mine1 (north of Bucoli), it is covering an area of 5.789.136 squars meters or 578,9 ha. The corner coordinates of this area are (1). 8^0 27' 20.20'' S: 126^0 20' 34.37'' E, (2). 8^0 28' 34.75'' S: 126^0 20' 57.58'' E , (3). 8^0 28' 11.67'' S: 126^0 22' 12.47'' E, (4). 8^0 26' 56.44'' S: 126^0 21' 49.29'' E. These corner coordinates are calculated with the datum WGS84 UTM Zone 52.

4.1.1 Lithologies of Boreholes

The lithologies of the boreholes are different and vary between one to another, such as:

a. Borehole AD-01

The limestone is alongs to Baucau formation and it is greyish to brownish in color. The limestone is fossiliferous in nature, have bio-clast in matrix, deposited in coral reef condition of marine environment. The thickness of limestone as encountered in this borehole varies from zero m to 42 m and then from 42 m to 46.5 m it is a clay.

Figure 4.1 The core of borehole additional 01.

b. Borehole AD-02

The limestone color is greyish to brownish in color, the thickness of lithologic units that are encountered in this borehole are: from zero meter to 20m is coral reef limestone, from 20m to 35m sandy limestone, from 35m to 51m limestone and from 51m to 55,5m it is clay.

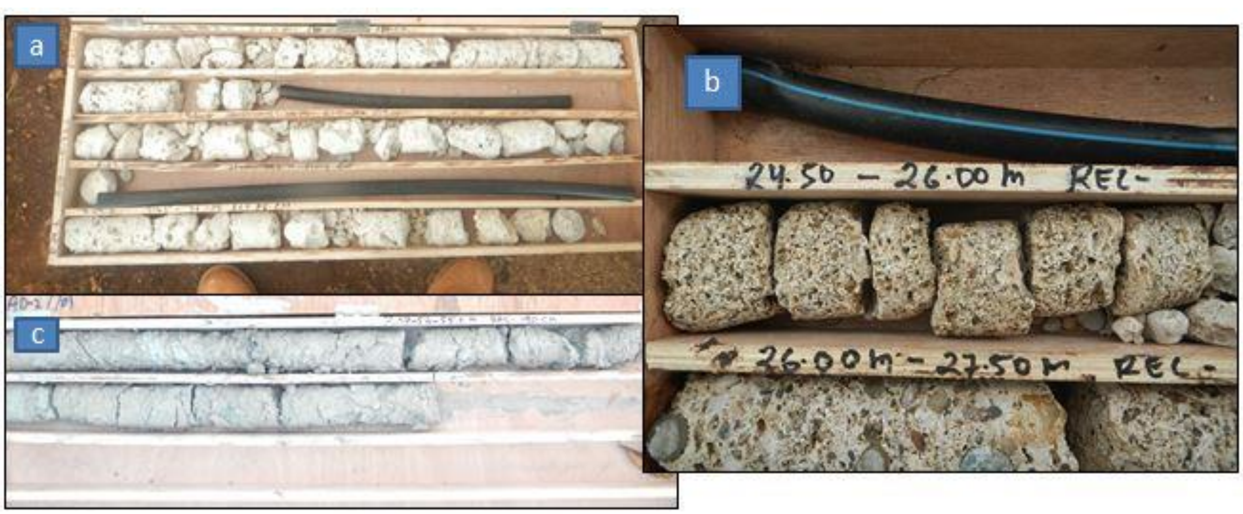

Figure 4.2 The core of borehole additional 02.

c. Borehole AD-03

The lithologic units that encountered in this borehole are: from zero to 6m is coral reef limestone, 6m to 31m slightly gravel and sandy limestone, 31 to 73m is coral reef limestone, 73 to 79m is sandy limestone and continue with clay till 82,5m.

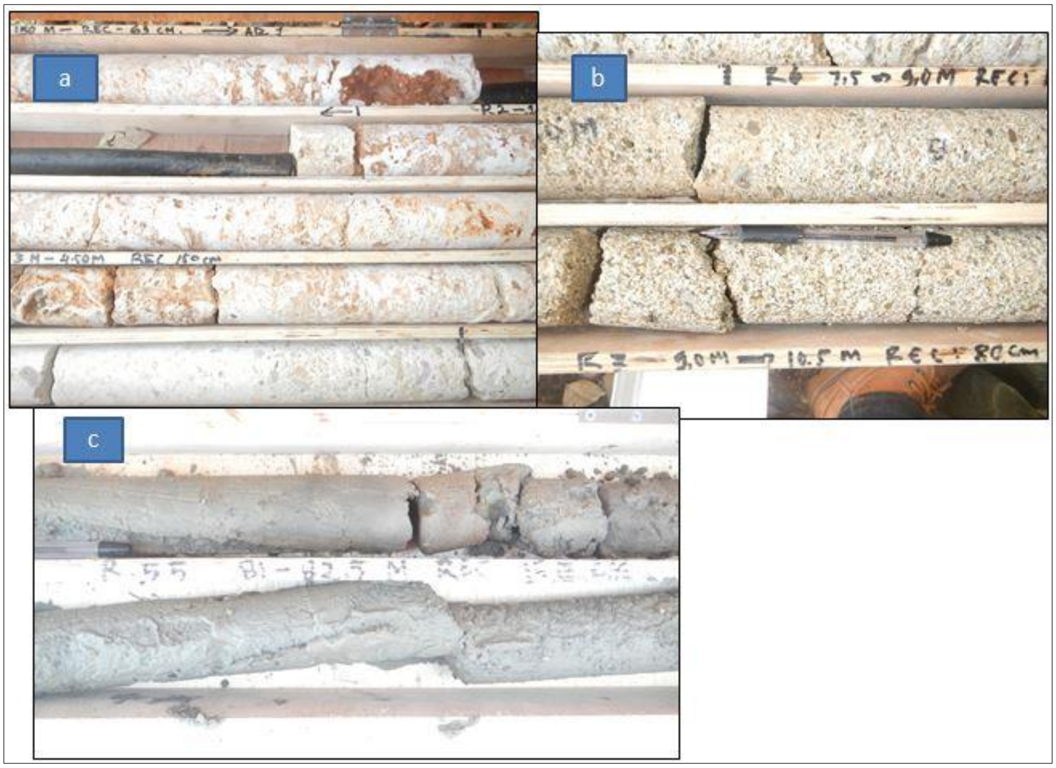

Figure 4.3 The core of borehole additonal 03.

d. Borehole AD-04

The lithologic units that are encountered in this borehole AD-04 are: from zero to 18m is coral reef limestone, 18 to 60m slightly gravel and sandy limestone, 60 to 70m is coral reef limestone, 70 to 81m is soft limestone of chalky and continue with clay till 87m.

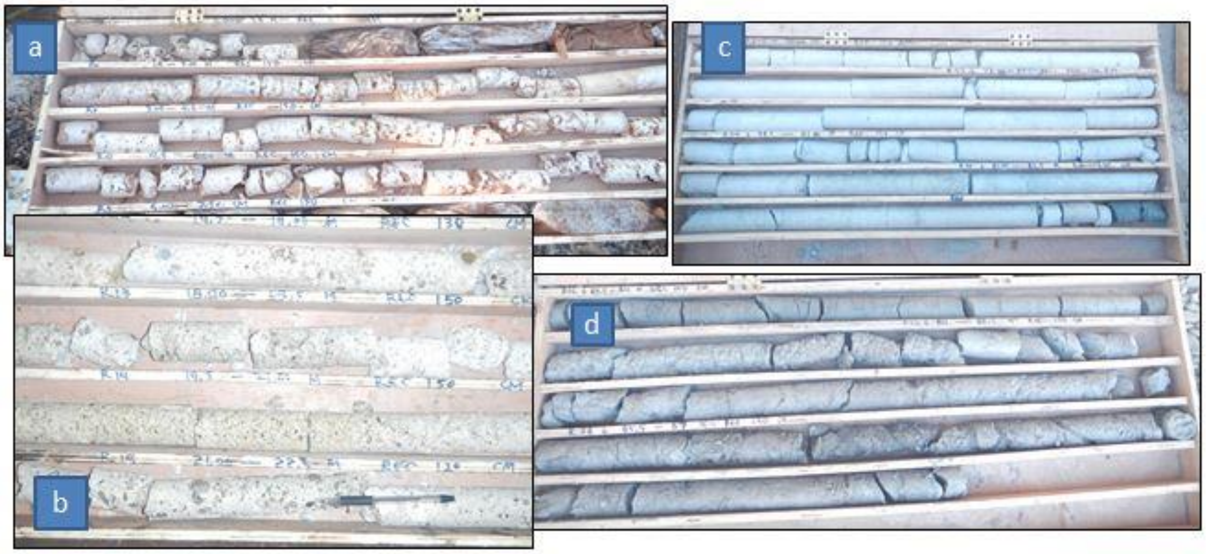

Figure 4.4 The core box of additional 04.

e. Borehole AD-05

The lithologic units that are encountered in this boreholes AD-05 are various from zero to 9m is coral reef limestone, 9 to 25m and sandy limestone and then continue with clay till 28.5m.

Figure 4.5 The core of additional 05

f. Borehole AD-06

The lithologic units that are encountered in this borehole AD-06 are: from zero to 7.5m is coral reef limestone, 7.5 to 49.5m is clay. The thickness of clay in this borehole is about 42m.

Figure 4.6 The core of additional 06

g. Borehole AD-07

The lithologic units that are encountered in this borehole AD-07 are coralreef limestone only, it starts from zero meter and goes down to 91.5m.

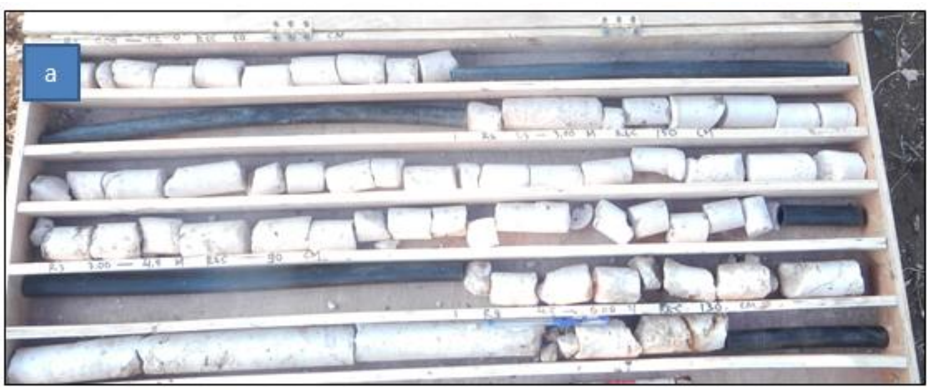

Figure 4.7 The core of additional 07

h. Borehole AD-08

The lithologic units that are encountered in this borehole AD-08 are: from zero to 84m is coral reef limestone, 84 to 96m is sandy limestone and then continue with clay till 100m.

Figure 4.8 The core of additional 08

i. Borehole MI-01

The lithologic units that are encountered in this borehole MI-01 are: from zero to 42.5m is coral reef limestone, 42.5 to 51m is sandy limestone and then continue with clay till 54m.

j. Borehole MI-02

The lithologic units that are encountered in this borehole MI-02 are: from zero to 26m is coral reef limestone, 26 to 69m is sandy limestone and then continues with coral reef limestone till 100m.

Figure 4.9 The core of MI-02

k. Borehole MI-03

The lithologic units that are encountered in this borehole MI-03 are: from zero to 64.5m is coral reef limestone and then continue with clay till 67.5m.

Figure 4.10 The core of MI-03

l. Borehole MI-04

The lithologic units that are encountered in this borehole MI-04 are: from zero to 63.5m is coral reef limestone, 63.5 to 67m is sandy limestone and then continue with clay till 70.5m.

Figure 4.11 The core of MI-04

4.1.2 Chemical Analysis

The core logging and core sampling was carried out by **HOLTEC**. The core samples were prepared generally for 1.5 m in length; however, the sample lengths varied depending upon the lithology of the area. Altogether 679 core samples were prepared from the core drilling carried out in the area. The core samples were analyzed for **LOI, SiO_2, AL_2O_3, CaO, MgO, Na_2O, K_2O, P_2O_5, SO_3, Cl, MnO and TiO_2 by SGS**, Australia utilizing X-Ray Fluorescence **(XRF)** method. Thus, the drilled area is dominated by CaO, with grades between **30 % and 54 %**. The detailed results for each borehole are given in the following tables.

- **BH AD-03**

This borehole is dominated by CaO, with values between 33.5 and 55% with an average of 50.4%, while the other averages are: Al_2O_3 0.78%; Cl 0.01%; Fe_2O_3 0.34%; K_2O 0.12%; MgO 0.82%; Mno 0.02%; Na_2O 0.13%; P_2O_5 0.06%; SO_3 0.02%; SiO_2 6.33% and TiO_2 0.04%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
AD-3/1	1.51	50.9	<0.005	0.64	0.09	0.42	0.02	0.02	0.06	0.05	5.61	0.08	40.8
AD-3/2	1.58	50.2	<0.005	0.66	0.1	0.39	0.02	0.03	0.08	0.08	6.52	0.09	40.3
AD-3/3	1.38	44.7	<0.005	0.56	0.12	0.47	0.03	0.43	0.04	0.02	16.3	0.07	35.9
AD-3/4	2.37	40.2	<0.005	1	0.36	0.61	0.06	0.41	0.07	0.03	23.1	0.13	31.8
AD-3/5	1.66	45	0.006	0.83	0.24	0.45	0.04	0.33	0.08	0.01	15.7	0.1	35.5
AD-3/6	2.8	36.9	<0.005	1.46	0.41	0.56	0.07	0.6	0.08	0.01	27.3	0.18	29.3
AD-3/7	2.52	39	<0.005	1.32	0.36	0.53	0.07	0.55	0.07	<0.01	24.2	0.16	30.9
AD-3/8	1.61	37.5	<0.005	0.79	0.2	0.31	0.04	0.46	0.06	<0.01	28.4	0.09	30.2
AD-3/9	1.14	33.5	<0.005	0.41	0.12	0.24	0.03	0.37	0.05	<0.01	37.4	0.06	26.5
AD-3/10	0.73	49.5	<0.005	0.27	0.11	0.29	0.02	0.19	0.06	<0.01	8.91	0.04	39.1
AD-3/11	0.57	52.4	0.008	0.19	0.11	0.36	0.01	0.12	0.06	<0.01	4.55	0.03	41.4
AD-3/12	0.5	52.3	0.008	0.18	0.11	0.35	0.01	0.12	0.05	0.01	4.14	0.02	41.8
AD-3/13	0.36	53.4	0.007	0.12	0.06	0.36	0.01	0.08	0.05	0.02	2.61	0.02	42.6
AD-3/14	0.31	54.4	<0.005	0.11	0.04	0.38	0.01	0.05	0.06	<0.01	2.05	0.03	42.3
AD-3/15	0.29	54	0.008	0.14	0.06	0.37	<0.01	0.05	0.05	0.02	2.03	0.02	42.7
AD-3/16	0.59	52.4	0.007	0.27	0.08	0.41	0.01	0.13	0.07	0.01	4.02	0.02	41.7
AD-3/17	0.74	51.8	0.007	0.25	0.09	0.33	0.02	0.2	0.06	<0.01	4.9	0.04	41.2
AD-3/18	0.32	54	0.007	0.11	0.07	0.3	0.01	0.07	0.05	<0.01	1.73	0.03	43
AD-3/19	0.27	54.2	0.009	0.1	0.05	0.3	<0.01	0.05	0.06	<0.01	1.78	0.02	43
AD-3/20	0.46	53.2	0.007	0.24	0.07	0.32	0.01	0.09	0.06	<0.01	2.84	0.03	42.3
AD-3/21	0.43	53.7	0.007	0.15	0.09	0.28	0.01	0.07	0.06	<0.01	2.31	0.03	42.6
AD-3/22	0.14	55.1	<0.005	0.07	0.04	0.25	<0.01	0.02	0.04	<0.01	0.62	0.02	43.6
AD-3/23	0.11	55.1	<0.005	0.06	0.02	0.23	<0.01	0.02	0.04	<0.01	0.36	0.01	43.7
AD-3/24	0.23	54.4	0.006	0.11	0.05	0.28	0.02	0.04	0.06	<0.01	0.98	0.02	43.3
AD-3/25	0.4	53.9	0.008	0.15	0.07	0.34	0.02	0.07	0.06	0.01	1.67	0.02	42.9
AD-3/26	0.48	53.2	0.01	0.2	0.12	0.51	0.02	0.08	0.07	0.01	2.12	0.04	42.6
AD-3/27	0.37	53.3	<0.005	0.18	0.08	0.82	0.01	0.06	0.07	<0.01	1.57	0.03	42.9
AD-3/28	0.44	52.7	<0.005	0.16	0.1	0.95	0.01	0.08	0.07	<0.01	1.93	0.03	42.8
AD-3/29	0.69	52	<0.005	0.26	0.14	1.01	0.02	0.08	0.08	<0.01	2.86	0.04	42.2
AD-3/30	0.6	52.3	<0.005	0.24	0.12	0.99	0.02	0.09	0.07	<0.01	2.57	0.03	42.4
AD-3/31	0.67	51.9	<0.005	0.24	0.12	1.38	0.01	0.06	0.08	<0.01	2.49	0.03	42.5
AD-3/32	0.67	50.5	0.007	0.25	0.19	1.51	0.02	0.11	0.07	<0.01	4.18	0.03	41.8
AD-3/33	0.3	52.6	0.007	0.14	0.06	1.27	0.01	0.04	0.05	<0.01	1.82	0.02	43.1
AD-3/34	0.74	51	0.005	0.31	0.13	1.67	0.02	0.06	0.07	<0.01	2.98	0.05	42.3

AD-3/35	0.76	51	0.008	0.29	0.15	1.57	0.01	0.07	0.05	<0.01	3.29	0.04	42.1
AD-3/36	0.49	52.6	0.006	0.2	0.09	1.45	<0.01	0.04	0.06	<0.01	1.59	0.02	43.1
AD-3/37	0.48	52.7	0.007	0.19	0.09	1.32	<0.01	0.05	0.06	0.01	1.8	0.03	43
AD-3/38	0.66	52.1	0.009	0.26	0.13	1.33	0.03	0.06	0.07	<0.01	3.11	0.04	42.2
AD-3/39	0.42	52.9	0.006	0.17	0.08	1.31	0.01	0.05	0.06	<0.01	2.19	0.02	42.8
AD-3/40	0.56	52.1	<0.005	0.22	0.11	1.41	0.02	0.06	0.07	0.01	2.49	0.03	42.6
AD-3/41	0.68	51	0.005	0.27	0.14	1.49	0.02	0.08	0.07	0.01	3.94	0.04	41.9
AD-3/42	0.7	51.2	0.006	0.29	0.12	1.84	0.01	0.06	0.07	0.01	2.67	0.04	42.5
AD-3/43	0.65	51	0.01	0.3	0.11	2.37	0.02	0.04	0.08	0.02	2	0.03	43
AD-3/44	0.95	49.8	0.009	0.43	0.16	2.93	0.02	0.05	0.1	0.03	3.04	0.05	42.4
AD-3/45	1.91	36	0.005	0.91	0.27	0.96	0.07	0.37	0.12	0.01	28.7	0.11	30.2
AD-3/46	2.16	28.4	0.008	0.99	0.3	0.67	0.07	0.46	0.08	<0.01	43.4	0.13	23
AD-3/47	1.44	36.4	0.01	0.69	0.22	0.61	0.07	0.32	0.07	<0.01	30.5	0.1	29.3
AD-3/48	0.87	42	0.008	0.45	0.16	0.61	0.06	0.14	0.07	<0.01	22	0.07	33.4
AD-3/49	1.45	47.7	0.009	0.74	0.16	0.54	0.04	0.12	0.07	<0.01	10.2	0.09	38.5
AD-3/50	2.91	38.9	0.013	1.39	0.34	0.73	0.05	0.2	0.12	<0.01	23.5	0.2	31.5
AD-3/51	1.74	40.7	<0.005	0.96	0.27	0.54	0.1	0.08	0.14	<0.01	21.9	0.13	33.5
AD-3/52	1.13	49.4	<0.005	0.64	0.16	0.46	0.06	0.03	0.09	<0.01	9.03	0.08	39.2
AD-3/53	16.6	3.88	<0.005	7.01	2.79	2.64	0.06	0.32	0.16	0.36	57.3	0.75	8.13
AD-3/54	16.4	5.04	<0.005	6.3	2.67	2.28	0.11	0.35	0.15	0.34	56.9	0.76	8.77
Averages	***0.78***	***50.40***	***0.01***	***0.34***	***0.12***	***0.82***	***0.02***	***0.13***	***0.06***	***0.02***	***6.33***	***0.05***	***40.60***

Table 4.1 The laboratory analysis results for borehole additional 03 (adapted from SGS, 2014)

- **BH AD-04**

This borehole is dominated by CaO, with values from 35 to 55.3% with an average of 43.3%, while the other averages are Al_2O_3 1.9%, Cl 0.01%, Fe_2O_3 0.91%, K_2O 0.18%, MgO 0.43%, MnO 0.07%, Na_2O 0.28%, P_2O_5 0.06%, SO_3 0.03%, SiO_2 17.9% and TiO_2 0.12%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
AD-4/1	1.02	51.5	0.005	0.45	0.05	0.28	0.04	0.03	0.04	0.04	5.48	0.06	41.1
AD-4/2	10.4	3.61	<0.005	4.86	0.1	0.23	0.1	0.12	0.07	0.04	72.1	0.62	7.84
AD-4/3	0.69	53.2	<0.005	0.34	0.03	0.2	0.05	0.01	0.03	0.04	2.94	0.04	42.3
AD-4/4	0.54	53.5	<0.005	0.24	0.04	0.28	0.01	0.01	0.04	0.03	2.77	0.04	42.5
AD-4/5	0.38	54.5	<0.005	0.15	0.03	0.25	0.01	<0.01	0.04	<0.01	1.6	0.02	43.1
AD-4/6	10.3	7.59	<0.005	4.86	0.11	0.26	0.11	0.13	0.07	0.03	64.7	0.61	11.1
AD-4/7	0.26	54.7	<0.005	0.1	0.03	0.31	<0.01	<0.01	0.03	<0.01	0.85	0.01	43.5
AD-4/8	0.21	55.3	<0.005	0.04	0.02	0.22	<0.01	<0.01	0.02	0.01	0.37	0.01	43.7
AD-4/9	0.65	48.7	<0.005	0.28	0.07	0.28	0.02	0.09	0.04	<0.01	11.1	0.04	38.6
AD-4/10	2.29	29.3	<0.005	1.08	0.17	0.43	0.09	0.53	0.06	<0.01	42.5	0.14	23.2
AD-4/11	2.56	30.1	<0.005	1.26	0.23	0.55	0.09	0.61	0.07	<0.01	40.2	0.14	24

AD-4/12	2.07	35.7	<0.005	1.16	0.25	0.47	0.08	0.44	0.09	<0.01	31.2	0.13	28.2
AD-4/13	1.69	40.3	<0.005	0.83	0.21	0.39	0.05	0.38	0.07	<0.01	24.2	0.11	31.8
AD-4/14	1.48	42.4	<0.005	0.67	0.18	0.35	0.04	0.38	0.06	<0.01	20.2	0.09	33.8
AD-4/15	1.81	41	<0.005	0.81	0.21	0.41	0.05	0.47	0.06	<0.01	22.3	0.11	32.4
AD-4/16	2.06	38.2	<0.005	0.99	0.26	0.44	0.06	0.47	0.06	<0.01	27	0.13	30.3
AD-4/17	2.13	36.5	<0.005	1	0.24	0.45	0.05	0.57	0.07	<0.01	30.1	0.14	28.7
AD-4/18	2.04	39.9	<0.005	0.98	0.24	0.47	0.06	0.51	0.08	<0.01	24.1	0.14	31.4
AD-4/19	1.35	46	<0.005	0.61	0.17	0.41	0.04	0.3	0.06	<0.01	14.7	0.1	36.3
AD-4/20	1.47	44.7	<0.005	0.73	0.17	0.43	0.05	0.36	0.07	<0.01	16.5	0.12	35.3
AD-4/21	1.86	39.6	<0.005	0.89	0.2	0.45	0.04	0.56	0.07	<0.01	24.6	0.14	31.4
AD-4/22	1.49	43.5	<0.005	0.79	0.17	0.43	0.05	0.37	0.07	<0.01	18.5	0.11	34.4
AD-4/23	1.56	44.7	<0.005	0.72	0.19	0.45	0.05	0.4	0.06	<0.01	15.9	0.11	35.5
AD-4/24	1.38	43.9	<0.005	0.65	0.16	0.44	0.04	0.36	0.06	<0.01	18	0.11	34.7
AD-4/25	1.48	45.3	<0.005	0.7	0.17	0.46	0.05	0.37	0.06	<0.01	15	0.11	36
AD-4/26	1.41	44.8	<0.005	0.7	0.19	0.42	0.05	0.33	0.06	<0.01	15.9	0.12	35.7
AD-4/27	1.83	40.7	<0.005	0.97	0.26	0.51	0.08	0.38	0.17	<0.01	22.4	0.16	32.2
AD-4/28	1.83	36	<0.005	0.85	0.23	0.47	0.05	0.45	0.06	<0.01	31.3	0.12	28.4
AD-4/29	2.24	39.9	<0.005	1.11	0.35	0.62	0.07	0.42	0.08	<0.01	23.1	0.15	31.7
AD-4/30	1.55	41.7	<0.005	0.8	0.21	0.54	0.05	0.29	0.06	<0.01	21.1	0.1	33.3
AD-4/31	2.57	36.4	<0.005	1.27	0.4	0.61	0.08	0.48	0.09	<0.01	28.7	0.17	29
AD-4/32	0.47	51.7	<0.005	0.26	0.07	0.43	0.02	0.08	0.05	<0.01	6.09	0.03	40.9
AD-4/33	0.84	50.6	<0.005	0.4	0.14	0.5	0.03	0.16	0.05	<0.01	6.92	0.05	40.2
AD-4/34	1.41	45	<0.005	0.65	0.24	0.54	0.03	0.25	0.07	0.01	15.5	0.08	36
AD-4/35	1.03	52.1	<0.005	0.44	0.18	0.38	0.02	0.07	0.06	0.02	3.87	0.06	41.6
AD-4/36	0.27	54.5	<0.005	0.11	0.05	0.25	<0.01	0.04	0.05	<0.01	1.05	0.03	43.4
AD-4/37	1.21	51.4	<0.005	0.51	0.19	0.43	0.02	0.04	0.08	0.01	4.68	0.07	41.2
AD-4/38	0.94	52.2	<0.005	0.36	0.15	0.35	0.02	0.05	0.05	0.01	4.52	0.05	41.6
AD-4/39	0.57	53.3	<0.005	0.23	0.05	0.36	0.02	0.06	0.03	0.03	3	0.04	42.4
AD-4/40	2.71	47.9	<0.005	1.21	0.32	0.67	0.16	0.09	0.09	0.03	7.87	0.12	38.7
AD-4/41	3.04	46.4	<0.005	1.35	0.37	0.77	0.19	0.13	0.09	0.04	9.34	0.14	37.7
AD-4/42	2.59	47.9	<0.005	1.19	0.32	0.69	0.23	0.13	0.07	0.06	8.31	0.12	38.5
AD-4/43	2.87	46.7	<0.005	1.32	0.34	0.71	0.26	0.18	0.08	0.1	9.17	0.13	37.8
AD-4/44	4.23	42.9	<0.005	1.72	0.46	1.01	0.25	0.29	0.08	0.07	13.5	0.19	35.1
AD-4/45	3.97	43.8	<0.005	1.68	0.51	0.94	0.28	0.26	0.1	0.09	12.6	0.18	35.6
AD-4/46	7.16	33.3	<0.005	3.32	0.97	1.91	0.24	0.42	0.12	0.13	23.6	0.32	28.1
AD-4/47	10.4	23.1	<0.005	4.71	1.41	2.69	0.22	0.59	0.14	0.13	34.4	0.44	21.5
AD-4/48	16.9	1.83	<0.005	8.21	2.42	4.21	0.13	0.96	0.15	0.09	56.3	0.71	7.87
AD-4/49	18.8	1.37	<0.005	6.78	3.18	2.07	0.23	0.54	0.12	2.22	57.1	0.72	6.86
AD-4/50	19.2	1.58	<0.005	7.01	3.23	2.05	0.27	0.52	0.12	2.01	56.1	0.75	7.03
AD-4/51	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-4/52	-	-	-	-	-	-	-	-	-	-	-	-	-

AD-4/53	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-4/54	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-4/55	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-4/56	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-4/57	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***1.92***	***43.32***	***0.01***	***0.91***	***0.18***	***0.43***	***0.07***	***0.28***	***0.06***	***0.03***	***17.90***	***0.12***	***34.68***

Table 4.2 The laboratory analysis results for borehole additional 04 (adapted from SGS, 2014)

- **BH AD-06**

This borehole is dominated by CaO, with values from 47.7 to 51.7% and an average of 42.6%, while the other averages are: Al_2O_3 2.6%, Cl 0.01%, Fe_2O_3 1.39%, K_2O 0.23%, MgO 0.61%, MnO 0.09%, Na_2O 0.16%, P_2O_5 0.05%, SO_3 0.03%, SiO_2 16.83% and TiO_2 0.21%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
AD-6/1	10.7	4.44	0.005	5.28	0.6	0.64	0.2	0.27	0.08	0.06	66.6	0.82	10
AD-6/2	1	50.6	<0.005	0.58	0.12	0.57	0.03	0.08	0.03	0.03	6.65	0.07	40.3
AD-6/3	0.89	51.7	<0.005	0.49	0.13	0.44	0.02	0.06	0.03	0.02	5.14	0.06	41.1
AD-6/4	1.43	47.9	<0.005	0.85	0.2	0.45	0.04	0.17	0.03	0.03	10.4	0.18	38.2
AD-6/5	1.49	46.7	<0.005	0.78	0.27	0.6	0.07	0.22	0.07	0.04	11.9	0.12	37.5
AD-6/6	0.88	49.6	<0.005	0.5	0.12	0.46	0.02	0.12	0.05	0.01	8.99	0.1	39.3
AD-6/7	1.83	47.7	<0.005	1.24	0.2	1.14	0.25	0.2	0.04	0.02	8.15	0.12	38.7
AD-6/8	16	3.93	<0.005	6.34	2.81	2.27	0.15	0.55	0.09	0.04	58.9	0.73	7.97
AD-6/9	17	2.84	<0.005	6.63	2.9	2.09	0.17	0.39	0.11	0.07	59.5	0.78	7.54
AD-6/10	19.2	1.49	<0.005	7.26	3.27	1.81	0.16	0.34	0.12	0.81	57.7	0.76	7.02
AD-6/11	17.6	4.25	0.007	6.25	3.02	2.02	0.2	0.51	0.12	1.05	56.6	0.7	8.37
AD-6/12	16.9	2.75	<0.005	7	2.75	2.61	0.33	0.57	0.11	0.39	58.5	0.78	7.54
AD-6/13	16.5	4.9	0.006	7.62	3.02	4.08	0.29	0.92	0.21	0.88	52.4	1.17	8.45
AD-6/14	16.5	4.5	0.014	6.47	3.1	2.15	0.28	0.79	0.15	0.71	56.6	0.69	8.2
AD-6/15	16.1	6.38	0.017	6	2.97	1.91	0.7	0.78	0.15	0.86	54.5	0.67	9.23
AD-6/16	17.5	2.91	0.026	6.31	3.2	2.06	0.16	0.91	0.12	0.7	59.1	0.74	6.83
AD-6/17	16.1	5.48	0.023	5.89	3.06	1.92	0.19	0.96	0.11	0.57	57	0.69	8.34
AD-6/18	17.6	2.84	0.023	6.28	3.17	2.01	0.14	0.99	0.16	0.58	59	0.71	6.66
AD-6/19	7.67	1.14	<0.005	2.84	1.19	1.24	0.05	0.55	0.12	0.2	81.3	0.46	3.29
AD-6/20	16.5	2.3	0.025	6.28	2.77	1.87	0.24	0.68	0.12	1.48	60.8	0.69	6.68
Averages	***2.60***	***42.66***	***0.01***	***1.39***	***0.23***	***0.61***	***0.09***	***0.16***	***0.05***	***0.03***	***16.83***	***0.21***	***35.01***

Table 4.3 The laboratory analysis results for borehole additional 06 (adapted from SGS, 2014)

- **BH AD-07**

This borehole is dominated by CaO, with values varying from 50 to 54.7% and an average of 53.1%, while the other averages are: Al_2O_3 0.56%, Cl 0.005%, Fe_2O_3 0.22%, K_2O 0.09%, MgO 1.14%, MnO 0.01%, Na_2O 0.031%, P_2O_5 0.08%, SO_3 0.04%, SiO_2 1.44% and TiO_2 0.03%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
AD-7/1	0.49	53.8	0.005	0.19	0.05	0.46	<0.01	0.02	0.04	0.06	1.8	0.03	43
AD-7/2	0.94	52.2	<0.005	0.37	0.11	0.39	<0.01	0.03	0.04	0.08	3.6	0.06	42
AD-7/3	0.86	52.3	<0.005	0.33	0.12	0.45	<0.01	0.03	0.03	0.05	3.44	0.05	42.1
AD-7/4	0.87	52.4	<0.005	0.32	0.11	0.55	<0.01	0.02	0.03	0.04	3.38	0.05	42
AD-7/5	0.68	53.4	<0.005	0.25	0.09	0.74	<0.01	0.02	0.04	0.02	1.6	0.03	42.9
AD-7/6	0.69	53.5	<0.005	0.38	0.08	0.55	<0.01	0.02	0.04	0.02	1.44	0.03	43
AD-7/7	0.31	54.7	<0.005	0.1	0.05	0.39	<0.01	0.02	0.07	0.01	0.61	0.02	43.5
AD-7/8	0.68	54.1	<0.005	0.27	0.1	0.38	0.01	0.03	0.07	<0.01	1.29	0.04	43
AD-7/9	0.64	54.4	<0.005	0.24	0.1	0.33	0.01	0.03	0.06	<0.01	1.2	0.04	43
AD-7/10	0.56	54.4	<0.005	0.21	0.08	0.47	0.01	0.02	0.05	<0.01	1.09	0.03	43.2
AD-7/11	0.6	54.2	<0.005	0.24	0.09	0.53	0.01	0.02	0.06	<0.01	1.11	0.03	43.2
AD-7/12	0.76	53.4	<0.005	0.29	0.13	0.7	0.01	0.02	0.1	<0.01	1.37	0.04	42.9
AD-7/13	0.91	53.4	<0.005	0.34	0.14	0.74	0.01	0.03	0.13	<0.01	1.64	0.05	42.7
AD-7/14	0.69	53.6	<0.005	0.26	0.11	0.84	0.02	0.03	0.12	<0.01	1.25	0.04	43
AD-7/15	0.84	53.3	<0.005	0.32	0.13	0.88	0.02	0.04	0.15	<0.01	1.47	0.04	42.8
AD-7/16	0.93	53.1	<0.005	0.37	0.15	0.91	0.02	0.04	0.15	<0.01	1.64	0.05	42.7
AD-7/17	0.6	53.4	<0.005	0.24	0.1	0.93	0.01	0.03	0.14	<0.01	1.05	0.03	43.1
AD-7/18	0.52	53.3	<0.005	0.2	0.08	0.1	0.01	0.02	0.14	0.01	0.91	0.03	43.3
AD-7/19	0.56	53.3	<0.005	0.23	0.09	1.33	0.01	0.03	0.12	0.01	1.17	0.03	43.2
AD-7/20	0.44	53.4	<0.005	0.17	0.07	1.51	0.01	0.03	0.12	0.02	0.78	0.03	43.5
AD-7/21	0.41	52.9	<0.005	0.16	0.06	1.83	<0.01	0.05	0.12	0.02	0.83	0.03	43.7
AD-7/22	0.34	52.1	<0.005	0.12	0.05	2.7	<0.01	0.05	0.1	0.02	0.61	0.02	43.9
AD-7/23	0.22	52.9	<0.005	0.08	0.04	2.19	<0.01	0.05	0.1	0.03	0.37	0.01	44
AD-7/24	0.34	51.7	<0.005	0.13	0.06	3.17	<0.01	0.03	0.1	0.06	0.59	0.02	43.9
AD-7/25	0.2	51.1	<0.005	0.07	0.04	3.5	<0.01	0.09	0.09	0.04	0.35	0.02	44.2
AD-7/26	0.29	51.7	<0.005	0.13	0.06	3.01	<0.01	0.02	0.11	0.19	0.57	0.02	44
AD-7/27	0.4	50.7	<0.005	0.15	0.08	3.85	<0.01	0.02	0.08	0.03	0.74	0.03	44
AD-7/28	0.3	52.4	<0.005	0.11	0.05	2.46	<0.01	0.04	0.08	0.03	0.57	0.02	43.9
AD-7/29	0.43	53.2	<0.005	0.18	0.07	1.54	<0.01	0.02	0.09	0.02	1.03	0.03	43.4
AD-7/30	0.19	54.5	<0.005	0.08	0.03	0.54	<0.01	0.01	0.08	0.02	0.7	0.01	43.6
AD-7/31	0.15	55.2	<0.005	0.05	0.02	0.41	<0.01	0.02	0.06	<0.01	0.44	0.02	43.7
AD-7/32	0.16	54.7	<0.005	0.06	0.04	0.34	<0.01	<0.01	0.07	<0.01	1.11	0.02	43.4
AD-7/33	0.78	52.4	<0.005	0.32	0.12	0.51	<0.01	0.02	0.05	<0.01	3.46	0.04	42
AD-7/34	1	52.4	<0.005	0.4	0.15	0.62	0.01	0.05	0.06	0.01	3.66	0.06	41.8

AD-7/35	0.68	53.5	<0.005	0.29	0.11	0.61	0.02	0.04	0.08	<0.01	2.22	0.04	42.6
AD-7/36	0.86	52.8	<0.005	0.41	0.14	0.66	0.02	0.03	0.08	0.01	2.92	0.05	42.1
Averages	***0.56***	***53.16***	***0.005***	***0.22***	***0.09***	***1.14***	***0.01***	***0.031***	***0.08***	***0.04***	***1.44***	***0.03***	***43.12***

Table 4.4 The laboratory analysis results for borehole additional 07 (adapted from SGS, 2014)

- **BH AD-08**

This borehole is dominated by CaO, with values varying from 46.2 to 54.6% with an average of 52.9%, while the averages of Al_2O_3 0.62%, Cl 0.006%, Fe_2O_3 0.29%, K_2O 0.08%, MgO 0.96%, MnO 0.03%, Na_2O 0.03%, P_2O_5 0.08%, SO_3 0.03%, SiO_2 2.16% and TiO_2 0.04%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
AD-8/1	0.87	53.5	<0.005	0.33	0.07	0.36	0.02	0.04	0.06	0.02	1.91	0.05	42.8
AD-8/2	0.94	53.2	<0.005	0.39	0.08	0.31	0.02	0.01	0.04	0.03	2.05	0.05	42.7
AD-8/3	2	50.6	<0.005	0.86	0.1	0.31	0.02	0.05	0.07	0.09	4.47	0.12	41.5
AD-8/4	1.79	51.4	<0.005	0.67	0.12	0.32	0.07	0.05	0.06	0.05	4.12	0.1	41.4
AD-8/5	0.42	54.8	<0.005	0.14	0.06	0.23	<0.01	0.04	0.05	0.01	0.85	0.02	43.4
AD-8/6	0.56	54.3	<0.005	0.19	0.09	0.25	<0.01	0.01	0.06	0.01	1.05	0.03	43.2
AD-8/7	0.57	54.6	<0.005	0.22	0.09	0.32	0.01	0.03	0.06	<0.01	1.08	0.03	43.1
AD-8/8	0.72	53.9	<0.005	0.27	0.11	0.35	0.02	0.03	0.06	<0.01	1.34	0.04	43
AD-8/9	1.16	52.5	<0.005	0.49	0.08	0.25	0.01	0.02	0.05	0.03	2.76	0.07	42.3
AD-8/10	0.63	54.2	<0.005	0.24	0.1	0.37	0.01	0.02	0.08	<0.01	1.36	0.04	43
AD-8/11	1.44	52.1	<0.005	0.6	0.11	0.36	0.02	0.03	0.07	0.01	2.94	0.07	42.1
AD-8/12	0.84	53.8	<0.005	0.29	0.14	0.36	<0.01	0.02	0.08	<0.01	1.59	0.04	42.8
AD-8/13	1.59	51.7	<0.005	0.68	0.12	0.38	0.02	0.04	0.08	0.02	3.33	0.09	41.8
AD-8/14	0.67	54.1	<0.005	0.26	0.1	0.41	<0.01	0.02	0.07	<0.01	1.16	0.03	43.1
AD-8/15	0.58	54.1	<0.005	0.24	0.09	0.45	<0.01	<0.01	0.08	0.01	1	0.03	43.2
AD-8/16	0.5	54.3	<0.005	0.19	0.08	0.54	0.01	0.02	0.1	<0.01	0.85	0.03	43.3
AD-8/17	0.76	53.8	<0.005	0.29	0.12	0.54	0.01	0.01	0.12	<0.01	1.31	0.04	42.9
AD-8/18	0.62	54.1	<0.005	0.24	0.09	0.62	<0.01	0.01	0.12	<0.01	1.05	0.03	43.1
AD-8/19	0.48	54.2	<0.005	0.2	0.07	0.65	<0.01	0.01	0.1	<0.01	0.83	0.03	43.3
AD-8/20	0.76	53.7	<0.005	0.31	0.11	0.62	<0.01	0.01	0.08	<0.01	1.33	0.04	42.9
AD-8/21	0.74	54	<0.005	0.29	0.13	0.49	<0.01	0.01	0.09	<0.01	1.28	0.04	43
AD-8/22	0.48	54.5	<0.005	0.2	0.07	0.58	<0.01	0.01	0.11	0.02	0.82	0.03	43.4
AD-8/23	0.42	54.3	<0.005	0.16	0.06	0.64	<0.01	0.02	0.08	<0.01	0.69	0.02	43.3
AD-8/24	0.29	54.5	<0.005	0.12	0.05	0.63	<0.01	0.02	0.06	<0.01	0.5	0.01	43.6
AD-8/25	0.32	54.4	<0.005	0.13	0.05	0.61	<0.01	<0.01	0.05	0.01	0.62	0.02	43.6
AD-8/26	0.32	54.5	<0.005	0.12	0.04	0.72	<0.01	0.01	0.06	0.01	0.54	0.02	43.6
AD-8/27	0.33	54.3	<0.005	0.15	0.05	0.79	<0.01	0.02	0.06	0.01	0.56	0.02	43.6
AD-8/28	0.23	54.5	<0.005	0.09	0.03	0.72	<0.01	0.02	0.08	0.03	0.36	0.01	43.7
AD-8/29	0.19	54.4	<0.005	0.09	0.03	1.12	<0.01	0.03	0.1	0.1	0.3	0.01	43.9
AD-8/30	0.16	53.5	<0.005	0.07	0.02	1.68	<0.01	0.06	0.1	0.05	0.26	0.01	44

AD-8/31	0.14	54	0.006	0.07	0.02	1.33	<0.01	0.04	0.1	0.02	0.22	0.01	43.9
AD-8/32	0.18	54.1	<0.005	0.08	0.03	1.1	<0.01	0.02	0.1	0.02	0.31	0.01	43.8
AD-8/33	0.23	54.4	<0.005	0.1	0.03	0.91	<0.01	0.02	0.1	0.03	0.39	0.02	43.7
AD-8/34	0.17	53.6	<0.005	0.08	0.02	1.6	<0.01	0.02	0.09	0.01	0.29	0.01	43.9
AD-8/35	0.16	54.1	<0.005	0.07	0.02	1.03	<0.01	0.03	0.09	0.01	0.26	<0.01	43.9
AD-8/36	0.14	54.7	<0.005	0.07	0.02	0.74	<0.01	0.02	0.11	0.02	0.25	0.01	43.8
AD-8/37	0.13	54.6	<0.005	0.07	0.02	0.92	<0.01	0.02	0.09	0.05	0.24	0.01	43.8
AD-8/38	0.14	53	<0.005	0.15	0.02	2.22	<0.01	0.03	0.09	0.04	0.39	0.01	44
AD-8/39	0.15	52.5	<0.005	0.06	0.02	3.03	<0.01	0.03	0.1	0.02	0.26	0.02	44.2
AD-8/40	0.35	52.5	<0.005	0.13	0.04	2.04	<0.01	0.01	0.07	0.02	0.69	0.02	43.6
AD-8/41	0.18	54.1	<0.005	0.09	0.02	1.08	<0.01	0.02	0.06	0.02	0.43	<0.01	43.8
AD-8/42	0.03	54.2	<0.005	0.02	<0.01	1.17	<0.01	0.01	0.07	0.02	0.07	<0.01	44.1
AD-8/43	0.05	54.5	<0.005	0.03	<0.01	1.15	<0.01	0.02	0.08	0.02	0.12	0.02	44
AD-8/44	0.2	53.4	<0.005	0.11	0.02	1.29	<0.01	0.01	0.05	0.02	1.2	0.04	43.4
AD-8/45	0.36	52.4	<0.005	0.22	0.04	1.09	0.01	0.02	0.08	0.03	3.37	0.09	42.3
AD-8/46	0.98	49.3	<0.005	0.55	0.12	1.21	0.04	0.05	0.06	0.03	7.36	0.07	40
AD-8/47	0.67	50.8	<0.005	0.36	0.09	1.24	0.04	0.03	0.07	0.02	5.02	0.07	41.3
AD-8/48	0.77	49.7	<0.005	0.42	0.11	1.2	0.04	0.04	0.07	0.02	6.75	0.06	40.4
AD-8/49	0.61	51.7	<0.005	0.31	0.09	1.32	0.03	0.04	0.08	0.13	3.72	0.05	42
AD-8/50	0.61	50.9	<0.005	0.89	0.08	1.41	0.03	0.03	0.07	0.03	3.16	0.05	42.5
AD-8/51	0.52	51.8	<0.005	0.26	0.08	1.62	0.02	0.03	0.07	0.04	2.89	0.04	42.5
AD-8/52	0.57	50.3	<0.005	0.3	0.07	1.73	0.02	0.03	0.08	0.04	4.89	0.05	41.6
AD-8/53	0.78	50	<0.005	0.39	0.09	1.85	0.03	0.05	0.09	0.03	4.78	0.08	41.4
AD-8/54	0.87	49.7	<0.005	0.43	0.12	1.82	0.04	0.06	0.1	0.04	5.3	0.07	41.1
AD-8/55	0.73	50.4	<0.005	0.4	0.15	2.18	0.03	0.04	0.08	0.03	4.02	0.06	41.9
AD-8/56	0.64	51.9	<0.005	0.33	0.11	1.63	0.02	0.03	0.09	0.03	2.74	0.05	42.5
AD-8/57	2.12	46.2	<0.005	1.02	0.1	1.15	0.05	0.11	0.08	0.01	11.9	0.18	36.7
AD-8/58	1.35	49.8	<0.005	0.6	0.3	0.77	0.02	0.06	0.12	0.02	6.68	0.11	40
AD-8/59	1.48	49.3	<0.005	0.73	0.19	0.8	0.04	0.06	0.12	0.01	7.36	0.1	39.7
AD-8/60	16.4	3.41	<0.005	6.09	0.22	2.06	0.26	0.26	0.1	0.02	59.9	0.75	8.09
AD-8/61	17	1.7	<0.005	6.97	2.4	2.31	0.06	0.15	0.08	0.07	61.7	0.89	6.54
AD-8/62	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-8/63	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-8/64	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-8/65	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-8/66	-	-	-	-	-	-	-	-	-	-	-	-	-
AD-8/67	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***0.62***	***52.88***	***0.006***	***0.29***	***0.08***	***0.96***	***0.026***	***0.03***	***0.08***	***0.029***	***2.16***	***0.044***	***42.7***

Table 4.5 The laboratory analysis results for borehole additional 08 (adapted from SGS, 2014)

- **BH MI-01**

This borehole is dominated by CaO, with values varying from 43.6 to 53.8% with an average of 50.8%, while the averages of Al_2O_3 1.45%, Cl 0.01%, Fe_2O_3 0.55%, K_2O 0.23%, MgO 0.60%, MnO 0.02%, Na_2O 0.07%, P_2O_5 0.08%, SO_3 0.03%, SiO_2 5.1% and TiO_2 0.1%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
MI-01/1	0.57	53.4	0.005	0.22	0.05	0.35	0.02	0.07	0.03	0.03	2.98	0.04	42.4
MI-01/2	0.61	53.3	<0.005	0.29	0.06	0.5	<0.01	0.03	0.03	0.03	2.73	0.04	42.5
MI-01/3	0.52	53.8	<0.005	0.2	0.06	0.39	0.01	0.07	0.05	<0.01	2.43	0.04	42.7
MI-01/4	0.69	52.2	<0.005	0.25	0.08	0.42	0.02	0.13	0.06	<0.01	4.28	0.04	41.6
MI-01/5	1.2	50.9	<0.005	0.55	0.2	0.46	0.03	0.09	0.08	0.02	5.23	0.07	40.8
MI-01/6	1.13	51.8	<0.005	0.48	0.19	0.48	0.02	0.15	0.09	<0.01	4.14	0.06	41.5
MI-01/7	1.39	51	<0.005	0.47	0.23	0.83	0.01	0.05	0.12	<0.01	4.18	0.07	41.3
MI-01/8	2.17	49	<0.005	0.78	0.36	0.89	0.02	0.05	0.11	<0.01	6.59	0.1	39.8
MI-01/9	3.82	44.4	<0.005	1.41	0.63	0.83	0.03	0.07	0.1	<0.01	11.9	0.16	36.3
MI-01/10	2.75	47.4	<0.005	1.03	0.45	0.79	0.02	0.06	0.1	<0.01	8.43	0.13	38.5
MI-01/11	1.11	52.1	<0.005	0.41	0.18	0.71	0.01	0.04	0.08	<0.01	3.07	0.05	42
MI-01/12	9	21.4	<0.005	7.76	0.55	2.74	0.23	3.05	0.27	0.01	38	1.74	15
MI-01/13	3.12	42.2	<0.005	2.02	0.25	1.38	0.08	0.83	0.1	0.02	15.6	0.29	33.9
MI-01/14	3.27	41.4	<0.005	2.17	0.22	1.38	0.06	0.86	0.1	0.02	16.9	0.29	33.1
MI-01/15	3.47	39.8	<0.005	2.06	0.29	1.31	0.06	0.97	0.1	0.01	19.3	0.28	32
MI-01/16	2.32	43.6	<0.005	1.18	0.22	1.1	0.05	0.59	0.08	0.01	15.7	0.17	34.8
MI-01/17	4.65	32.5	<0.005	2.66	0.3	1.58	0.14	1.4	0.11	0.01	29.6	0.32	26.4
Averages	***1.45***	***50.8***	***0.01***	***0.55***	***0.23***	***0.60***	***0.02***	***0.07***	***0.08***	***0.03***	***5.09***	***0.07***	***40.9***

Table 4.6 The laboratory analysis results for borehole MI-01 (adapted from SGS, 2014)

- **BH MI-03**

This borehole is dominated by CaO, with values varying from 44 to 54.6% with an average of 52.6% , while the other averages of Al_2O_3 is 0.5%, Cl 0.41%, Fe_2O_3 0.25%, K_2O 0.1%, MgO 1.1%, MnO 0.02%, Na_2O 0.05%, P_2O_5 0.07%, SO_3 0.04%, SiO_2 2.7% and TiO_2 0.0%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
MI-03/1	1.75	44	0.41	0.91	0.22	0.48	0.05	0.44	0.05	0.08	15.4	0.15	35.8
MI-03/2	0.44	53.3	<0.005	0.21	0.06	0.48	0.01	0.08	0.04	0.06	3.16	0.03	42.3
MI-03/3	0.22	54.4	<0.005	0.12	0.04	0.4	<0.01	0.01	0.03	<0.01	1.25	0.02	43.3
MI-03/4	0.41	53.9	<0.005	0.21	0.06	0.42	<0.01	<0.01	0.03	<0.01	1.87	0.04	42.9
MI-03/5	0.37	54.4	<0.005	0.16	0.05	0.53	<0.01	0.03	0.05	0.03	1.3	0.03	43.2
MI-03/6	0.38	54.6	<0.005	0.16	0.06	0.49	<0.01	0.02	0.06	0.04	1	0.03	43.4
MI-03/7	0.45	54.4	<0.005	0.19	0.07	0.53	0.01	0.02	0.07	0.05	0.99	0.03	43.3

MI-03/8	0.46	54.4	<0.005	0.18	0.07	0.62	0.01	0.02	0.09	0.04	0.86	0.03	43.4
MI-03/9	0.43	54.3	<0.005	0.2	0.07	0.65	0.01	0.01	0.08	<0.01	0.87	0.03	43.4
MI-03/10	0.36	54.2	<0.005	0.19	0.06	0.68	<0.01	<0.01	0.06	<0.01	0.72	0.03	43.5
MI-03/11	0.32	54.1	<0.005	0.16	0.06	0.63	<0.01	<0.01	0.07	<0.01	0.77	0.02	43.5
MI-03/12	0.42	54.2	<0.005	0.2	0.08	0.48	<0.01	0.01	0.06	<0.01	1.38	0.03	43.2
MI-03/13	0.67	53.7	<0.005	0.25	0.1	0.56	0.01	0.03	0.08	0.03	1.95	0.04	42.8
MI-03/14	1.08	49.9	<0.005	0.52	0.23	0.64	0.03	0.12	0.09	0.03	7.69	0.07	39.8
MI-03/15	0.96	47.1	<0.005	0.41	0.21	2.56	0.02	0.12	0.08	0.04	8.83	0.06	39.7
MI-03/16	1.02	46.6	<0.005	0.47	0.23	4	0.02	0.13	0.08	0.05	6.79	0.08	40.8
MI-03/17	0.69	47.7	<0.005	0.27	0.15	3.99	0.02	0.11	0.07	0.04	4.67	0.05	42
MI-03/18	0.24	48.2	<0.005	0.11	0.05	5.68	<0.01	0.02	0.05	0.04	1.14	0.02	44.3
MI-03/19	0.34	51.4	<0.005	0.13	0.07	3.19	<0.01	0.03	0.08	0.09	1.18	0.02	43.7
MI-03/20	0.33	52.8	<0.005	0.11	0.06	2.26	<0.01	0.02	0.07	0.08	0.77	0.02	43.7
MI-03/21	0.36	53.9	<0.005	0.17	0.07	0.89	<0.01	0.02	0.06	0.02	0.94	0.02	43.4
MI-03/22	0.39	54.3	<0.005	0.14	0.07	0.82	<0.01	0.01	0.08	0.07	0.87	0.02	43.4
MI-03/23	0.38	54	<0.005	0.16	0.07	0.81	<0.01	0.02	0.07	0.02	0.9	0.03	43.4
MI-03/24	0.57	54	<0.005	0.26	0.1	0.68	<0.01	0.03	0.09	0.02	1.43	0.04	43
MI-03/25	0.67	53.4	<0.005	0.29	0.12	0.75	<0.01	0.02	0.09	0.02	1.68	0.04	42.8
MI-03/26	0.77	53.1	<0.005	0.34	0.13	0.78	0.01	<0.01	0.1	0.02	1.91	0.05	42.7
MI-03/27	0.56	53.5	<0.005	0.27	0.11	0.71	0.02	0.01	0.07	0.01	1.47	0.04	43
MI-03/28	0.62	53.1	<0.005	0.29	0.12	0.77	0.01	0.02	0.08	0.01	1.81	0.04	42.8
MI-03/29	0.67	53.3	<0.005	0.31	0.12	0.64	0.01	0.03	0.06	0.01	1.8	0.04	42.8
MI-03/30	0.34	52.4	<0.005	0.14	0.06	2.42	<0.01	0.02	0.08	0.02	0.7	0.02	43.9
MI-03/31	0.31	54.4	<0.005	0.12	0.06	0.58	0.01	0.03	0.07	<0.01	1.41	0.02	43.2
MI-03/32	0.56	52.2	<0.005	0.27	0.1	0.64	0.02	0.06	0.08	<0.01	4.58	0.04	41.7
MI-03/33	0.63	51.7	<0.005	0.27	0.1	0.51	0.02	0.04	0.08	0.05	5.67	0.05	41.1
MI-03/34	0.56	51.9	<0.005	0.26	0.1	0.44	0.02	0.03	0.06	<0.01	5.38	0.04	41.2
MI-03/35	0.36	54	<0.005	0.17	0.06	0.4	0.02	0.05	0.06	0.02	2.29	0.03	42.8
MI-03/36	0.41	53.4	<0.005	0.21	0.07	0.42	0.02	0.04	0.06	0.02	2.95	0.04	42.4
MI-03/37	0.7	52.9	<0.005	0.33	0.12	0.52	0.02	0.04	0.09	0.01	3.53	0.06	41.9
MI-03/38	0.43	53.7	<0.005	0.24	0.08	0.44	0.02	0.02	0.05	0.01	2.2	0.04	42.7
MI-03/39	0.56	53.9	<0.005	0.26	0.09	0.45	0.02	0.01	0.07	<0.01	2.05	0.04	42.7
MI-03/40	15.9	8.57	0.005	5.91	2.8	2.13	0.22	0.22	0.13	0.28	51.6	0.78	11
MI-03/41	17	5.49	0.008	6.1	3.1	2.25	0.16	0.29	0.13	0.38	55.4	0.71	9
Averages	***52.6***	***52.6***	***0.41***	***0.25***	***0.1***	***1.1***	***0.02***	***0.05***	***0.07***	***0.04***	***2.72***	***0.04***	***42.5***

Table 4.7 The laboratory analysis results for borehole MI-03 (adapted from SGS, 2014)

4.2 Block I-Mine2

In this block, there are 6 boreholes and it is covers an area of 8.634.380 squars metersor 863,4 ha. The coordinates of the corner points of this area are: (1). 8^0 26' 58.87'' S: 126^0 23' 10.89'' E; (2). 8^0 28' 13.36'' S: 126^0 23' 34.07'' E; (3). 8^0 27' 38.81'' S: 126^0 25' 26.44'' E; (4). 8^0 26' 24.22''

S: 126^0 25' 03.22'' E. These corner coordinates are calculated with the datum WGS84 UTM Zone 52.

4.2.1 Lithologic of Boreholes

The lithologies of each borehole are different with various units as follows:

1. Borehole MI-05

The lithologic units encountered in this borehole MI-05 are: from zero to 67.5m coral reef limestone, from 67.5 to 85m sandstone and then it continues with clay till 88.5m.

2. Borehole MI-06

The lithologic units encountered in this borehole MI-06 are: from zero to 40.5m coral reef limestone and then it continues with clay till 43.5m.

3. Borehole MI-07

The lithologic units encountered in this borehole MI-07 are: from zero to 48m coral reef limestone and then it continues with clay till 57m.

4. Borehole MI-08

The lithologic units encountered in this borehole MI-08 are: from zero to 34.5m coral reef limestone and then it continues with clay till 40.5m.

Figure 4.12 The core of borehole MI-08

5. Borehole MI-09

The lithologic units encountered in this borehole MI-04 are: from zero to 63.5 m coral reef limestone, from 63.5 to 67m is sandy limestone and then it continues with clay till 70.5 m.

Figure 4.13 The core of MI-09

6. Borehole MI-10

The lithologic units encountered in this borehole MI-04 are: from zero to 63.5m coral reef limestone, from 63.5 to 67m sandy limestone and then it continues with clay till 70.5m.

Figure 4.14 The core of borehole MI-10

4.2.2 Chemical Analysis

The core logging and core sampling was carried out by **HOLTEC**. The core sample were prepared generally for 1.5 m length, however the sample length varied depending upon the lithology of the area. The core samples were analyzed for **SiO_2, AL_2O_3, CaO, MgO, Na_2O, K_2O,**

P_2O_5, SO_3, Cl, MnO and TiO_2 by SGS, Australia utilizing X-Ray Fluorescence **(XRF)** method. Thus, the drilled area is dominated by CaO, with average values varying from **30 % to 54 %**. The detailed results for each borehole are as follows:

- **Borehole MI-05**

This borehole is dominated by CaO, varying from 53.9 to 55.8% with an average of 55.1% , while the other averages are: Al_2O_3 0.2%, Cl 0.01%, Fe_2O_3 0.08%, K_2O 0.04%, MgO 0.34%, MnO 0.01%, Na_2O 0.03%, P_2O_5 0.06%, SO_3 0.01%, SiO_2 0.4% and TiO_2 0.02%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
MI-05/1	0.29	55.1	0.005	0.1	0.02	0.2	<0.01	0.03	0.05	0.01	0.43	0.02	43.7
MI-05/2	0.33	54.9	<0.005	0.12	0.03	0.21	<0.01	0.03	0.05	<0.01	0.55	0.02	43.5
MI-05/3	0.59	54.6	<0.005	0.23	0.09	0.24	<0.01	<0.01	0.06	<0.01	1.07	0.03	43.1
MI-05/4	0.35	55	<0.005	0.13	0.06	0.24	<0.01	0.04	0.06	0.02	0.72	0.01	43.4
MI-05/5	0.17	55.5	<0.005	0.06	0.03	0.23	<0.01	0.03	0.07	<0.01	0.31	<0.01	43.7
MI-05/6	0.34	55.1	<0.005	0.13	0.06	0.23	<0.01	0.03	0.07	<0.01	0.63	0.02	43.5
MI-05/7	0.13	55.4	<0.005	0.05	0.03	0.25	<0.01	0.03	0.05	<0.01	0.22	<0.01	43.6
MI-05/8	0.16	54.5	<0.005	0.21	0.03	0.23	<0.01	0.06	0.05	0.01	1.02	0.01	43.7
MI-05/9	0.32	55	<0.005	0.13	0.06	0.26	<0.01	<0.01	0.05	<0.01	0.64	0.02	43.5
MI-05/10	0.13	55.4	<0.005	0.05	0.03	0.24	<0.01	<0.01	0.03	<0.01	0.24	0.02	43.8
MI-05/11	0.15	55.4	<0.005	0.05	0.03	0.24	<0.01	0.02	0.05	<0.01	0.27	<0.01	43.8
MI-05/12	0.11	55.1	<0.005	0.03	0.22	0.22	<0.01	0.02	0.06	<0.01	0.19	<0.01	43.8
MI-05/13	0.08	55.6	<0.005	0.03	0.02	0.23	<0.01	0.03	0.05	<0.01	0.15	<0.01	43.9
MI-05/14	0.06	55.7	<0.005	0.02	0.02	0.24	<0.01	0.02	0.05	<0.01	0.12	<0.01	43.9
MI-05/15	0.06	55.6	<0.005	0.02	0.02	0.23	<0.01	0.02	0.04	<0.01	0.1	<0.01	43.9
MI-05/16	0.13	55.4	<0.005	0.03	0.03	0.38	<0.01	0.02	0.05	<0.01	0.23	<0.01	43.8
MI-05/17	0.06	55.3	<0.005	0.02	0.02	0.24	<0.01	0.02	0.05	<0.01	0.1	<0.01	43.9
MI-05/18	0.07	55.8	<0.005	0.02	0.02	0.22	<0.01	0.02	0.04	<0.01	0.11	<0.01	43.9
MI-05/19	0.21	55.5	<0.005	0.08	0.04	0.24	<0.01	0.03	0.07	<0.01	0.38	<0.01	43.4
MI-05/20	0.18	55.3	<0.005	0.06	0.03	0.38	<0.01	0.03	0.06	<0.01	0.33	<0.01	43.8
MI-05/21	0.16	55.2	<0.005	0.05	0.03	0.44	<0.01	0.03	0.06	<0.01	0.28	<0.01	43.8
MI-05/22	0.15	55.2	<0.005	0.05	0.03	0.53	<0.01	0.03	0.06	<0.01	0.25	<0.01	43.9
MI-05/23	0.16	55.1	<0.005	0.05	0.03	0.41	<0.01	0.03	0.06	0.01	0.32	<0.01	43.8
MI-05/24	0.17	55.1	<0.005	0.06	0.03	0.49	<0.01	0.03	0.06	<0.01	0.35	<0.01	43.8
MI-05/25	0.2	55	<0.005	0.06	0.04	0.47	<0.01	0.03	0.06	<0.01	0.34	0.01	43.8
MI-05/26	0.19	55	<0.005	0.08	0.04	0.52	<0.01	<0.01	0.05	<0.01	0.38	0.02	43.6
MI-05/27	0.31	54.7	<0.005	0.11	0.05	0.42	<0.01	0.03	0.06	<0.01	0.56	0.01	43.5
MI-05/28	0.32	55	<0.005	0.12	0.05	0.58	<0.01	0.03	0.07	<0.01	0.59	0.02	43.9
MI-05/29	0.09	55.4	<0.005	0.03	0.02	0.46	<0.01	0.03	0.06	0.01	0.17	<0.01	43.8
MI-05/30	0.12	54.8	<0.005	0.05	0.02	0.45	<0.01	0.03	0.07	0.01	0.22	<0.01	43.7

MI-05/31	0.32	55	<0.005	0.12	0.06	0.26	<0.01	0.04	0.06	<0.01	0.6	0.01	43.7
MI-05/32	0.15	55.1	<0.005	0.07	0.03	0.49	<0.01	0.03	0.07	0.01	0.29	<0.01	43.8
MI-05/33	0.13	55	<0.005	0.06	0.03	0.58	<0.01	0.04	0.09	0.02	0.26	<0.01	43.5
MI-05/34	0.24	54	<0.005	0.13	0.04	0.42	<0.01	0.03	0.1	<0.01	0.55	0.01	42.9
MI-05/35	0.52	53.9	<0.005	0.3	0.08	0.33	0.01	0.02	0.09	<0.01	1.4	0.02	42.6
MI-05/36	0.7	35.2	<0.005	0.4	0.09	0.39	0.02	0.03	0.07	<0.01	1.89	0.04	29.9
MI-05/37	5.52	2.89	<0.005	6.68	0.45	2	0.08	0.39	0.18	0.01	19.1	0.31	8.19
MI-05/38	16.8	3.14	<0.005	7.43	2.46	3.11	0.46	0.27	0.14	0.02	56.9	0.68	7.86
MI-05/39	16.5	3.46	<0.005	6.67	2.5	3.2	0.58	0.55	0.29	0.04	58.2	0.67	12.1
MI-05/40	16	1.97	<0.005	3.8	0.6	4.92	0.13	0.51	0.2	0.05	55.7	0.68	7.29
MI-05/41	16.8	6.6	<0.005	6.1	2.64	2.83	1.91	0.42	0.1	0.12	60.6	0.66	10.3
MI-05/42	15.6	6.76	<0.005	5.73	2.18	2.83	0.33	0.47	0.13	0.25	54.9	0.64	10.2
MI-05/43	15.4	7.9	<0.005	6.33	2.5	2.37	0.26	0.43	0.15	0.23	54.6	0.63	10.8
MI-05/44	15	54.5	0.013	6.07	2.36	2.46	0.28	0.59	0.16	0.28	53.6	0.65	10.8
MI-05/45	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/46	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/47	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/48	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/49	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/50	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/51	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/52	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/53	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/54	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/55	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/56	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/57	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/58	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/59	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-05/60	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***0.20***	***55.11***	***0.01***	***0.08***	***0.04***	***0.34***	***0.01***	***0.029***	***0.059***	***0.01***	***0.41***	***0.02***	***43.6***

Table 4.8 The laboratory analysis results for borehole MI-05 (adapted from SGS, 2014)

- **Borehole MI-06**

This borehole is dominated by CaO, with values varying from 50 to 55.9% with an average of 54.8% , while the other averages are: of Al_2O_3 0.36%, Cl 0.01%, Fe_2O_3 0.15%, K_2O 0.05%, MgO 0.26%, MnO 0.03%, Na_2O 0.02%, P_2O_5 0.06%, SO_3 0.03%, SiO_2 0.79% and TiO_2 0.03%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
MI-06/1	0.58	54.5	0.005	0.21	0.05	0.23	<0.01	0.04	0.04	0.03	1.05	0.03	43.2

MI-06/2	0.48	54.6	<0.005	0.22	0.05	0.22	<0.01	<0.01	0.04	0.03	0.86	0.03	43.3
MI-06/3	0.79	53.7	<0.005	0.41	0.06	0.27	0.02	0.01	0.04	0.02	1.31	0.05	43
MI-06/4	0.27	54.7	<0.005	0.16	0.03	0.5	<0.01	0.01	0.04	0.03	0.79	0.02	43.7
MI-06/5	0.13	55.3	<0.005	0.04	0.02	0.18	<0.01	0.01	0.08	<0.01	0.21	0.01	43.4
MI-06/6	0.16	55.9	<0.005	0.06	0.02	0.19	<0.01	0.02	0.09	<0.01	0.29	0.02	43.7
MI-06/7	0.2	55.4	<0.005	0.07	0.03	0.22	<0.01	0.01	0.07	<0.01	0.4	0.02	43.8
MI-06/8	0.2	55.4	<0.005	0.07	0.02	0.18	<0.01	0.02	0.06	<0.01	0.29	0.02	43.7
MI-06/9	0.44	54.4	<0.005	0.15	0.03	0.2	0.01	0.01	0.06	<0.01	0.7	0.03	43.6
MI-06/10	0.12	55.9	<0.005	0.04	0.02	0.19	<0.01	0.01	0.07	<0.01	0.21	0.01	43.8
MI-06/11	0.13	55.3	<0.005	0.04	0.02	0.23	<0.01	<0.01	0.06	<0.01	0.23	0.02	43.8
MI-06/12	0.06	55.7	<0.005	0.02	<0.01	0.18	<0.01	0.02	0.04	<0.01	0.09	0.01	43.9
MI-06/13	0.07	55.5	<0.005	0.03	0.01	0.29	<0.01	0.01	0.05	<0.01	0.1	0.01	43.8
MI-06/14	0.15	55.5	<0.005	0.05	0.02	0.23	<0.01	0.02	0.05	<0.01	0.26	0.01	43.6
MI-06/15	0.23	55.3	<0.005	0.09	0.03	0.26	0.01	0.02	0.06	<0.01	0.4	0.02	43.6
MI-06/16	0.28	55.2	<0.005	0.09	0.04	0.3	0.01	0.01	0.06	<0.01	0.52	0.02	43.5
MI-06/17	0.35	54.8	<0.005	0.12	0.05	0.33	0.01	0.01	0.06	<0.01	0.68	0.02	43.5
MI-06/18	0.29	55.1	<0.005	0.11	0.04	0.27	<0.01	0.02	0.06	<0.01	0.58	0.02	43.4
MI-06/19	0.36	54.9	<0.005	0.13	0.05	0.26	<0.01	0.01	0.07	<0.01	0.79	0.02	43.4
MI-06/20	0.35	54.9	<0.005	0.15	0.06	0.28	<0.01	<0.01	0.05	<0.01	0.75	0.02	43.4
MI-06/21	0.38	54.8	<0.005	0.14	0.06	0.33	0.01	0.02	0.07	<0.01	0.8	0.03	43.3
MI-06/22	0.43	54.6	<0.005	0.16	0.07	0.28	0.01	0.02	0.07	<0.01	0.92	0.03	43.5
MI-06/23	0.33	54.7	<0.005	0.13	0.05	0.26	<0.01	0.02	0.05	<0.01	0.71	0.02	43.3
MI-06/24	0.47	54.7	<0.005	0.16	0.07	0.27	<0.01	0.01	0.06	<0.01	1.02	0.03	43.4
MI-06/25	0.34	54.7	<0.005	0.15	0.05	0.25	0.01	0.01	0.07	<0.01	0.76	0.03	40
MI-06/26	1.79	50	<0.005	0.9	0.22	0.45	0.17	0.02	0.12	<0.01	5.94	0.11	12.1
MI-06/27	15.8	8.86	<0.005	6.48	2.37	1.53	0.16	0.12	0.15	0.01	51.6	0.75	12.1
Averages	***0.36***	***54.83***	***0.01***	***0.15***	***0.05***	***0.26***	***0.03***	***0.02***	***0.06***	***0.03***	***0.79***	***0.03***	***42.18***

Table 4.9 The laboratory analysis results for borehole MI-07 (adapted from SGS, 2014)

- **Borehole MI-07**

This borehole is dominated by CaO, with values varying from 54 to 55.9% with an average of 55.3% , while the other averages are: Al_2O_3 0.21%, Cl 0.01%, Fe_2O_3 0.09%, K_2O 0.03%, MgO 0.26%, MnO 0.03%, Na_2O 0.01%, P_2O_5 0.05%, SO_3 0.02%, SiO_2 0.4% and TiO_2 0.02%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	**Al203**	**Ca0**	**Cl**	**Fe203**	**K20**	**Mg0**	**MnO**	**Na2O**	**P2O5**	**SO3**	**SiO2**	**TiO2**	**LOI**
MI-07/1	0.31	55.1	0.005	0.11	0.02	0.18	<0.0.1	0.02	0.03	0.03	0.44	0.02	43.7
MI-07/2	0.18	55.1	<0.005	0.08	0.02	0.22	<0.0.1	0.01	0.03	0.04	0.28	0.02	43.8
MI-07/3	0.34	55.1	<0.005	0.11	0.02	0.17	<0.0.1	0.01	0.03	0.01	0.53	0.02	43.6
MI-07/4	1.23	53.1	<0.005	0.49	0.06	0.18	0.04	0.01	0.04	0.03	1.95	0.07	42.5
MI-07/5	0.51	54.7	<0.005	0.56	0.02	0.18	0.02	<0.0.1	0.07	0.01	0.71	0.04	43.2

MI-07/6	0.46	54.7	<0.005	0.16	0.03	0.16	<0.0.1	<0.0.1	0.06	<0.01	0.71	0.03	43.5
MI-07/7	0.3	55.2	<0.005	0.11	0.02	0.17	<0.0.1	<0.0.1	0.06	<0.01	0.47	0.02	43.6
MI-07/8	0.1	55.5	<0.005	0.05	0.02	0.18	<0.0.1	0.01	0.04	0.01	0.18	0.01	43.8
MI-07/9	0.09	55.7	<0.005	0.02	<0.01	0.16	<0.0.1	<0.0.1	0.04	<0.01	0.11	<0.01	43.9
MI-07/10	0.08	55.7	<0.005	0.03	<0.01	0.17	<0.0.1	0.01	0.05	0.02	0.1	0.01	43.9
MI-07/11	0.09	55.7	<0.005	0.03	<0.01	0.15	<0.0.1	0.02	0.05	0.04	0.12	0.01	43.9
MI-07/12	0.08	55.9	<0.005	0.03	<0.01	0.15	<0.0.1	<0.01	0.05	<0.01	0.1	0.01	43.9
MI-07/13	0.06	55.8	<0.005	0.02	<0.01	0.14	<0.0.1	0.01	0.05	0.01	0.09	0.01	43.9
MI-07/14	0.06	55.7	<0.005	0.01	<0.01	0.14	<0.0.1	<0.01	0.05	<0.01	0.08	<0.01	43.9
MI-07/15	0.07	55.7	<0.005	0.02	<0.01	0.15	<0.0.1	0.01	0.05	<0.01	0.11	<0.01	43.9
MI-07/16	0.05	55.7	<0.005	0.02	<0.01	0.2	<0.0.1	<0.01	0.06	<0.01	0.08	0.01	43.9
MI-07/17	0.09	55.6	<0.005	0.03	0.01	0.24	<0.0.1	0.01	0.08	<0.01	0.13	0.01	43.9
MI-07/18	0.06	55.5	<0.005	0.02	<0.01	0.21	<0.0.1	0.02	0.05	<0.01	0.09	0.01	43.9
MI-07/19	0.04	55.5	<0.005	0.02	<0.01	0.25	<0.0.1	<0.01	0.05	<0.01	0.06	0.01	43.9
MI-07/20	0.06	55.7	<0.005	0.02	<0.01	0.23	<0.0.1	<0.01	0.04	<0.01	0.09	0.01	43.9
MI-07/21	0.09	55.6	<0.005	0.03	0.01	0.24	<0.0.1	0.01	0.05	<0.01	0.15	0.01	43.9
MI-07/22	0.08	55.4	<0.005	0.09	0.01	0.3	<0.0.1	<0.01	0.06	<0.01	0.14	0.01	43.9
MI-07/23	0.09	55.4	<0.005	0.05	0.01	0.37	<0.0.1	0.01	0.07	<0.01	0.14	<0.01	43.9
MI-07/24	0.21	55.2	<0.005	0.07	0.03	0.28	<0.0.1	0.01	0.06	<0.01	0.42	0.02	43.6
MI-07/25	0.14	55.4	<0.005	0.07	0.03	0.26	<0.0.1	<0.01	0.05	<0.01	0.35	0.01	43.7
MI-07/26	0.24	55.2	<0.005	0.09	0.03	0.22	<0.0.1	0.01	0.07	<0.01	0.51	0.02	43.6
MI-07/27	0.53	54.6	<0.005	0.21	0.08	1.72	0.04	0.02	0.08	<0.01	1.43	0.03	42.9
MI-07/28	18.7	4.81	<0.005	5.62	3.17	1.91	0.08	0.18	0.1	0.51	55.8	0.68	8.92
MI-07/29	15.3	9.94	<0.005	5.82	2.27	1.92	0.19	0.21	0.1	0.96	50.1	0.64	12.6
MI-07/30	17.4	4.42	<0.005	8.78	2.27	1.92	0.29	0.14	0.23	0.05	53.4	0.86	10
MI-07/31	17.7	4.47	<0.005	5.75	2.99	1.7	0.18	0.26	0.1	0.4	56.1	0.66	9.12
MI-07/32	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/33	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/34	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/35	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/36	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/37	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/38	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-07/39	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***0.21***	***55.31***	***0.01***	***0.09***	***0.03***	***0.26***	***0.033***	***0.013***	***0.053***	***0.02***	***0.35***	***0.02***	***43.7***

Table 4.10 The laboratory analysis results for borehole MI-07 (adapted from SGS, 2014)

- **Borehole MI-08**

This borehole is dominated by CaO, with values varying from 53 to 55.6% with an average of 55.1% , while the other averages are: Al_2O_3 is 0.20%, Cl 0.01%, Fe_2O_3 0.08%, K_2O 0.03%, MgO

0.24%, MnO 0.02%, Na_2O 0.02%, P_2O_5 0.05%, SO_3 0.02%, SiO_2 0.32% and TiO_2 0.02%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI
MI-08/1	1.21	53.8	0.005	0.46	0.04	0.19	0.01	0.01	0.04	0.04	1.31	0.07	43
MI-08/2	0.48	54.5	<0.005	0.18	0.02	0.22	<0.01	0.02	0.04	0.03	0.54	0.03	43.6
MI-08/3	0.03	55.2	<0.005	0.01	<0.01	0.25	<0.01	0.04	0.02	0.05	0.04	<0.01	43.9
MI-08/4	0.06	55.1	<0.005	0.03	<0.01	0.26	<0.01	0.02	0.03	0.02	0.1	<0.01	43.9
MI-08/5	0.06	55.3	<0.005	0.02	<0.01	0.28	<0.01	0.02	0.04	0.01	0.09	<0.01	43.9
MI-08/6	0.06	55.4	<0.005	0.04	<0.01	0.24	<0.01	<0.01	0.05	0.01	0.11	0.01	43.9
MI-08/7	0.05	55.4	<0.005	0.03	<0.01	0.21	<0.01	<0.01	0.05	<0.01	0.08	<0.01	43.9
MI-08/8	0.03	55.3	<0.005	0.02	<0.01	0.22	<0.01	<0.01	0.06	<0.01	0.04	<0.01	43.9
MI-08/9	0.04	55.6	<0.005	0.02	<0.01	0.24	<0.01	<0.01	0.06	<0.01	0.05	<0.01	43.9
MI-08/10	0.04	55.3	<0.005	0.02	<0.01	0.26	<0.01	<0.01	0.06	0.01	0.07	<0.01	43.9
MI-08/11	0.06	55.2	<0.005	0.02	<0.01	0.23	<0.01	<0.01	0.07	<0.01	0.09	<0.01	43.9
MI-08/12	0.03	55.3	<0.005	0.01	<0.01	0.19	<0.01	0.01	0.04	<0.01	0.04	<0.01	44
MI-08/13	0.16	55.3	<0.005	0.05	0.02	0.26	<0.01	<0.01	0.05	<0.01	0.34	0.01	43.8
MI-08/14	0.26	55.1	<0.005	0.08	0.03	0.22	<0.01	<0.01	0.05	<0.01	0.49	0.02	43.6
MI-08/15	0.23	55.2	<0.005	0.08	0.03	0.22	<0.01	<0.01	0.06	<0.01	0.53	0.02	43.7
MI-08/16	0.2	55.2	<0.005	0.06	0.02	0.22	<0.01	<0.01	0.05	<0.01	0.34	0.01	43.7
MI-08/17	0.29	55.2	<0.005	0.1	0.04	0.23	<0.01	0.01	0.05	<0.01	0.53	0.02	43.6
MI-08/18	0.26	55	<0.005	0.14	0.03	0.31	0.03	<0.01	0.09	<0.01	0.5	0.02	43.6
MI-08/19	0.33	54.9	<0.005	0.16	0.04	0.25	0.03	<0.01	0.09	<0.01	0.71	0.02	43.5
MI-08/20	17.4	4.19	<0.005	6.33	2.85	1.7	0.13	0.09	0.11	0.02	58.1	0.79	8.12
MI-08/21	20.9	1.64	<0.005	6.43	3.16	1.86	0.06	0.22	0.12	2.03	57.7	0.8	7.07
MI-08/22	18.3	3.54	<0.005	7.24	2.79	2.32	0.26	0.33	0.17	1.08	55.8	0.93	7.68
MI-08/23	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-08/24	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-08/25	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-08/26	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-08/27	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-08/28	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***0.20***	***55.12***	***0.01***	***0.08***	***0.03***	***0.24***	***0.02***	***0.02***	***0.05***	***0.02***	***0.32***	***0.02***	***43.75***

Table 4.11 The laboratory analysis results for borehole MI-08 (adapted from SGS, 2014)

- **Borehole MI-09**

This borehole is dominated by CaO, with values varying from 54 to 55.6% with an average of 54.9%, while the averages of Al_2O_3 0.25%, Cl 0.01%, Fe_2O_3 0.11%, K_2O 0.04%, MgO 0.29%, MnO 0.04%, Na_2O 0.02%, P_2O_5 0.06%, SO_3 0.02%, SiO_2 0.51% and TiO_2 0.02%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	Al203	Ca0	Cl	Fe203	K20	Mg0	MnO	Na2O	P2O5	SO3	SiO2	TiO2	LOI

MI-09/1	0.3	54.9	0.005	0.12	0.02	0.21	<0.01	0.02	0.05	0.03	0.46	0.02	43.8
MI-09/2	0.32	55.4	<0.005	0.12	0.02	0.21	<0.01	0.01	0.05	0.02	0.43	0.02	43.1
MI-09/3	0.39	54.9	<0.005	0.16	0.03	0.22	<0.01	<0.01	0.05	0.03	0.56	0.03	43.6
MI-09/4	0.47	54.7	<0.005	0.17	0.03	0.25	<0.01	<0.01	0.04	0.03	0.73	0.03	43.4
MI-09/5	0.08	55	<0.005	0.02	<0.01	0.38	<0.01	0.02	0.04	0.02	0.13	<0.01	43.9
MI-09/6	0.1	54.8	<0.005	0.04	<0.01	0.36	<0.01	0.01	0.04	0.03	0.24	<0.01	43.9
MI-09/7	0.07	55.3	<0.005	0.04	<0.01	0.4	<0.01	<0.01	0.06	0.02	0.14	<0.01	43.9
MI-09/8	0.04	55.6	<0.005	0.02	<0.01	0.28	<0.01	0.01	0.05	0.01	0.06	<0.01	44
MI-09/9	0.03	55.4	<0.005	0.02	<0.01	0.21	<0.01	<0.01	0.05	<0.01	0.06	<0.01	44
MI-09/10	0.04	55.6	<0.005	0.03	<0.01	0.2	<0.01	<0.01	0.06	<0.01	0.08	<0.01	44
MI-09/11	0.05	55.6	<0.005	0.03	<0.01	0.29	<0.01	<0.01	0.04	0.01	0.09	<0.01	44
MI-09/12	0.18	55.3	<0.005	0.08	0.02	0.33	<0.01	0.01	0.05	0.01	0.34	0.02	43.8
MI-09/13	0.27	55.1	<0.005	0.12	0.04	0.29	<0.01	<0.01	0.06	0.02	0.63	0.02	43.5
MI-09/14	0.3	55	<0.005	0.14	0.04	0.25	<0.01	<0.01	0.05	0.02	0.62	0.02	43.5
MI-09/15	0.28	54.8	<0.005	0.12	0.04	0.23	<0.01	0.02	0.04	0.02	0.58	0.02	43.5
MI-09/16	0.35	54.5	<0.005	0.13	0.05	0.26	<0.01	0.02	0.05	0.02	0.83	0.02	43.3
MI-09/17	0.25	54.8	<0.005	0.1	0.03	0.27	<0.01	0.01	0.08	<0.01	0.51	0.02	43.6
MI-09/18	0.24	54.6	<0.005	0.09	0.06	0.55	<0.01	0.08	0.1	0.02	0.74	0.02	43.5
MI-09/19	0.41	54.4	<0.005	0.16	0.05	0.37	<0.01	<0.01	0.08	<0.01	0.81	0.02	43.3
MI-09/20	0.59	54.1	<0.005	0.25	0.08	0.29	0.02	0.01	0.06	<0.01	1.28	0.03	43
MI-09/21	0.59	54.1	<0.005	0.28	0.08	0.28	0.06	<0.01	0.06	<0.01	1.39	0.03	42.9
MI-09/22	16.4	3.65	<0.005	6.23	2.86	1.78	0.19	0.14	0.11	0.98	60.7	0.67	6.67
MI-09/23	17.8	2.47	<0.005	7.17	2.97	2.35	0.2	0.27	0.12	1.27	57.6	0.74	6.87
MI-09/24	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/25	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/26	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/27	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/28	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/29	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/30	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-09/31	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***0.25***	***54.9***	***0.01***	***0.11***	***0.04***	***0.29***	***0.04***	***0.02***	***0.06***	***0.02***	***0.51***	***0.02***	***43.6***

Table 4.12 The laboratory analysis results for borehole MI-09 (adapted from SGS, 2014)

- **Borehole MI-10**

This borehole is dominated by CaO, with values varying from 53.7 to 55.6% with an average of 54.9% , while the other averages are Al_2O_3 is 0.2%, Cl 0.01%, Fe_2O_3 0.09%, K_2O 0.03%, MgO 0.31%, MnO 0.03%, Na_2O 0.02%, P_2O_5 0.06%, SO_3 0.03%, SiO_2 0.38% and TiO_2 0.03%. The details (values in percentage (%)) are shown in the following table.

Bore Hole	**Al203**	**Ca0**	**Cl**	**Fe203**	**K20**	**Mg0**	**MnO**	**Na2O**	**P2O5**	**SO3**	**SiO2**	**TiO2**	**LOI**

MI-10/1	0.48	54.5	0.005	0.18	0.03	0.23	<0.01	<0.01	0.04	0.04	0.81	0.03	43.4
MI-10/2	0.67	54	<0.005	0.28	0.04	0.23	0.01	0.02	0.04	0.03	1.03	0.04	43.2
MI-10/3	0.91	53.7	<0.005	0.38	0.05	0.28	0.02	0.01	0.03	0.05	1.36	0.05	42.9
MI-10/4	0.1	55.2	<0.005	0.04	<0.01	0.27	<0.01	0.01	0.04	0.03	0.13	<0.01	43.8
MI-10/5	0.04	55.4	<0.005	<0.01	<0.01	0.21	<0.01	0.01	0.04	0.02	0.05	<0.01	44
MI-10/6	0.03	55.5	<0.005	<0.01	<0.01	0.19	<0.01	<0.01	0.07	<0.01	0.04	<0.01	43.9
MI-10/7	0.05	55.4	<0.005	0.02	<0.01	0.2	<0.01	0.01	0.06	<0.01	0.08	<0.01	43.9
MI-10/8	0.05	55.6	<0.005	<0.01	<0.01	0.21	<0.01	<0.01	0.06	<0.01	0.06	<0.01	43.9
MI-10/9	0.04	55.4	<0.005	<0.01	<0.01	0.2	<0.01	0.01	0.06	<0.01	0.06	<0.01	43.9
MI-10/10	0.04	55.6	<0.005	<0.01	<0.01	0.21	<0.01	0.02	0.06	<0.01	0.04	<0.01	43.9
MI-10/11	0.06	55.3	<0.005	0.03	0.01	0.22	<0.01	0.01	0.07	<0.01	0.14	<0.01	43.8
MI-10/12	0.06	55.3	<0.005	0.03	0.01	0.23	<0.01	<0.01	0.07	<0.01	0.11	<0.01	43.9
MI-10/13	0.07	55.4	<0.005	0.04	0.01	0.23	<0.01	0.01	0.06	<0.01	0.12	<0.01	43.9
MI-10/14	0.09	55.3	<0.005	0.03	0.02	0.23	<0.01	0.01	0.06	<0.01	0.16	<0.01	43.8
MI-10/15	0.07	55.3	<0.005	0.03	0.01	0.26	<0.01	0.01	0.06	<0.01	0.14	<0.01	43.9
MI-10/16	0.06	55.1	<0.005	0.02	<0.01	0.2998	<0.01	0.02	0.05	<0.01	0.1	<0.01	43.9
MI-10/17	0.05	55.1	<0.005	0.02	<0.01	0.36	<0.01	0.02	0.06	<0.01	0.08	<0.01	44
MI-10/18	0.05	55.2	<0.005	0.02	<0.01	0.34	<0.01	0.02	0.07	<0.01	0.07	<0.01	44
MI-10/19	0.11	54.9	<0.005	0.05	0.02	0.39	<0.01	0.02	0.07	<0.01	0.2	<0.01	43.9
MI-10/20	0.18	55	<0.005	0.07	0.03	0.4	<0.01	0.02	0.08	<0.01	0.37	0.01	43.7
MI-10/21	0.17	55.1	<0.005	0.07	0.03	0.4	<0.01	0.02	0.08	<0.01	0.3	<0.01	43.7
MI-10/22	0.18	54.9	<0.005	0.07	0.01	0.37	<0.01	0.01	0.05	<0.01	0.32	<0.01	43.8
MI-10/23	0.1	55	<0.005	0.03	0.01	0.38	<0.01	0.02	0.05	<0.01	0.16	<0.01	43.9
MI-10/24	0.09	55	<0.005	0.03	0.02	0.45	<0.01	0.01	0.06	<0.01	0.14	<0.01	43.9
MI-10/25	0.12	54.9	<0.005	0.04	0.03	0.47	<0.01	<0.01	0.06	<0.01	0.22	<0.01	43.9
MI-10/26	0.19	54.8	<0.005	0.07	0.03	0.39	<0.01	0.02	0.07	<0.01	0.35	<0.01	43.8
MI-10/27	0.2	54.7	<0.005	0.06	0.04	0.51	<0.01	0.02	0.06	<0.01	0.36	<0.01	43.8
MI-10/28	0.27	54.7	<0.005	0.09	0.04	0.35	<0.01	0.02	0.07	<0.01	0.51	0.01	43.6
MI-10/29	0.28	54.5	<0.005	0.1	0.06	0.39	<0.01	0.03	0.08	<0.01	0.55	0.02	43.6
MI-10/30	0.37	54.5	<0.005	0.12	0.07	0.37	<0.01	0.04	0.07	<0.01	0.72	0.02	43.5
MI-10/31	0.43	54.4	<0.005	0.17	0.06	0.28	0.01	0.01	0.06	<0.01	1.01	0.02	43.3
MI-10/32	0.42	54.4	<0.005	0.18	0.06	0.28	0.02	0.02	0.06	0.01	0.95	0.02	43.3
MI-10/33	0.65	53.7	<0.005	0.28	0.1	0.3	0.11	0.02	0.11	0.01	1.66	0.03	42.8
MI-10/34	9.18	27.1	<0.005	3.76	1.48	1.19	0.19	0.07	0.11	0.78	30.3	0.44	25.9
MI-10/35	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-10/36	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-10/37	-	-	-	-	-	-	-	-	-	-	-	-	-
MI-10/38	-	-	-	-	-	-	-	-	-	-	-	-	-
Averages	***0.20***	***54.9***	***0.01***	***0.09***	***0.03***	***0.31***	***0.03***	***0.02***	***0.06***	***0.03***	***0.38***	***0.03***	***43.7***

Table 4.13 The laboratory analysis results for borehole MI-10 (adapted from SGS, 2014)

Chapter 5
Results and Interpretations

5.1 Block I-Mine1

There are twelve (12) boreholes in this area, various of lithologic units are encountered at different depths and with different averages of the chemical composition. In particular Al_2O_3, Cl, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, SO_3, SiO_2 and TiO_2 have been analysed using the X-Ray Fluorescence (XRF) method. The mineral license area at Block I-Mine1 (Bucoli North Area) has 5.789.136 square meters or 578.9 ha.

5.1.1 Modelling chemical distributions

The modelling method selected was a conventional method, utilizing software RockWorks (v17). For modelling the chemical distributions, the algorithm IDW-Anisotropic (Inverse Distance interpolation) has been used, but selecting only the closest eight control points when computing a value for each voxel (volume element).

5.1.1.1 Chemical Composition Models

Based on the laboratory results, six chemical distributions were modelled and some cut off models are shown in the following pages:

a) Al_2O_3 distribution above 8% (middle value)

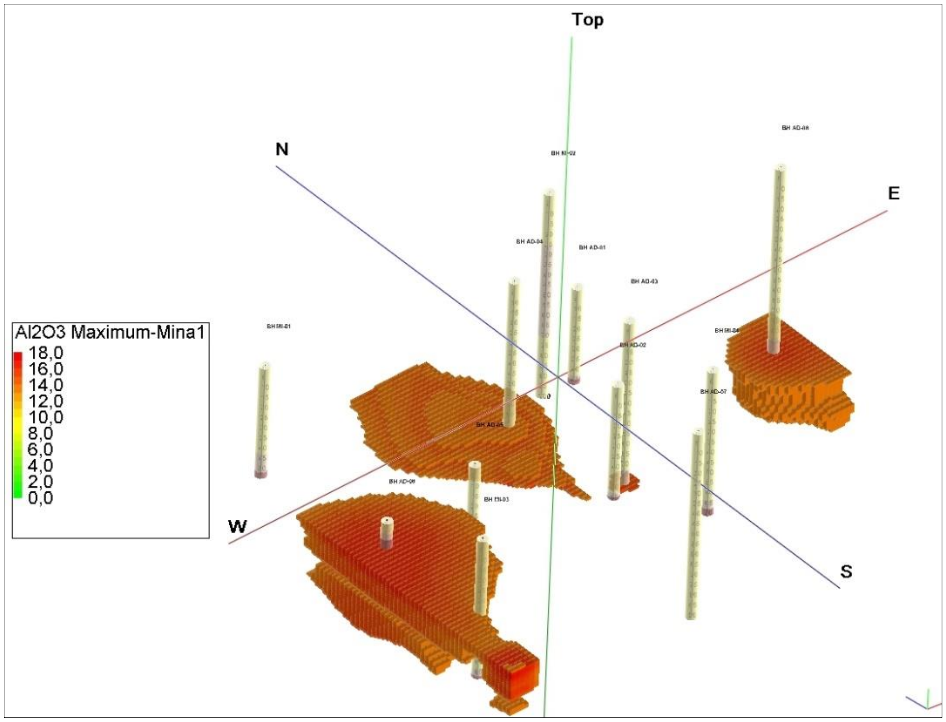

Figure 5.1 Model showing the distribution of Al_2O_3 above 8 percent, the higher values are found in the western part of conccesion area, Clay is present between depths 10-49.5m at borehole additional 06, while in the two other boreholes it only appear in the last 1-3 meters of the bottom.

b) CaO distribution above 40% (cut-off grade)

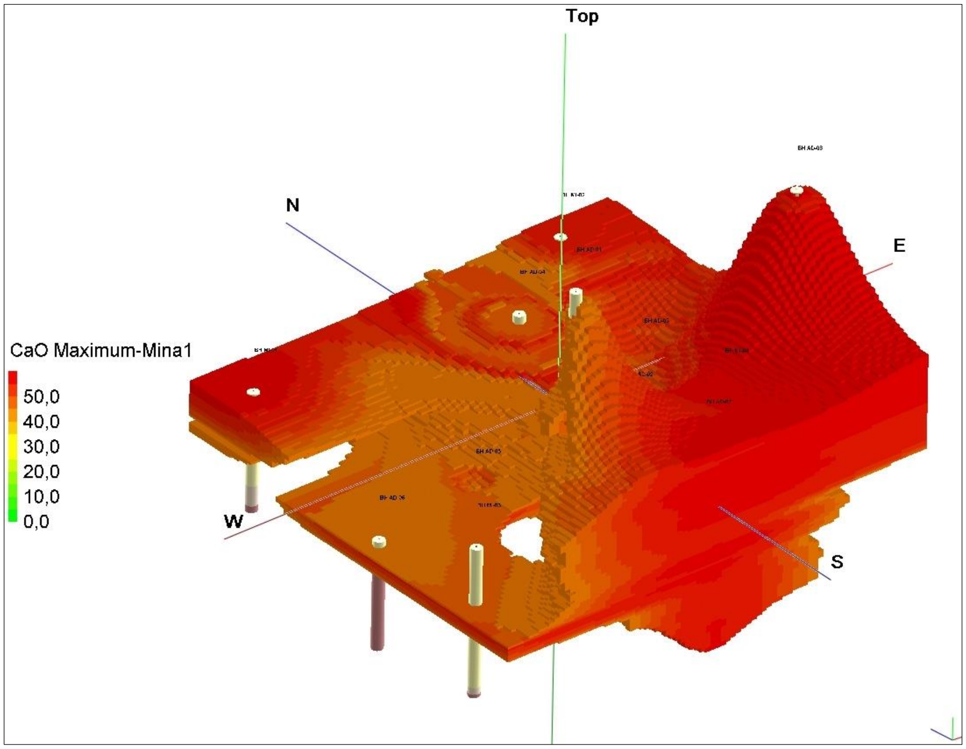

Figure 5.2 Model showing, the distribution of CaO at Mine1 above 40 percent, in the northern and western parts that the thickness of CaO is lower, while the eastern and southern parts indicate higher thickness of CaO.

c) Cl distribution above 0,04% (middle value)

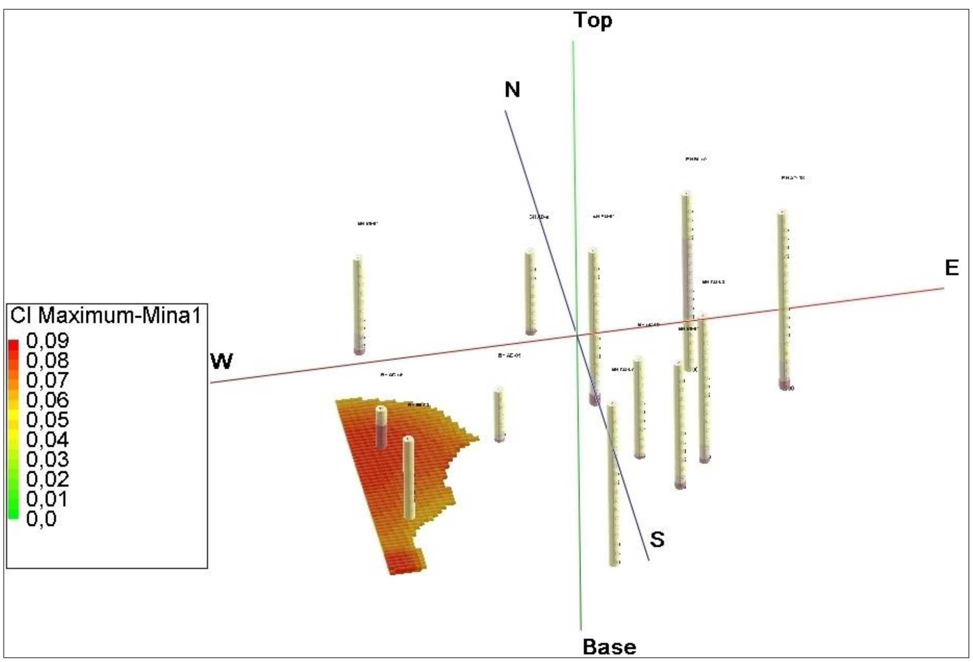

Figure 5.3 Model showing, the distribution of Cl above 0.04 percent at the western part of concession area. Higher values observed in boreholes AD-06 and MI-03 but only in the bottom, while the ten other show values below 0.04 percent of Chlorine.

d) Fe_2O_3 distribution above 4% (middle value)

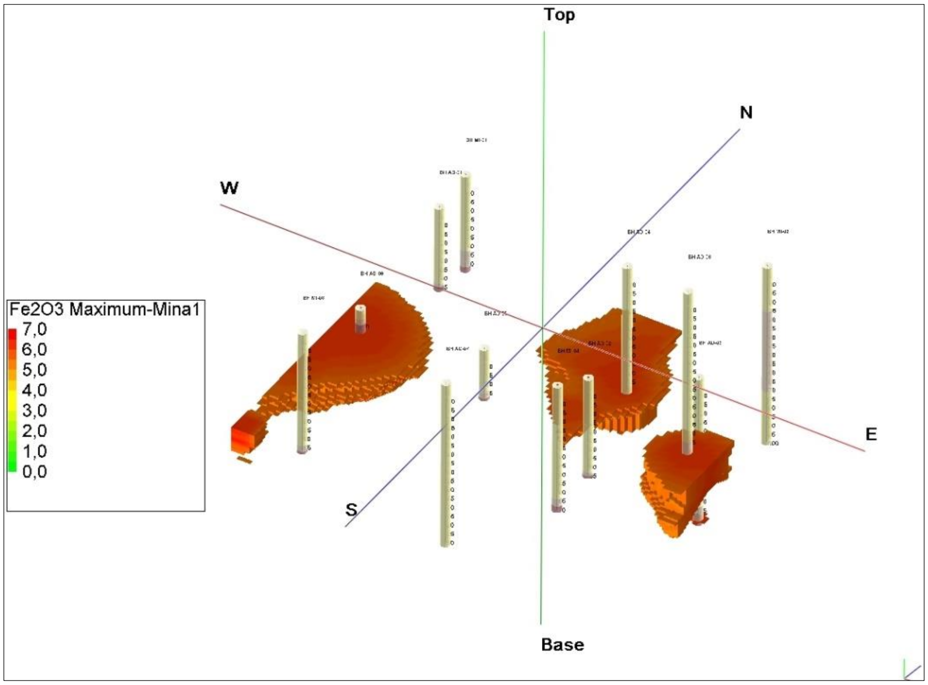

Figure 5.4 The maximum values of Fe_2O_3 (above 4 percent), appear in boreholes AD-06 (west part), AD-04 and AD-08, only in the bottom of the boreholes.

e) K2O distribution above 1,6% (middle value)

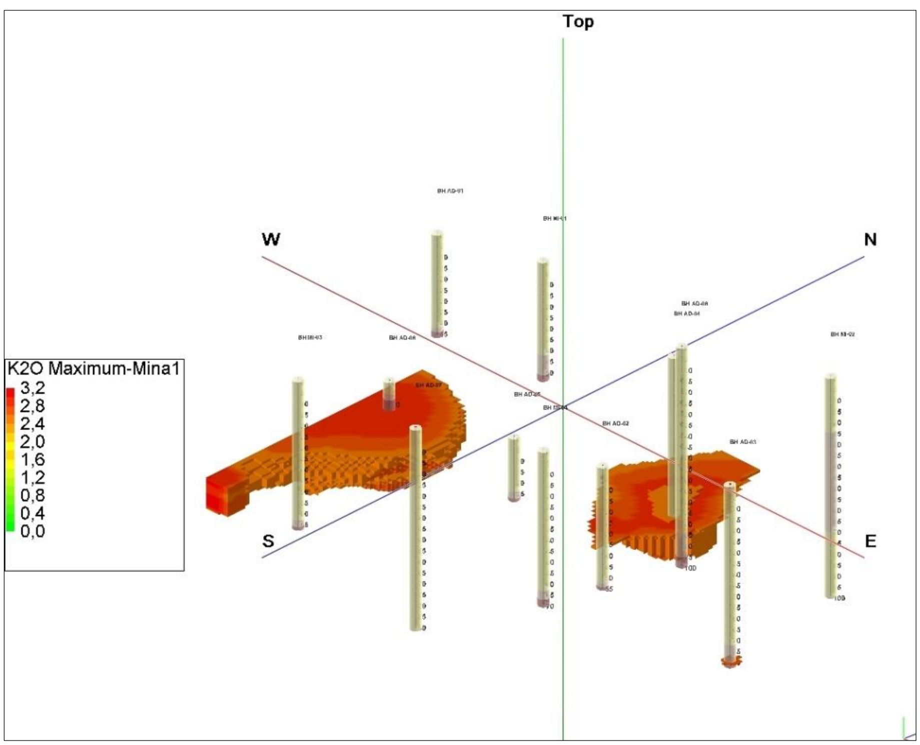

Figure 5.5 Model showing, the distribution of K2O above 1.6 percent, it is only significant in boreholes AD-06 and AD-04, while the others show values below 1.6 percent.

f) MgO distribution above 1,8% (middle value)

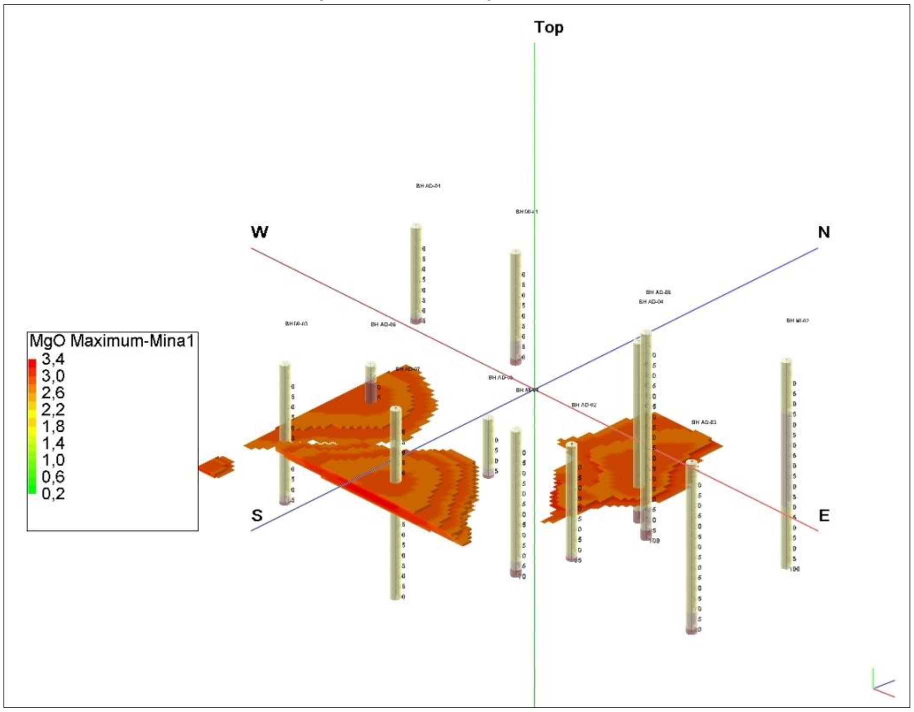

Figure 5.6 Model showing, the distribution of MgO above 1.8 percent, it only shows in boreholes AD-06, AD-07 and AD-03, while the other boreholes have values below 1.8 percent

5.1.1.2 Average Models

The following table summarizes the average overall results of oxides present in the sampling and surveys carried out. After the table figures display the areal average distributions.

Boreholes	% CaO	Al_2O_3	% MgO	% Fe_2O_3	% SiO_2
AD-03	50.4	0.7	0.82	0.34	6.3
AD-04	43.3	1.72	0.43	0.91	17.9
AD-06	42.6	2.6	0.61	1.39	16.8
AD-07	53.1	0.56	1.14	0.22	1.44
AD-08	52.9	0.62	0.96	0.29	2.16
MI-01	50.8	1.43	0.6	0.55	5.1
MI-03	52.6	0.5	1.1	0.25	2.7
MI-05	55.1	0.2	0.34	0.08	0.4
MI-06	54.8	0.36	0.26	0.15	0.79
MI-07	55.3	0.21	0.26	0.09	0.4
MI-08	55.1	0.2	0.24	0.08	0.32
MI-09	54.9	0.25	0.29	0.11	0.51
MI-10	54.9	0.2	0.31	0.09	0.38

Table 5.1 The averages of CaO, Al_2O_3, MgO, Fe_2O_3 and SiO_2 at Mine and Mine2

- Areal average CaO distribution

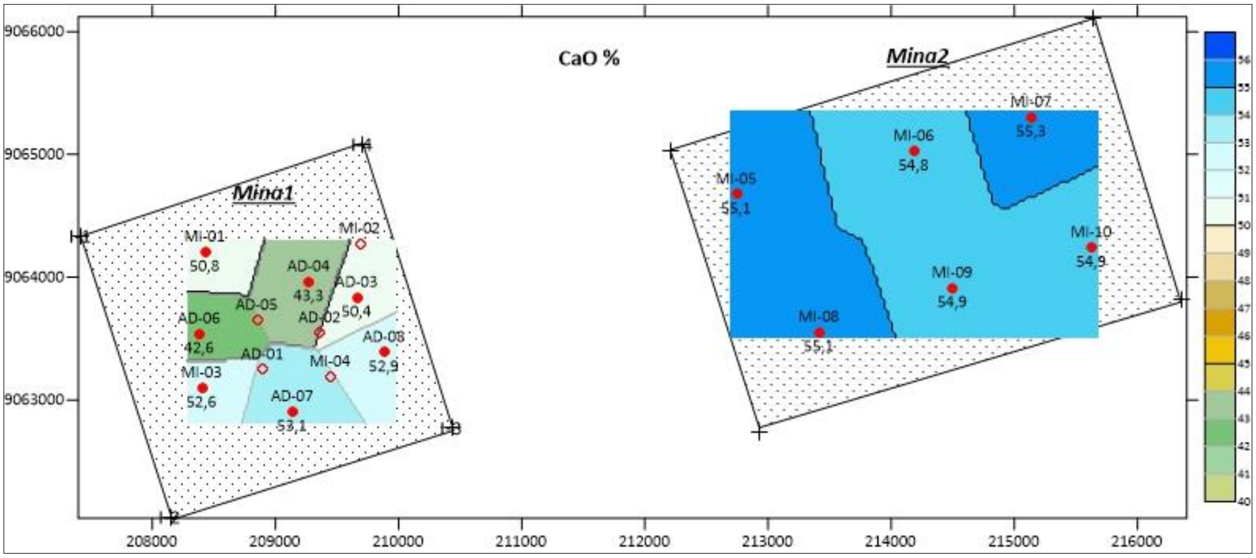

Figure 5.6 For Mine1, the average areal distribution of CaO shows that the, western part around boreholes AD-06 and AD-04 is of lower quality(below 45percent), the southern and eastern area are above 50 percent. The average areal distribution of CaO at Mine2 is shows high quality limestone (above 54 percent).

- Areal average Al_2O_3 distribution

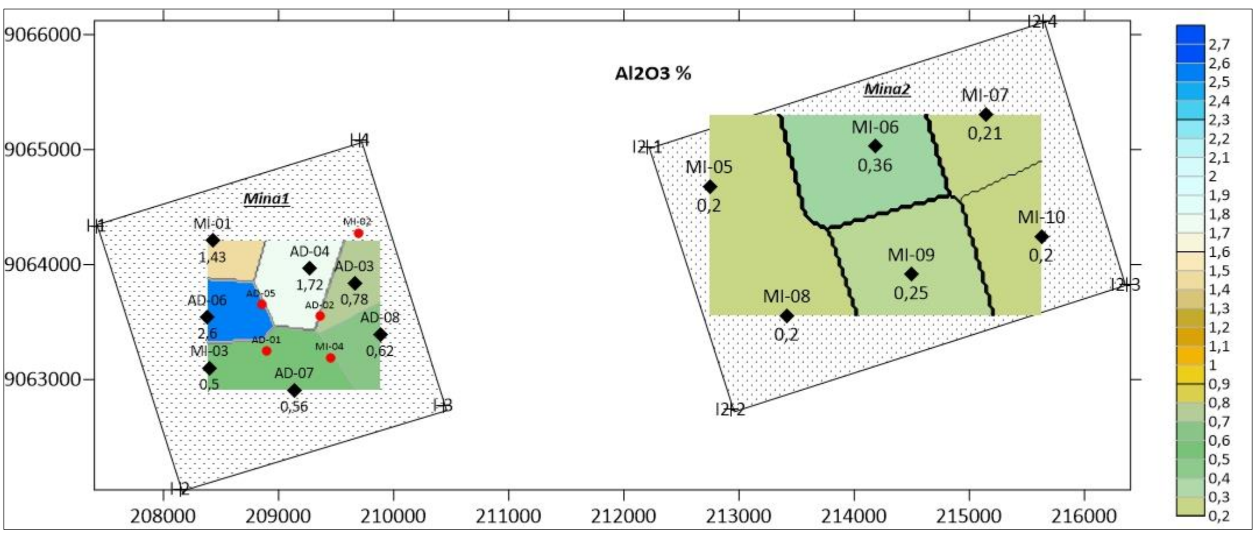

Figure 5.7 Areal distribution of Al_2O_3 at Mine1 and Mine2, lower values in Mine2 and higher values in the western part of Mine1

- Areal average MgO distribution

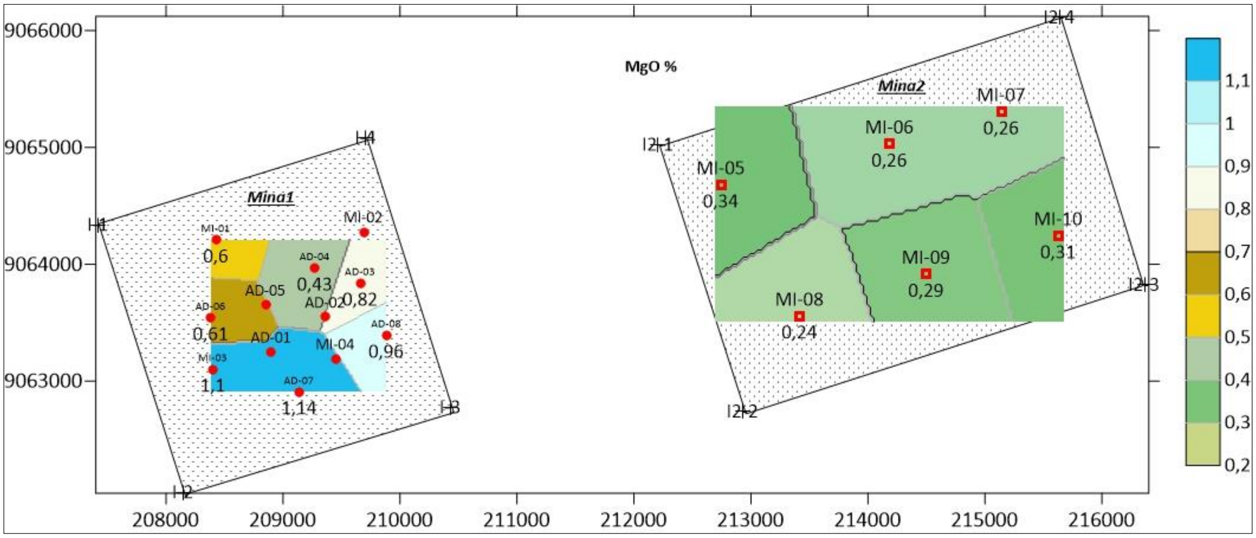

Figure 5.8 The areal average distribution of MgO at Mine1 and Mine2

- Areal average Fe_2O_3 distribution

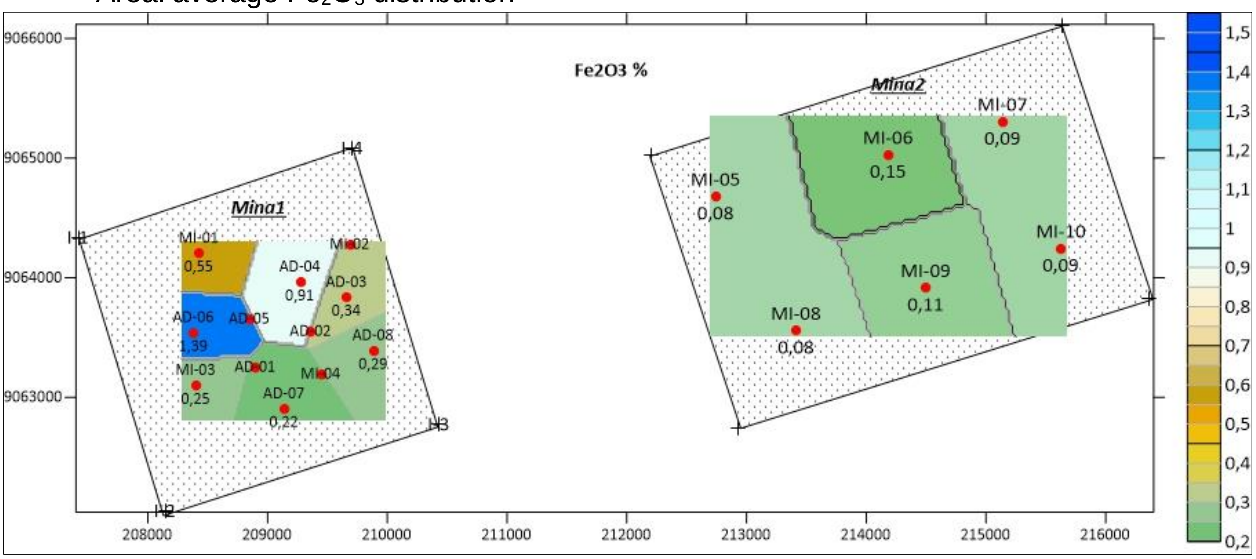

Figure 5.9 Areal average distribution of of Fe_2O_3 at Mine1 and Mine2

- Areal average SiO_2 distribution

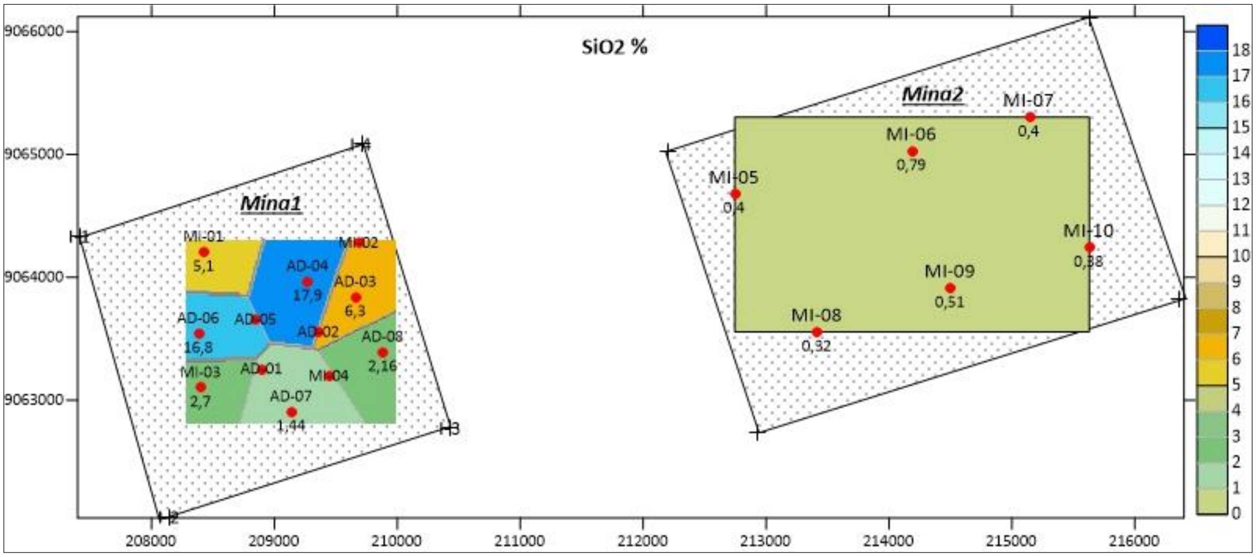

Figure 5.10 Areal average distribution of SiO_2. At Mine1 values above 16 percent are found in boreholes AD-06 and AD-04, while the others are lower than 6 percent. At Mine2 the average is always below 1 percent.

5.1.1.3 Hydraulicity Index

The hydraulic index, silica aluminum ferric and lime saturation were calculated based on the following formulas:

- I_h = $\%CaO / (\%SiO_2 + \%Al_2O_3 + \%Fe_2O_3)$
- Silica Module = $\%SiO_2 / (\%Al_2O_3 + \%Fe_2O_3)$
- Aluminum ferric module = $\%Al_2O_3 / \%Fe_2O_3$
- Lime saturation module = $\%CaO / (2,8 \times \%SiO_2 + 1,2x\ \%Al_2O_3 + 0,65 \times \%Fe_2O_3)$

The values for these parameter are shown in the following table.

Borehole	Ih	Modules		
		Si	Al-Fe	Lime Saturation
AD-03	6.8	5.6	2.3	2.7
AD-04	2.1	6.8	1.9	0.8
AD-06	2.0	4.2	1.9	0.8
AD-07	23.9	1.8	2.5	11.0
AD-08	17.2	2.8	2.1	7.6
MI-01	7.2	2.6	2.6	3.1
MI-03	15.2	3.6	2.0	6.3
MI-05	81.0	1.4	2.5	39.0
MI-06	42.2	1.5	2.4	20.0
MI-07	79.0	1.3	2.3	38.7
MI-08	91.8	1.1	2.5	46.4
MI-09	63.1	1.4	2.3	30.5
MI-10	81.9	1.3	2.2	40.3

Table 5.2 The Hydraulicity index at Mine1 and Mine2

Based on the index hydraulic on several modules, they are shown in the following map:

- Index of Hydraulicity

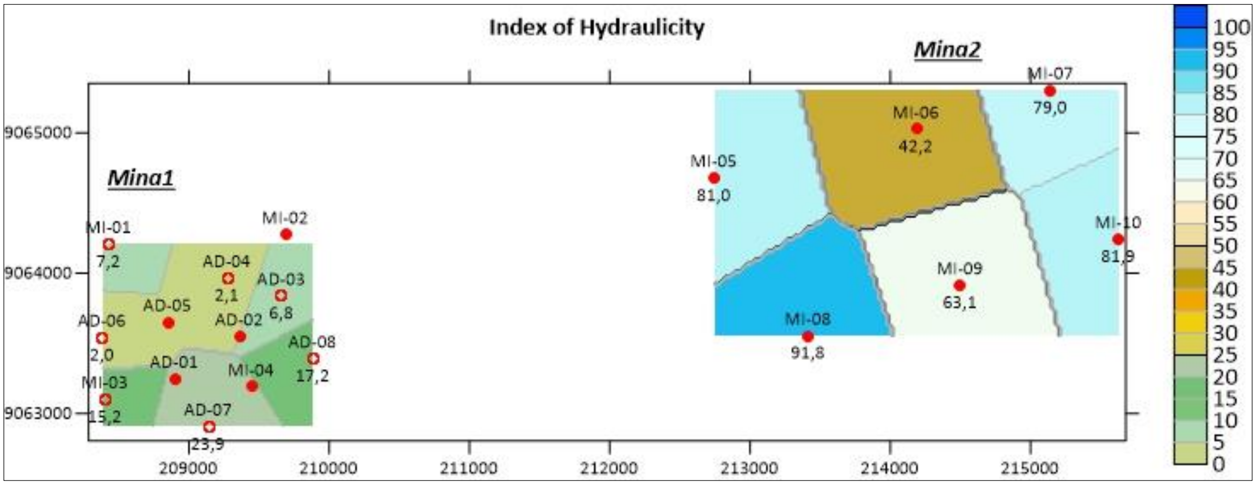

Figure 5.11 Index hydraulicity model at Mine1 and Mine2

- Silica module

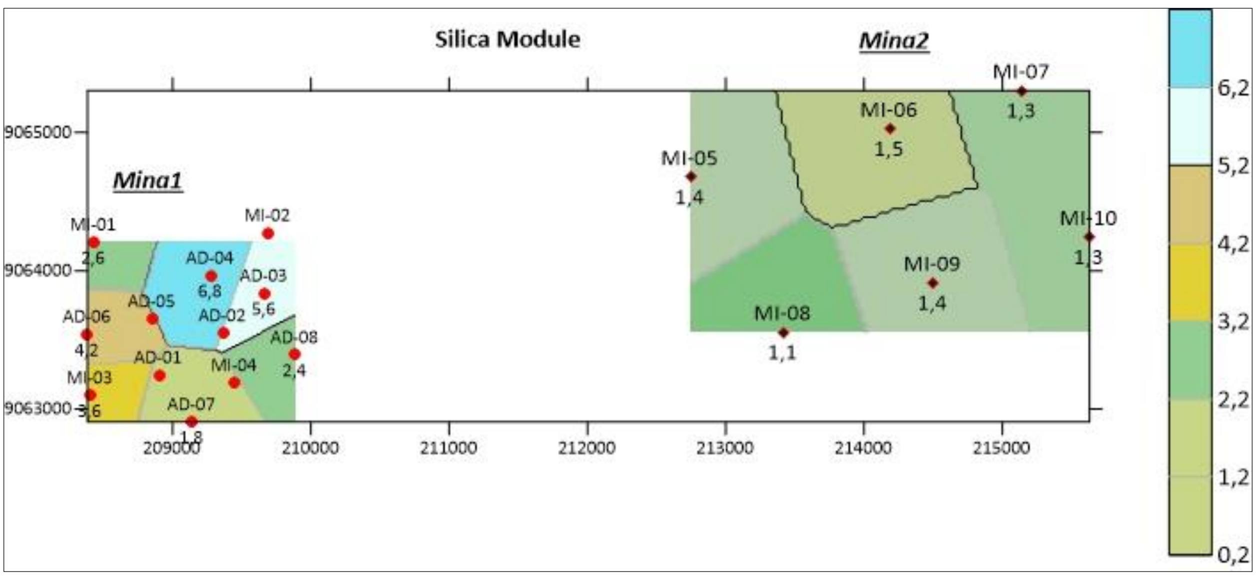

Figure 5.12 Silica model at Mine1 and Mine2

- Al-Fe module

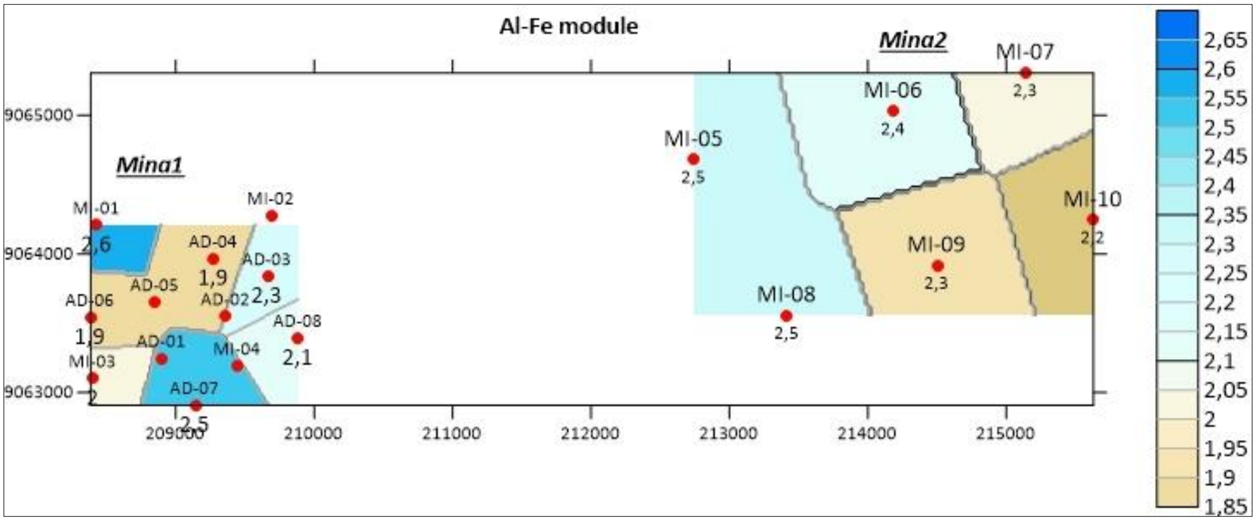

Figure 5.13 The module showing Al and Fe at Mine1 and Mine2

- Lime saturation module

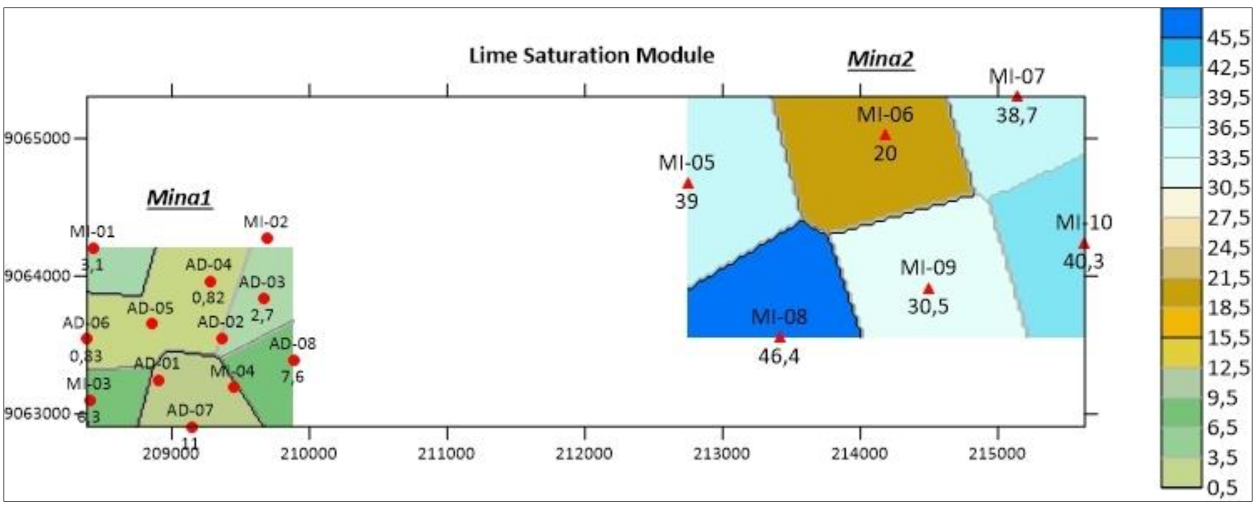

Figure 5.14 The figure showing lime saturation model at Mine1 and Mine2

5.1.1.4 Cross Section Profiles

For building lithologic profile sections, the closest point method has been used due to the fact that there are few boreholes available. For Mine1 three profiles are shown: A-B (direction), C-D (direction) and E-F (direction):

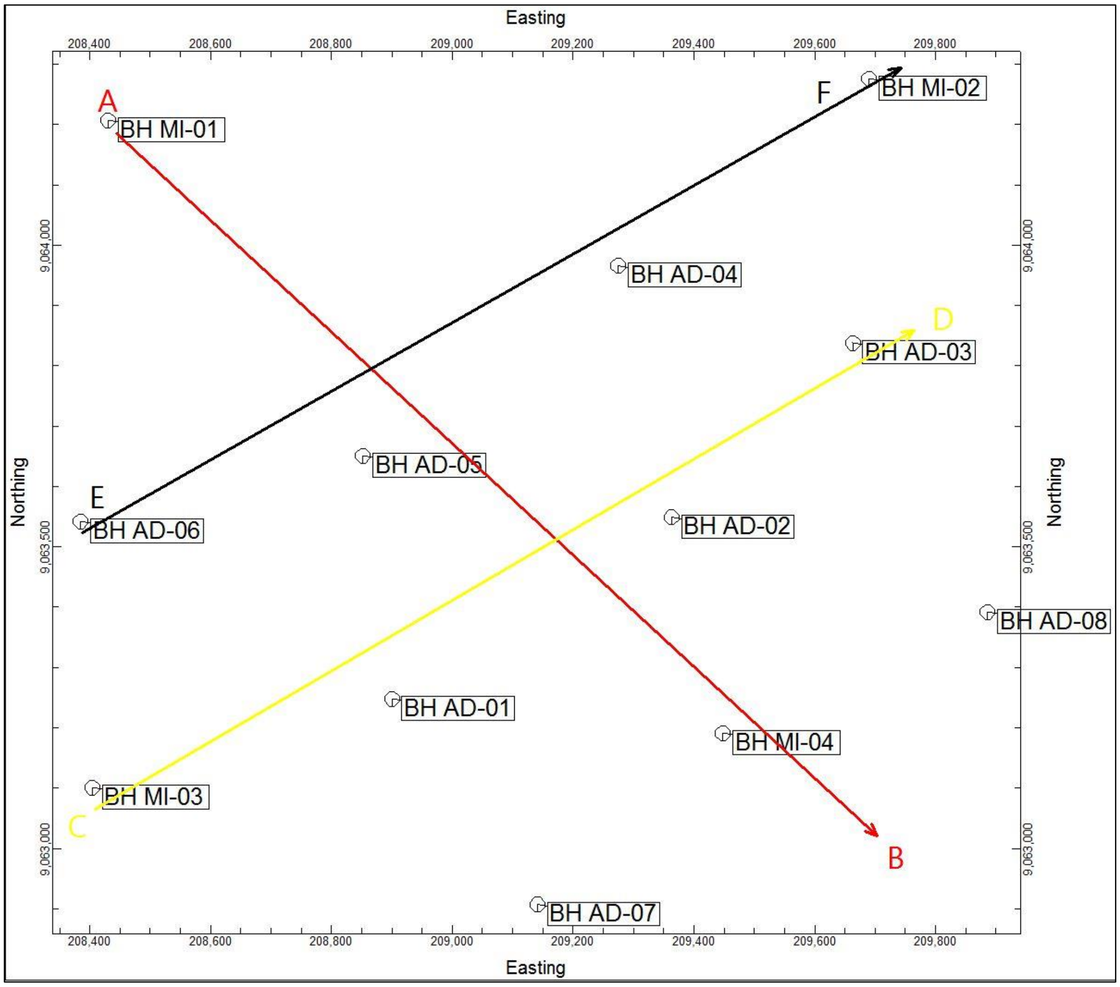

Figure 5.15 Lithology profiles section index map in block I-Mine1.

- Lithology section profiles A to B

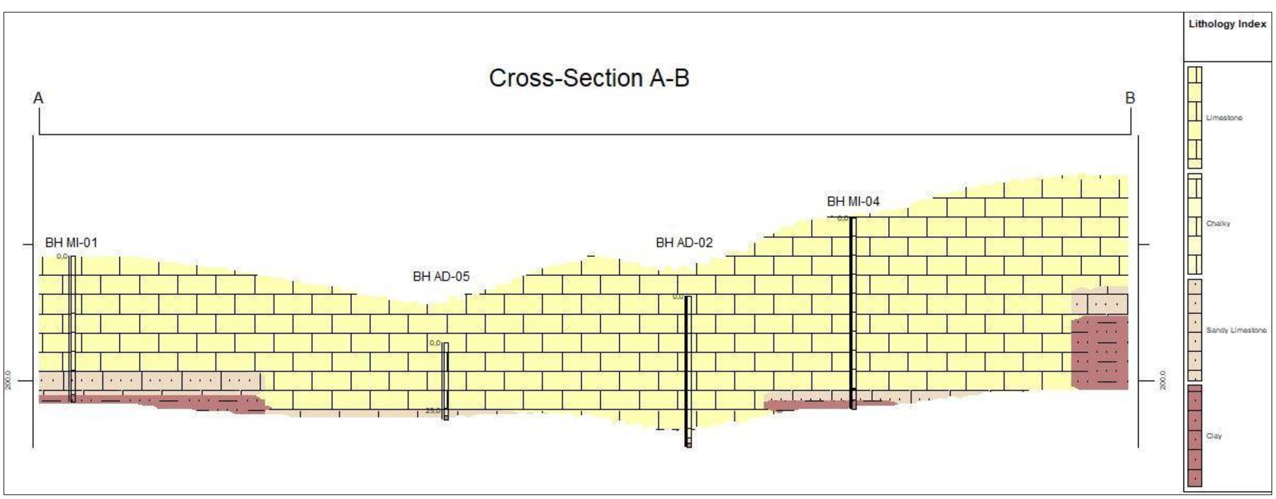

Figure 5.16 Lithology profile section A-B at Mine1, from borehole MI-01, AD-05, AD-02 and MI-04, there are limestone, sandy limestone and clay.

- Lithology section profiles C to D

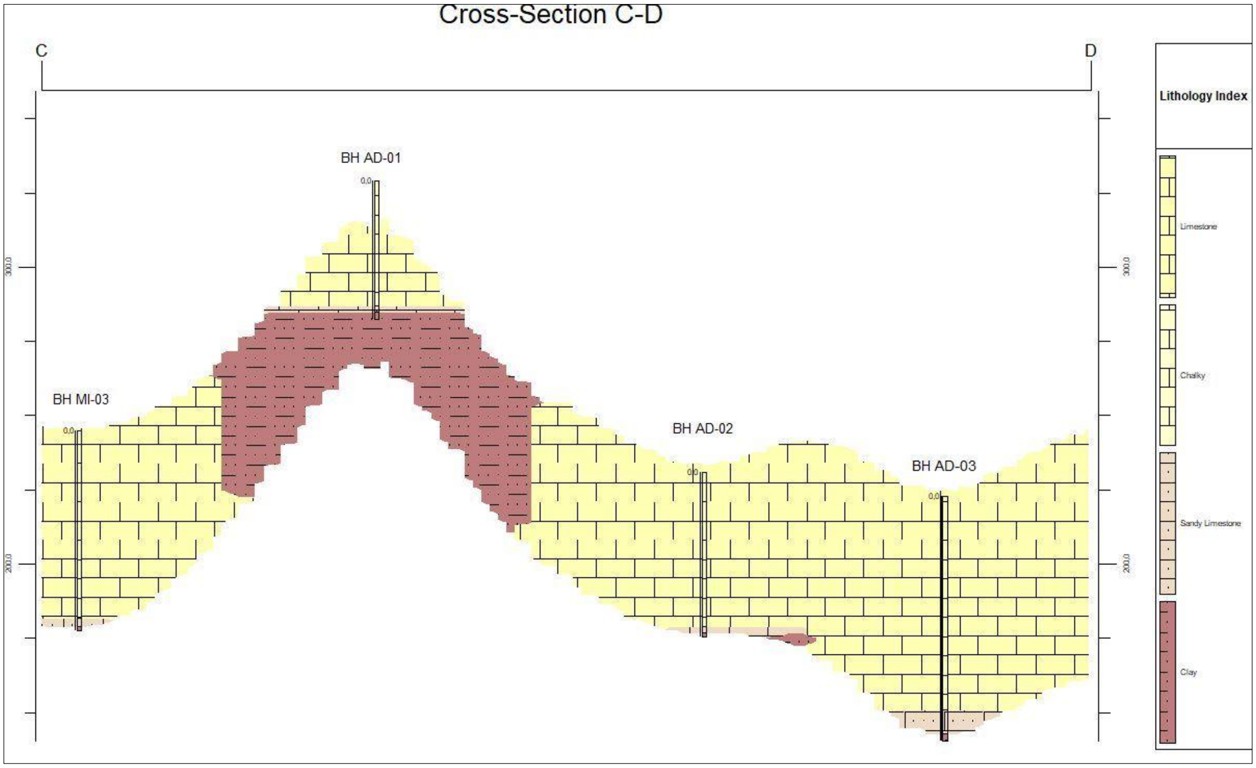

Figure 5.17 Lithology profile C-D at Mine1, based on this model there is structure at borehole AD-01.

- Lithology section profile E to F

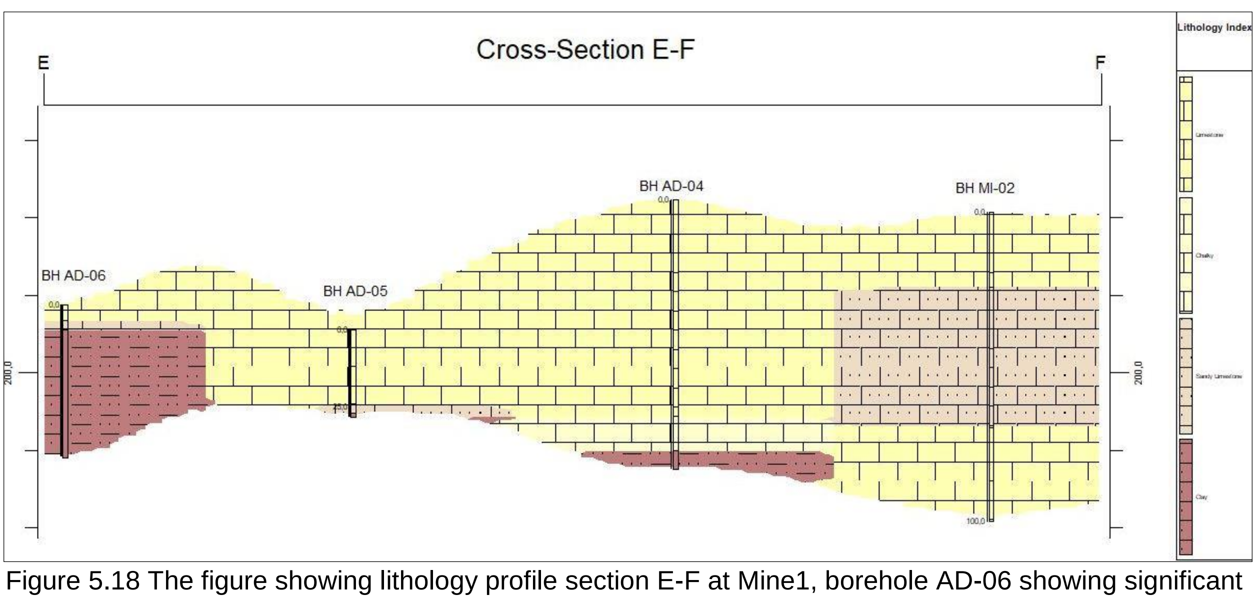

Figure 5.18 The figure showing lithology profile section E-F at Mine1, borehole AD-06 showing significant thickness of clay, borehole AD-04 showing limestone, chalky and clay, then borehole MI-02 showing significant sandy limestone and there is no clay.

5.1.2 Resources

5.1.2.1 Resources

The geological characteristics of a mineral deposit such as location, quality, grade, and continuity are deducted, estimated or interpreted from specific geological evidence and knowledge. Mineral resources are an occurrence of material of real economic interest in the area in such form and quantity that there are reasonable prospects for eventual economic extraction.

The general exploration conducted in the area has revealed that the limestone present in the surveyed area is of suitable quality and it will be the main component of raw-mix for cement manufacturing.

The **JORC (Joint Ore Reserves Committee) Code** is the Australian code for reporting of exploration results, mineral resources and ore reserves and a professional code of practice that sets minimum standards for public reporting of minerals exploration results, mineral resources and ore reserves. The **JORC code** provides a mandatory system for the classification of minerals exploration results, mineral resources and ore reserves according to the levels of confidence in geological knowledge and technical and economic consideration in public reports. The **JORC code** was first published in 1989, with the most recent revision being published late in 2012 (http://www.jorc.org/index.asp).

The Australian Joint Ore Reserves Committee Code (JORC) for mineral resources is an universally applicable scheme for classifying or evaluating mineral reserves and resources. Most importantly, it allows a common and necessary international understanding of these classifications or evaluations. Based on JORC code, there are several systems for classifying mineral deposits that consist in considering mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and government factors. Thus, the resources have been categorized as **Indicated Mineral Resources** as defined by the JORC code because the physical characteristics (quantity, grade, quality), can be estimated with **sufficient** confidence to allow the application of Modifying Factors in **sufficient** detail to support mine planning and evaluation of the economic viability of the deposit. However the level of confidence is not enough to be considered a “Measured Mineral Resource”. For this further studies are required.

Therefore, the total of limestone resources at the Block I-Mine1 are **89 854 800 cubic meters or 197 680 560 tons (assuming an average density of 2.2 tons/m^3)**. The detailed results are shown in the following. They have been calculated using the module ‘’ExtractSolid’’ of RockWorks (v17).

Solid Extraction Statistics

CaO:

Volume ... 89 854 800 Cubic meters

Mass ..... 197 680 560,0 Tons

Overburden:

Volume ... 23 978 000 cubic meters

Mass ..... 52 751 600,0 tons

Mine 1:

Volume ... 113 832 800 cubic meters

Mass ..... 250 432 160,0 tons

Stripping Ratio: 0,267:1

Maximum Mine 1 Depth: 94,8 meters

Stripping Ratio: 0,267:1

Assumptions:

- No maximum pit depth specified.
- Maximum Slope = -60,0 degrees.
- Maximum Bench Height = 10,0 meters
- CaO volume based on the following cutoff values;

  Minimum CaO Value: 40,0 percent
- Density Conversion Factor: 2,2 tons per cubic meters

5.1.2.2 Allowance (Correction Factor)

An allowance (Corection Factor) of 30% for cavity, error of estimation and mining losses has been considered.

Resources	= 197 680 560,0 tons
Correction Factor	= 30%
	= Resources x 70%
	= **197 680 560,0 tons x 70%**
	= **138 376 392 tons**

5.1.2.3 Mining Period

The mining period is a dynamic variable, dependent on the market and demand, but the TL Cement has targeted an average production around 1.65 million tons of cement per year. Theoritically, this means that if we want to produce 1.65 million tons of cement per year, then the quality of limestone needed will be about 3.3 million tons per year. Under these assumption, the mining period will be:

Reserves	= **138 376 392 tons**
Production Per Year	= **1 650 000 tons of cement equivalent 3 300 000 tons of limestone**
Mining Period	= **138 376 392 tons / 3 300 000 tons**
	= **42 years.**

5.1.2.4 Conceptual Open Pit

The conceptual open pit has been devised assuming the following constrainst:

- No maximum pit depth specified
- Maximum slope: 60^o
- Maximum bench height 10 m
- Cut-off grade of CaO: 40 %
- Density: 2,2

The conceptual (extraction diagram) open pit mining calculated using the module ‘’ExtractSoli’’ of RockWorks (v17) is shown in the following figure:

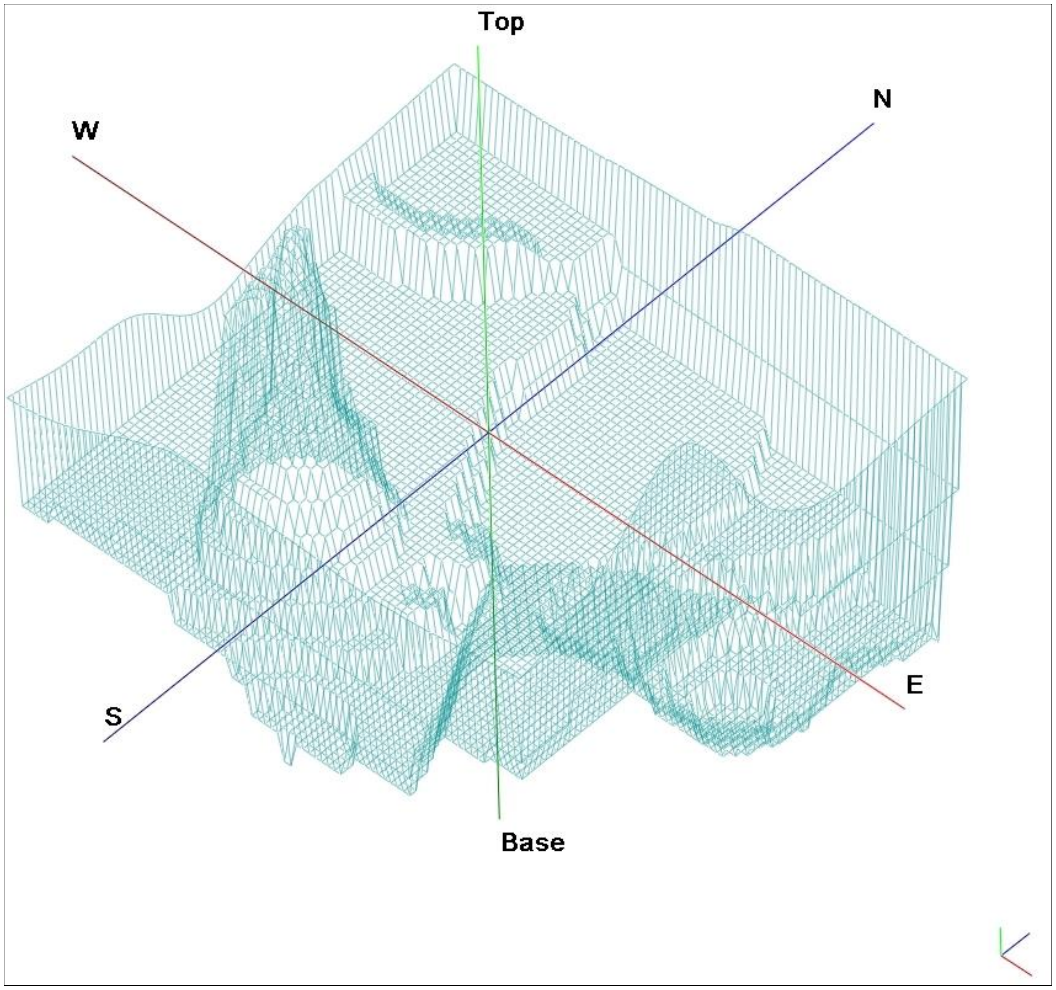

Figure 5.19 The conceptual view of open pit mining at Mine1 (extraction diagram)

5.2 Block I (Mine2)

There are six (6) boreholes in this area, where different lithologic units are found at different depths and with different averages in the chemical composition. In particular Al_2O_3, Cl, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, SO_3, SiO_2 and TiO_2 have been analyzed using the X-Ray Fluorescence (XRF) method. The mineral license area at Block I-Mine2 (Bucoli North Area) has **8 634 380 square meters** or **863.4 ha**.

5.2.1 Modelling chemical distributions

The modelling method selected was a conventional method, utilizing software RockWorks (v17). For modelling the chemical distribution, the algorithm IDW-Anisotropic (Inverse Distance interpolation) has been used, but selecting only the closest eight control points when computing a value for each voxel (volume element).

5.2.1.1 Chemical Composition Models

Based on laboratory results, six chemical composition models were built and some results are showing in the following figures:

a. Al_2O_3 distribution above 10%

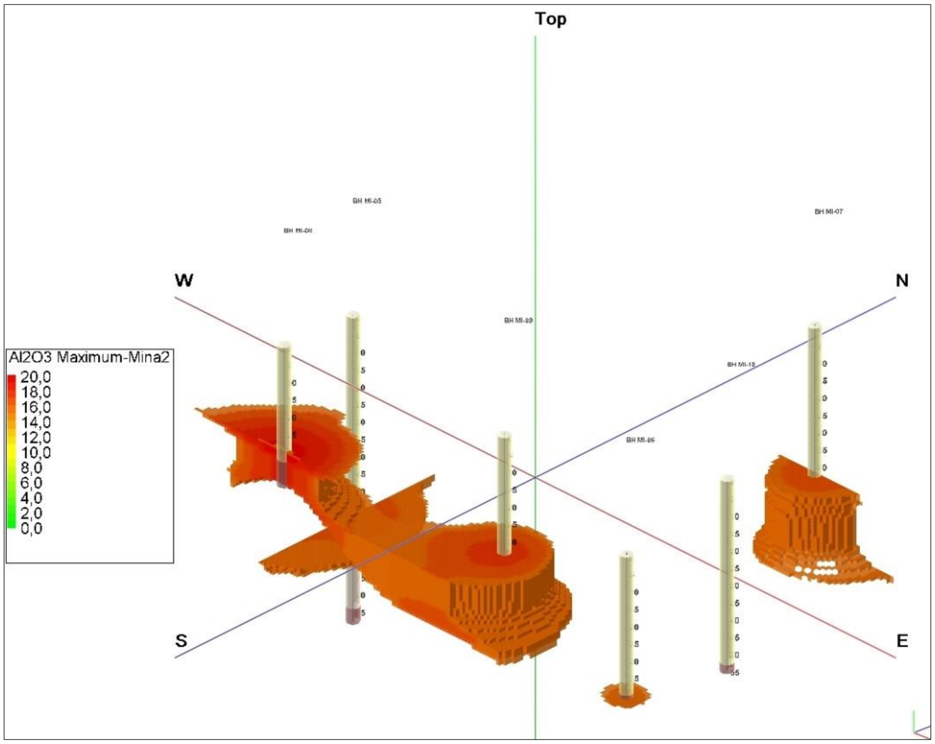

Figure 5.20 Model showing the distribution of Al_2O_3 above 10 percent at the southern part of this concession, while in the northern part it is associated with borehole MI-07.

b. CaO distribution above 40%

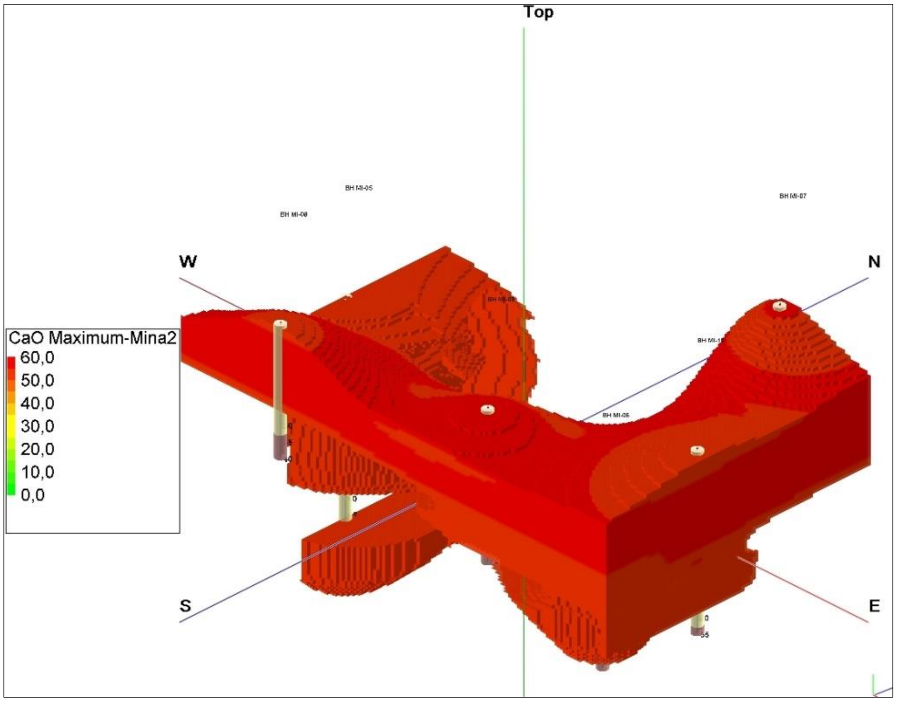

Figure 5.21 Model showing the distribution of Cao above 40 percent. Almost all boreholes in this concenssion have good quality limestone.

c. Cl distribution above 0,008%

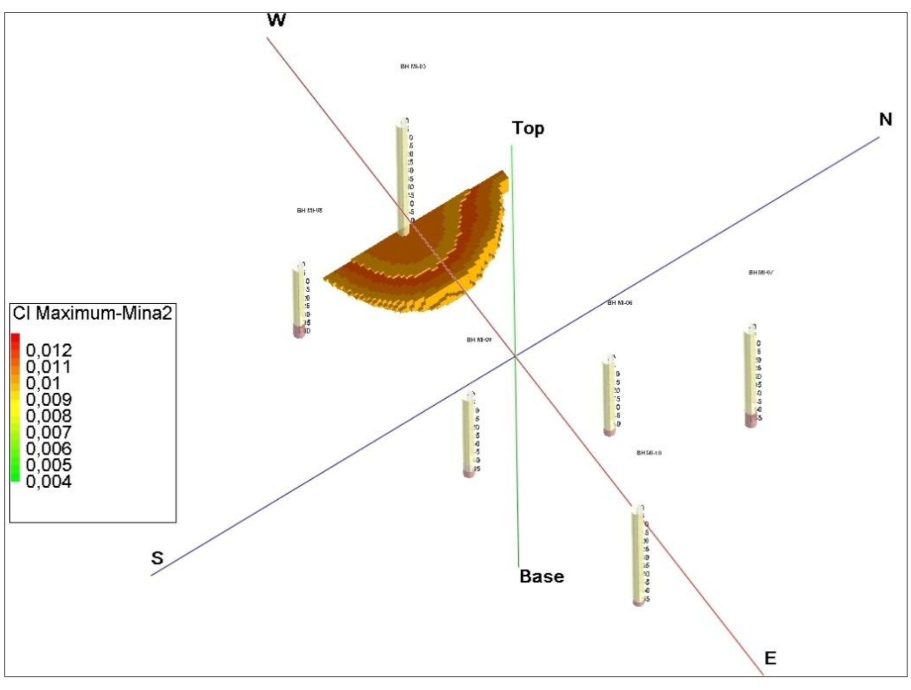

Figure 5.22 The maximum values of Cl (above 0.008 percent), only appear in the bottom of borehole MI-05. All the other boreholes have nothing.

d. Fe_2O_3 distribution above 4%

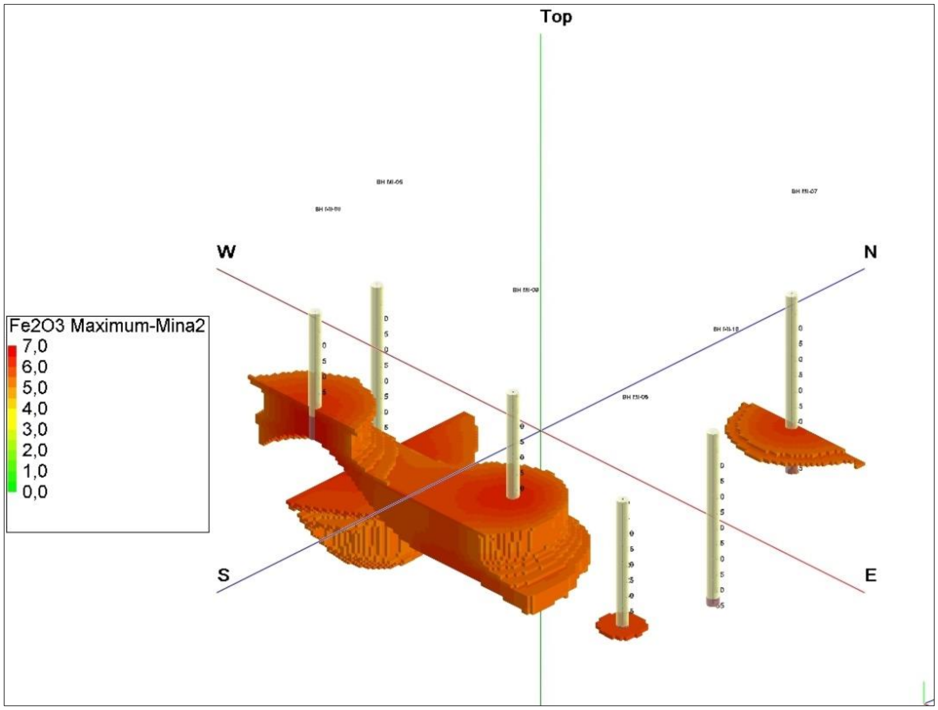

Figure 5.23 The maximum values of Fe_2O_3 (above 4 percent), appear in the bottom of the boreholes

e. K_2O distribution above 1.6%

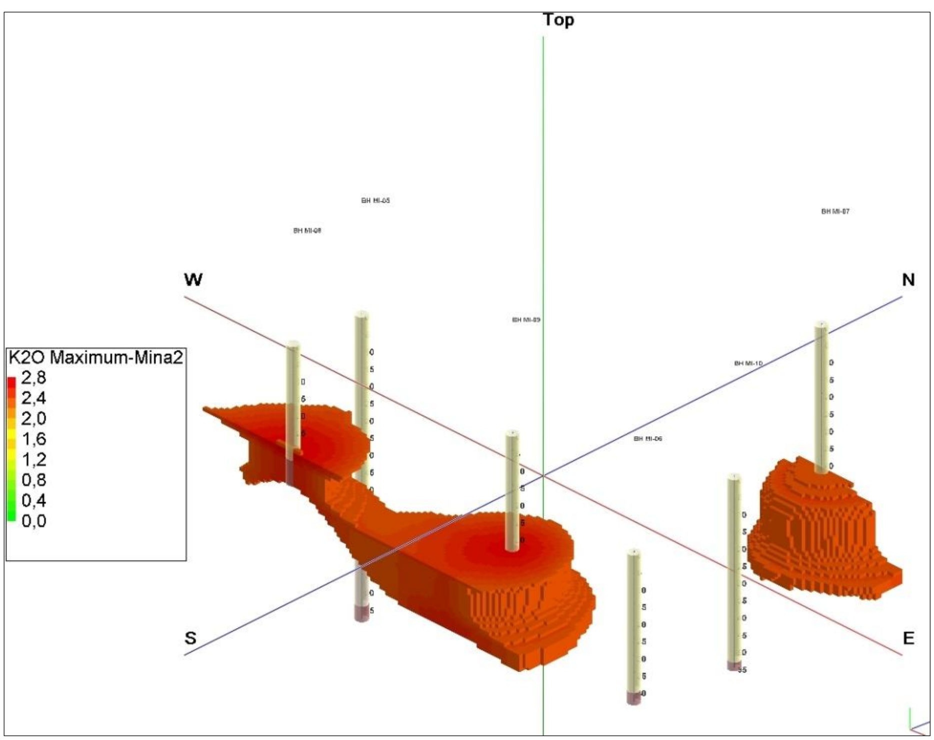

Figure 5.24 Model showing, the maximum K_2O values (above 1.6 percent) at boreholes MI-07, MI-08 and MI-09 at of the bottom of these boreholes. The others have values below 1.6 percent.

f. MgO distribution above 2%

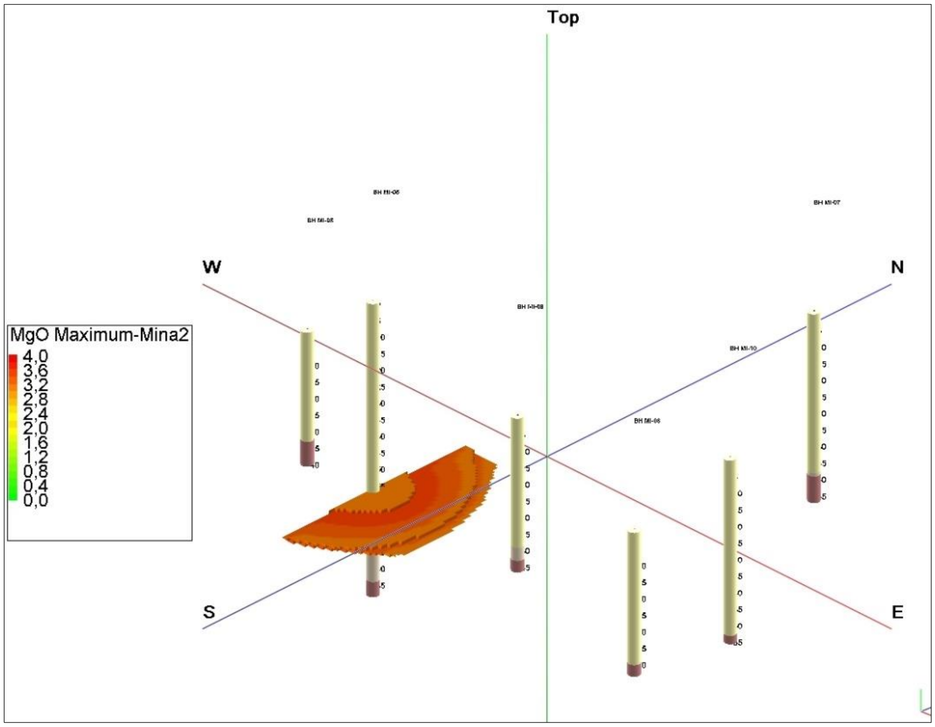

Figure 5.25 Model showing maximum values of MgO (above 2 percent) at borehole MI-05. All the other boreholes have values below 2 percent.

5.2.1.2 Cross Section lithology Profiles

For building the lithology profile section, it has been used the method ''closest point'' of RockWorks (v17) due to the fact that there are few boreholes available. Three profiles are represented: A-B (direction), C-D (direction), E-F (direction). The figures are shown below.

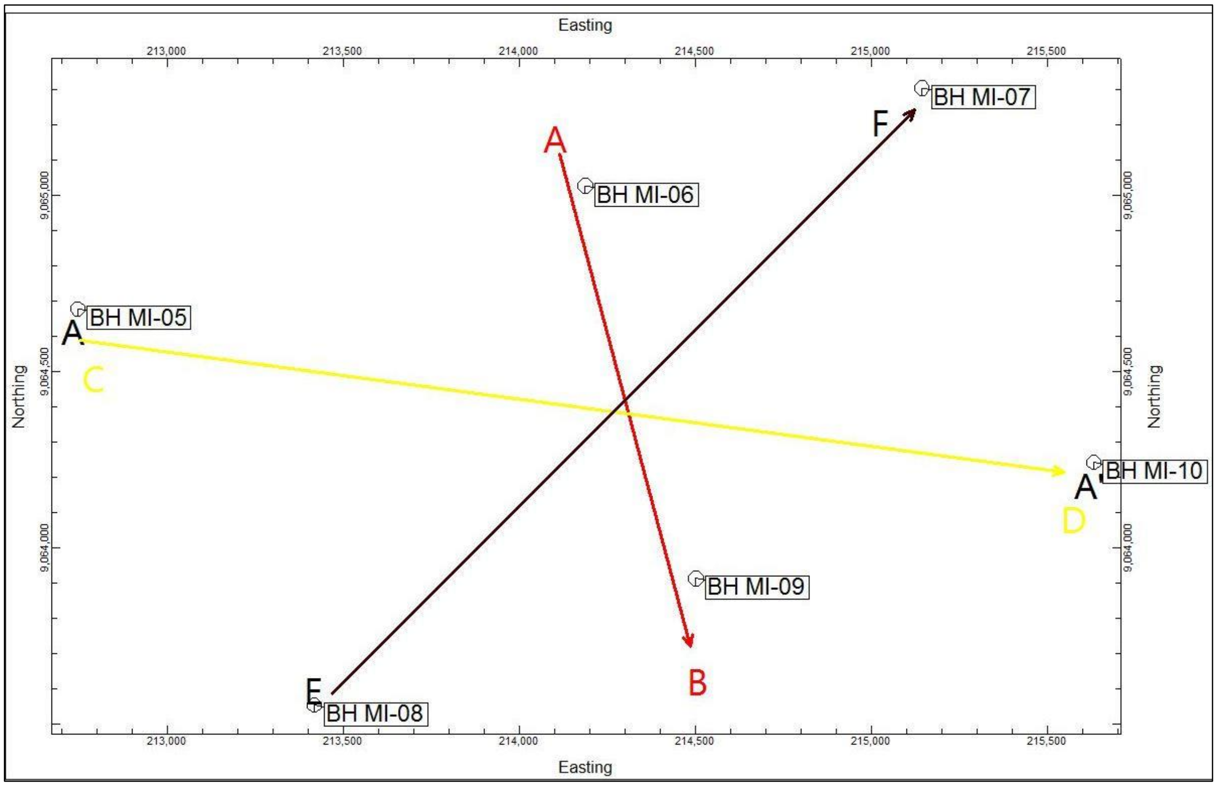

Figure 5.26 Lithology profile section index map in block I-Mine2

- Lithology profile section A-B

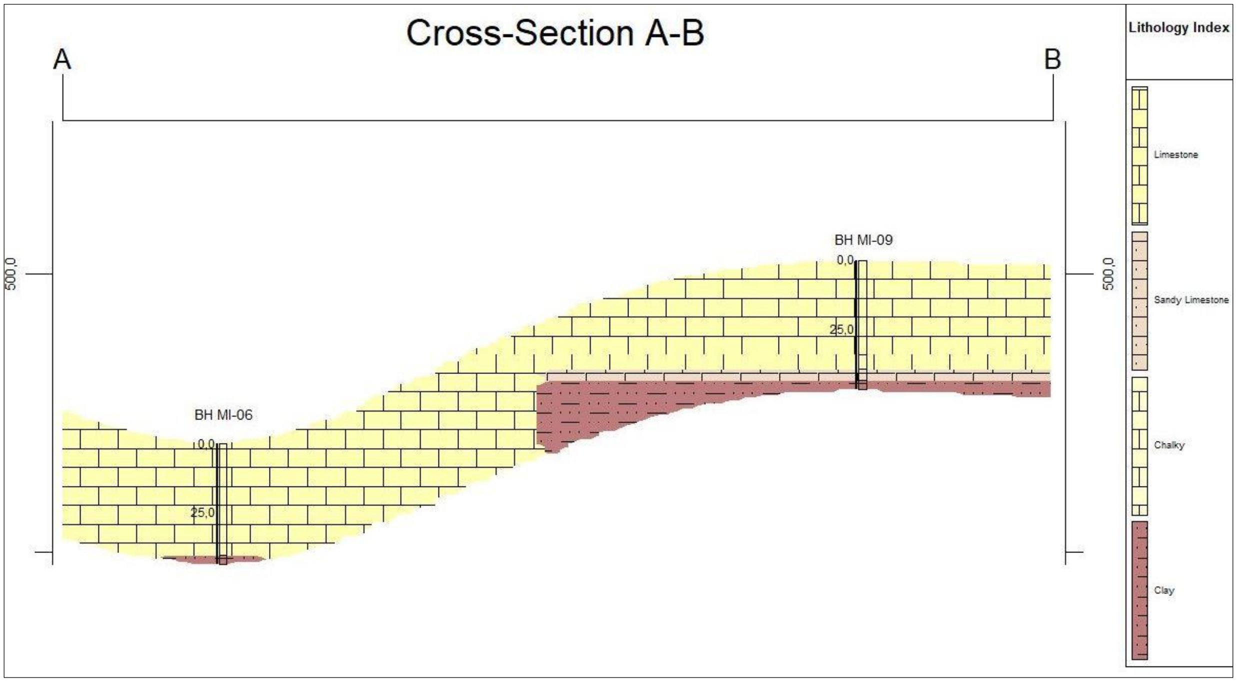

Figure 5.27 Lithology profile section A-B at Mine2 from borehole MI-06 to MI-09

- Lithology profile section C-D

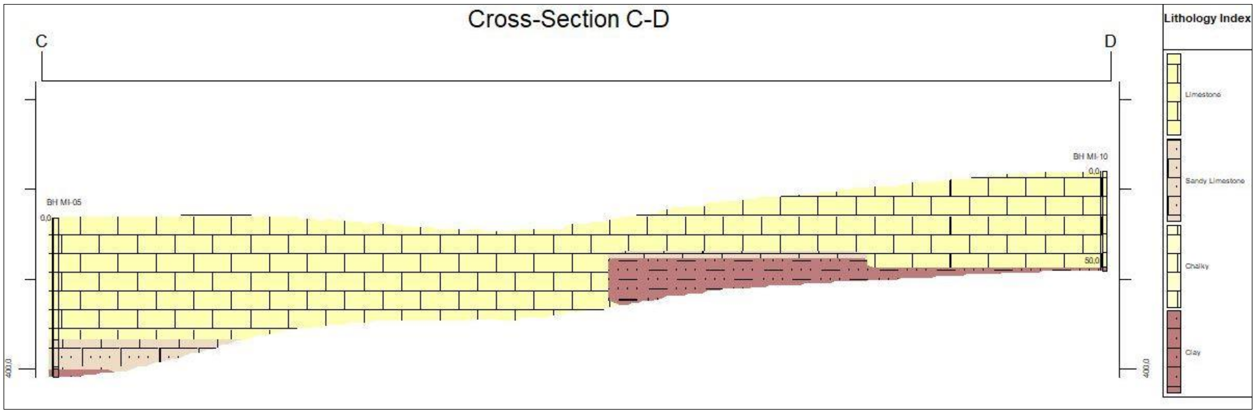

Figure 5.28 Lithology profile section B-C at Mine2

- Lithology profile section E-F

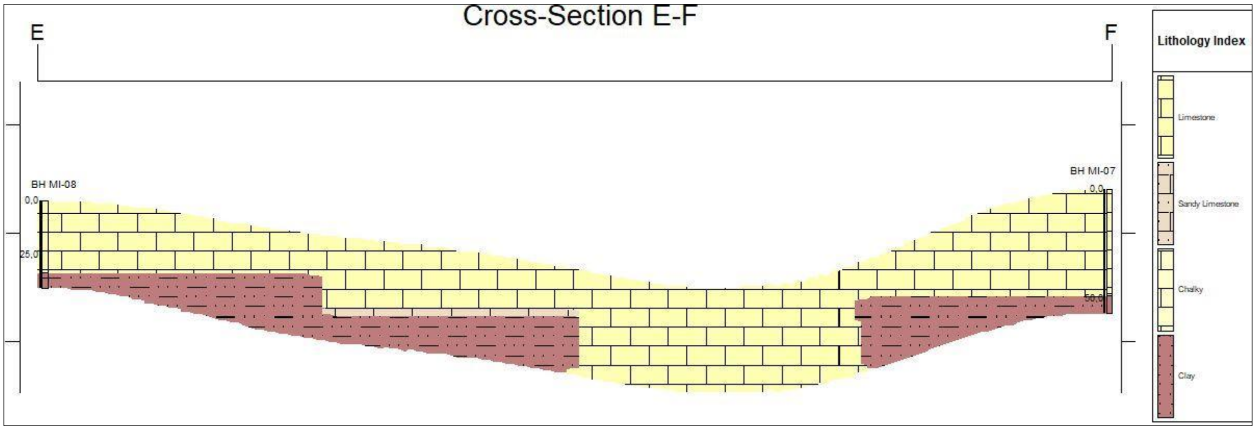

Figure 5.29 Lithology profile cross section E-F at Mine2

5.2.2 Resources

5.2.2.1 Resources

The Australian Joint Ore Reserves Committee Code (JORC) for mineral resources is an universally applicable scheme for classifying or evaluating mineral reserves and resources. Most importantly, it allows a common and necessary international understanding of these classifications or evaluations. Based on JORC code, there are several systems for classifying the mineral deposits that consist in considering mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and government factors. Thus, the resources have been categorized as **Indicated Mineral Resources** as defined by the JORC code because the physical characteristics (quantity, grade, quality), can be estimated with **sufficient** confidence to allow the application of Modifying Factors in **sufficient** detail to support mine planning and evaluation of the economic viability of the deposit. However the level of confidence is not enough to be considered a “Measured Mineral Resource”. For this further studies are required.

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Therefore, the total of limestone resources at the Block I–Mine2 are **181 627 600 cubic meters or 399 580 720 tons** (assuming a density of 2.2 tons/m3). The detailed results calculated using module ''Extract Solid'' from RockWorks (v17) are shown below.

Solid Extraction Statistics

CaO:

Volume ... 181 627 600 cubic meters

Mass ..... 399 580 720,0 tons

Overburden:

Volume ... 22 007 200 cubic meters

Mass ..... 48 415 840,0 Tons

Pit Name:

Volume ... 203 634 800 cubic meters

Mass ..... 447 996 560,0 tons

Stripping Ratio: 0,121:1

Maximum Pit Name Depth: 88,6 meters

Stripping Ratio: 0,121:1

Assumptions:

- No maximum pit depth specified.
- Maximum Slope = -60,0 degrees.
- Maximum Bench Height = 10,0 meters
- CaO volume based on the following cutoff values;

    Minimum CaO Value: 40,0 percent

- Density Factor: 2,2 tons/m3

5.2.2.2 Allowance or Correction Factor

An allowance (Correction Factor) of 30% for cavity, error of estimation and mining losses has been considered.

Resources	= **399 580 720,0 tons**
Correction Factor	= **30%**
	= **Resources x 70%**
	= **399 580 720,0 tons x 70%**
	= **279 706 504 tons**

5.2.3 Mining Period

The mining period is a dynamic variable, dependent on the market and demand, but TL Cement has defined that production will be around 1.65 million tons of cement per year. Teoritically, this means that if we want to produce 1.65 million tons of cement per year, the quality of limestone necessary will be around 3.3 million tons per year. Therefore, the mining period will be:

Resources	= **279 706 504 tons**
Production Per Year	= **1 650 000 tons of cement equivalent 3 300 000 Tons of Limestone**
Mining Period	= **279 706 504 tons / 3 300 000 tons**
	= **85 years.**

5.2.4 Conceptual Open Pit

The conceptual open pit at Mine2 has been modelled using the module ''Extract solid'' from RockWorks (v17). The following assumptions have been considered:

- No maximum pit depth specified
- Maximum slope: 60º
- Maximum bench height 10 m
- Cut-Off value of CaO 40 %
- Density : 2,2

The resulting conceptual (extraction diagram) open pit mining is shown in the following figure:

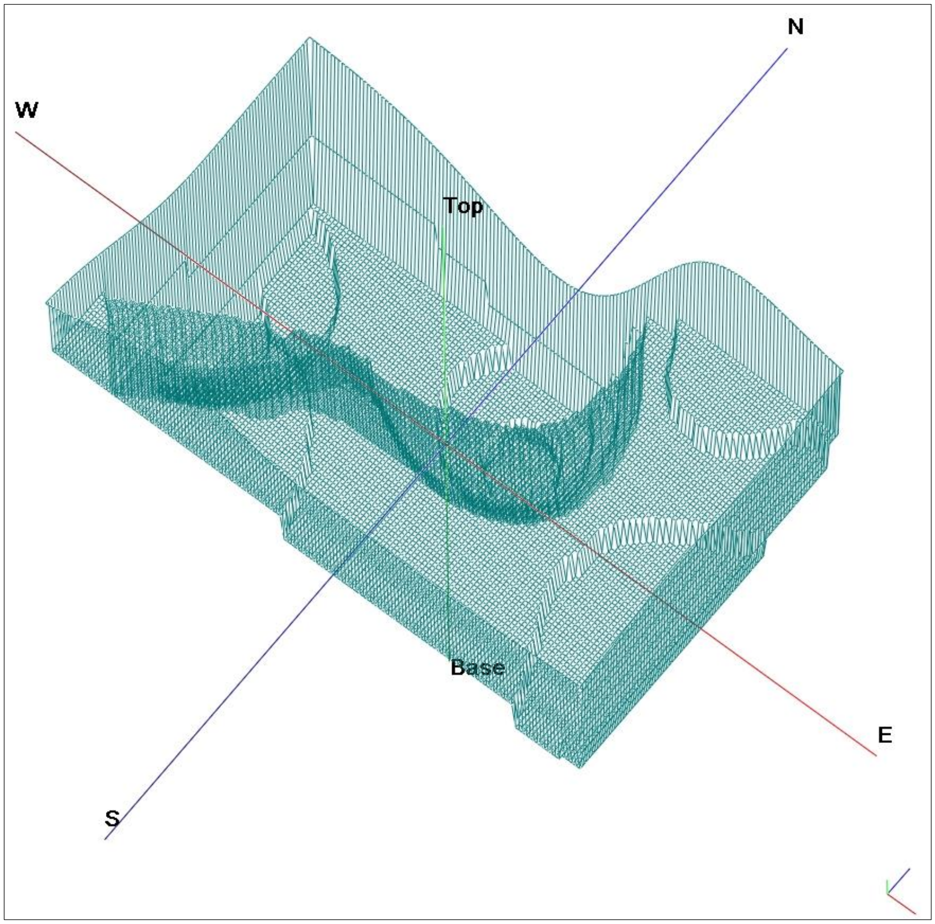

Figure 5.30 Extraction diagram for Mine2

Chapter 6
Conclusions and Recommendations

6.1 Conclusions

Limestone is one of the main ingredients for producing cement, while gypsum, silica and clay are the complementary raw materials.

In the licensing area that the company has obtained, there are two blocks at the concession area that consist of block I (Mine1 and Mine2) and block II (Mine3). A total of 12 boreholes have been drilled in block I-Mine1, 6 boreholes in block I-Mine2 and 2 boreholes in block II-Mine3. The case of block II-Mine3 is just mentioned but it has not been analyzed due to the lack of borehole data. From the borehole data available and general geological information, it has been concluded that:

1. At the concession areas several lithologic units are encountered namely; top soil, coral reef limestone, sandy limestone, chalky and clay,
2. The concession area of block I-Mine 1 is **5.789.136 square meters or 578.9 ha** and the area of block I-Mine2 is **8.634.380 square meters or 863.4 ha**. For the estimation of resources the total areas were not considered, only partial areas due to existing, roads, rice fields community residence and available borehole data,
3. Modelling of chemical distributions and lithology has been made with RockWorks (v17). Surfer (v16) has been used for 2D mapping,
4. The calculated limestone resources at block I-Mine1 are **138 376 392 tons** resulting in the mining period of about **42 years** based on the company target of **1.65 tons** of cement per year. However, the mining life is dynamic variable dependent on the market demand,
5. The calculated limestone resources at block I-Mine2 are **279 706 504 tons** resulting in a mining period of about **85 years**,

6.2 Recommendations

1. A more detailed resource estimation would require borehole data and more detailed studies on the concession area,
2. For the future, the company should follow good mining practices in order to reduce environmental impacts,
3. The quality of limestone at block I-Mine 2 is good with and average of 54-55% of CaO while in block I-Mine1 the average varies from 42-53%. Thus, it is recommended that the company mines both Mine1 and Mine2, in order to obtain a mix from both sites of very good quality throughout the production period (of around 120 years).

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