وزارة الطاقة والثروة المعدنية

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Ministry of Energy and Mineral Resources

Directorate of Natural Resources Studies

Prospecting Studies Department

# Gypsum in the Azraq Area

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# Summary

The exploration of gypsum project for Azraq area began in 2017. The project defined presence of gypsum outcrops in Azraq formation which located in Al-Azraq area about 120 km south of Amman. GP1 to GP 60 Boreholes have been drilled in Al-Azraq area, so that the gypsum thickness reached 3 meters that increases in south and southwest of the study area, and decreases as we move towards the north and northwest of study area. The overburden thickness is ranged between zero and 1.5 meters. The gypsum beds characterized by white and pure gray colors and sometimes mixed with small proportions of greenish-gray clay, fine sand, silt and calcite. The chemical analyses showed that average of gypsum ranged between 60 & 80% .The total primary reserves of gypsum in project reached about 6 million metric tons until now.

# (1) Introduction

## 1.1Overview

Gypsum is one of non-metallic sedimentary ores and characterized by white color & varies according to impurities of ore. The hardness of gypsum ranged between 1.5 & 2.5 with specific weight about 2.3.

Gypsum chemically composed of hydrated calcium sulfate through precipitation of $CaSO_4.2H_2O$ as a result of evaporation of supersaturated aqueous solutions in shallow seas of carbonates, then sulfates and chlorides, which have a high content of $SO_4^{-2}$ and $Ca^{+2}$ ions (Lutzi, 1957).

CaO: 31-34(٪32.6) ٪

$SO_3$: 40-47(٪46.5) ٪

$H_2O$: 21٪

Gypsum associates with different quantities of carbonate, clay, and other impurities. It also can be found in many forms such as: selenite, satin spar (fibrous), gibbsite and cluster gypsum.

## 1.2 Gypsum uses

Gypsum is usually found in the earth's crust, mined, processed and used in construction or decoration which formed as baster or alabaster since 9000 BC.

(www.eurogypsum.org).

Gypsum can be also:

added to bread and dough mixtures as a calcium resource in baking process

used as a filler and fire retardant in plastic products

used in Portland cement and specialty cement products to control expansion and stabilization.

used as a source of calcium and sulfate for plant growth.

used as a modeling material for dental restorations.

used with glass to manufacture large and lightweight architectural decorations

used as a molding material for manufacturing chassis parts specified for trucks and cars.

used as a catalyst in extracting juice for some fruits and vegetables.

used as gypsum board where was discovered by American Augustine Sackett in 1888 when he invented a machine to produce gypsum board (also known as drywall and wallboard) that consists of several layers of paper with gypsum interchangeably.

Natural, uncalcined gypsum is used for the following purposes:

1. Cement industry.
2. Fertilizers
3. Increasing the soil permeability
4. Glass Industry
5. Carrier of insecticides for its high absorbency.
6. Wood filler, fabric, paper and paint industry.
7. Chimney desulfurization
8. Drilling the oil boreholes with mud

**On the other side, calcined gypsum is used in:**

1. Building decorations
2. Medical and pharmaceutical industries
3. Ceramic industries and molds.

## 1.3 Background

The gypsum deposits has been recorded in Jordan for the first time in 1970. Since that time, many exploration and geological studies have been conducted to estimate the reserves and characteristics of these deposits.

The gypsum in Jordan has attracted many workers because of its economic value and wide distribution. These studies include:

- In 1984, Muhammad Tuaima studied the existence of gypsum in Jebel Malih area / Tafila district. This study included mapping, prospecting & drilling. Many samples were collected and analyzed, and the geological reserve of gypsum was estimated.
- In 1984, Technostone S.P.A. Company studied gypsum in Wadi Zarqa and collected many samples. The results of chemical analyses of these samples showed that gypsum in this area is pure and suitable for Portland cement and plaster industries.
- In 1986, Ajlouni and Gharaibeh studied the existence of gypsum in Jebel Malih area. Many boreholes were drilled; the samples were collected for chemical analyses and estimation of the geological reserve of gypsum.
- In 2000, Madanat and others. Muhammad Ali, Study of the existence of gypsum in the area between Wadi Dahl and Rashidiya / Tafila District. Several trenches were drilled and many samples were collected for chemical analyses and gypsum reserve estimation.
- In 2018, Jordan's production of mineral gypsum was published globally for the years 2014 to 2018, as shown in Table (1.1)

***Table (1.1) Jordan's production of gypsum (thousand metric tons)***
(USGS Minerals Year Book ،2018)

| Year | 2018 | 2017 | 2016 | 2015 | 2014 |
|---|---|---|---|---|---|
| Production | 250 | 253 | 240 | 228 | 223 |

## 1.4 Gypsum existence in Jordan

1-Zarqa River Basin / Al-Subaihi area. Gypsum outcrops at the confluence of Wadi Al-Azab and Al-Huna with the Zarqa River in the Abu Ruwais Formation - Triassic period. The thickness of gypsum reaches 60m, and the rocks overhead it are about 14m thick.

2-South Jordan region, gypsum deposits lie in the following areas:

- Malih / Tafila
- Wadi Al-Hassa
- Karak
- Wadi Mujib

Gypsum layers, ranging in thickness from 20cm to 4m , were found in the undifferentiated region of the Fuheis, Hamar and Shuaib formations (late Kinomanian - early Turonian) and in the lower part of the Wadi Sir (Turoni) formation.

3- Azraq area: gypsum deposits are located in the Azraq Formation (Holocene) in the form of alternating layers with clay or thin layers up to 25-50cm thick in the south and southwest of the Azraq basin.

4- Al Lisan area: The deposits in the Al Lisan area emerged in the formation of Al Lisan Marl (Holocene).

5- Jabal Bani Hameedah area, gypsum covers at the intersection of Wadi Al-Haidan and Wadi Mujib within the Suhaib Formation (Snomani). Covering thickness reaches 4-6m.

## 1.5The geological location and setting in general at Jordan

Figure (1.1) and Table (1.2) &(1.3) represent the areas that have been studied for gypsum ore by the Natural Resources Authority

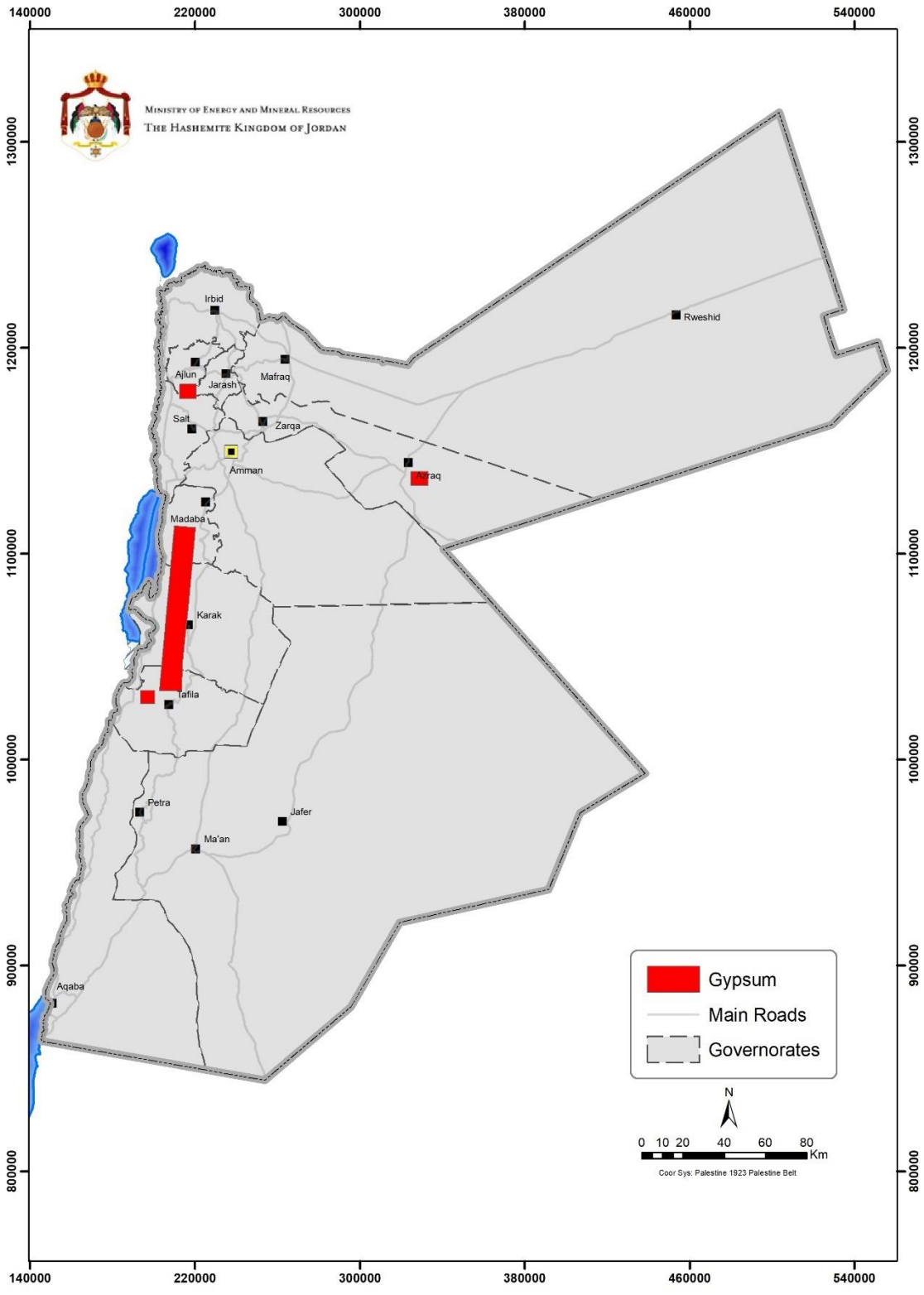



*Figure (1.1) the studied areas of gypsum ore by the Natural Resources Authority*

*Table (1.2) Areas of gypsum existence in Jordan*

| | Area | Coordinates | | Image name |
|---|---|---|---|---|
| | | North | East | |
| | Zarqa river | 1176.5 – 1177.5 | 217 – 220.8 | Salt |
| | Jabal Bani Hameedah | 1095 - 1102 | 207 - 214 | Rabbeh and Ma'in |
| | Wadi Mujib | 1093.7 -1095.8 | 226 – 228.5 | Dhiban- Wadi Mujib |
| | Wadi Bin Hammad&Wadi AL-Karak | 1073.5 -1080 | 211.5 - 213.5 | rabba |
| | North Wadi al-Hasa Jabal Malīḥ | 1038 -1044 | 202 - 210 | At-Tafilah |
| | Azraq | 1110 - 1121 | 352 - 362 | ALHaziem boreholes |
| | Wadi ad Dahl | 1023 -1028.5 | 190 – 196.5 | Fifa |

*Table (1.3) the five most important areas of gypsum existence in Jordan*

| Number | Area | Configuration | Age |
|---|---|---|---|
| 1 | Zarqa River Basin | Abu Ruwais | Triassic |
| 2 | Central and southern of Jordan : (Maleih / Tafila, Wadi Al-Hasa, Wadi Karak, Wadi Mujib) | Fuhais, Hamar, Shuaib, Wadi Al-Seer | Turonian-Sinomani |
| 3 | Azraq | Azraq | The Quaternary |
| 4 | Lisan | Lisan Marl | The Quaternary |
| 5 | Jabal Bani Hameedah | Shuaib | Sinomani |
| 6 | ad Dahl | Fuhais, Hamar, Shuaib | Sinomani |

## 1.6 Chemical composition and reserves of gypsum in Jordan

The mineral composition of gypsum has been studied in the most important areas in Jordan, the highest value of gypsum was in Jabal Bani Hameedah , as shown in Table (1.4). As for the purity of rock containing gypsum, it is shown in Table (1.5).

***Table (1.4) the areas of gypsum existence in Jordan and the chemical properties of the gypsum***

| Area | $SO_3$ % | CaO % |
|---|---|---|
| Zarqa River Basin | 40-47 | 31-34 |
| Central and southern of Jordan | 37-46 | 25-35 |
| Azraq | 42-45 | 32-35 |
| Lisan | 35-43 | 23-36 |
| Jabal Bani Hameedah | 45-60 | 32-36 |
| Ad Dahl | 36-55 | 29-39 |

***Table (1.5) the areas of gypsum existence in Jordan and the chemical properties of the gypsum-containing rock***

| المنطقة | $SiO_2$ | $Al_2O_3$ | CaO | $TiO_2$ | $Na_2O$ | $K_2O$ | $Fe_2O_3$ | MgO | $SO_3$ | L.O.I |
|---|---|---|---|---|---|---|---|---|---|---|
| Wadi Zarqa[1] | 3.23 | 1.56 | 36.10 | ---- | 0.46 | 0.09 | ---- | 0.84 | 48.51 | 9.10 |
| Azraq | | | 32-35 | | | | | | 42-45 | |
| Lisan | | | 23-36 | | | | | | 35-43 | |
| Jabal Bani Hameedah | | | 32.93-36.43 | | | | | | 45.30-50.9 | |
| South of Jordan | | | | | | | | | | |
| Ad Dahl[1] | 0.82-5.85 | 0.05-1.93 | 29.43-39.50 | 0.01-0.09 | 0.04-6.53 | 0.05-1.73 | 0.04-1.29 | 0.05-3.40 | 36.01-55.15 | 2.11-22.98 |
| Al mlih[3] | 0.90-7.35 | 0.02-0.93 | 26.32-43.60 | ---- | 0.01-1.11 | 0.01-0.36 | 0.01-1.57 | 0.03-4.89 | 40.56-51.38 | 5.77-24.22 |
| Al mlih[2] | 1.11-11.95 | 0.02-0.34 | 28.42-36.92 | ---- | 0.02-0.13 | 0.03-0.82 | 0.03-3.2 | 0.11-4.15 | 33.83-47.19 | 7.97-20.90 |
| Wadi Al Gar [2] | | | 25.36-35.00 | | | | | | 37.62-45.89 | |
| Emma[2] | | | 25.98-35.00 | | | | | | 32.05-43.37 | |
| Nimta [2] | | | 30.23 | | | | | | 39.11 | |
| sanifahat [2] | | | 30.49-30.78 | | | | | | 38.09-41.47 | |
| Wadi Al-Hasa[2] | | | 31.00-37.63 | | | | | | 42.08-46.12 | |
| Wadi Karak[2] | | | 28.12-31.52 | | | | | | 39.82-44.71 | |
| Jabal Bani Hameedah[2] | | | 29.31 | | | | | | 40.98 | |
| Wadi Mujib[2] | | | 28.79-32.56 | | | | | | 37.37-44.72 | |

Compound sample results: [1]
Results of trench samples: [2]
Boreholes samples results: [3]

*Table (1.6) the geological reserve of gypsum in Jordan*

| **Area** | The geological reserve(**million tons)** | **Gypsum thickness (m)** |
|---|---|---|
| Zarqa River Basin | 10 | 60 |
| Central and southern of Jordan | 8 | 0.2-4 |
| AL Azraq | 3 | 0.25-0.5 |
| AL lisan | Not estimated | 1-1.2 |
| Jabal Bani Hameedah2 | Not estimated | 0.8-1.2 |
| Ad Dahl | 0.284 | 0.5-3.9 |

*Table (1.7) Estimation of the various reserves of gypsum in Jordan*

| **Area** | **Thickness** | **Reserve** | | |
|---|---|---|---|---|
| | | **'The geological** | **The signifier** | **Fixative** |
| Wadi Al Zarqa | | 10 MT | 1.725 M.ton | |
| Wadi Al Gar | 3.2-5.9 m | | 167000 ton | |
| Imma/Namta | 1.2-3.2 m | | 165000 ton | |
| Wadi Al-Hasa | 1-.2.9 m | | 73000 ton | |
| Al mlih | 1.5-2.5 m | | 562000 ton | |
| Wadi Mujib | 7.25 m (sum) | | 2367 M ton | |
| Ad Dahl( five areas ) | 4.9 m (sum) | | | 284189 ton |
| Azraq | 0.25-0.50 m | 3 M.ton | | |
| Al Lesan | 0.4-1.2 m | | | Undefined |
| Jabal Bani Hameedah (four areas) | 0.6-1.2 m | 741750 ton | | |

## 1.7 Aim of the project

This project aims to find the main area to attract the companies for investment in gypsum.

## 1.8 The study area location

The study area can be determined by the coordinates given in Figure (1.2) by the Palestinian square

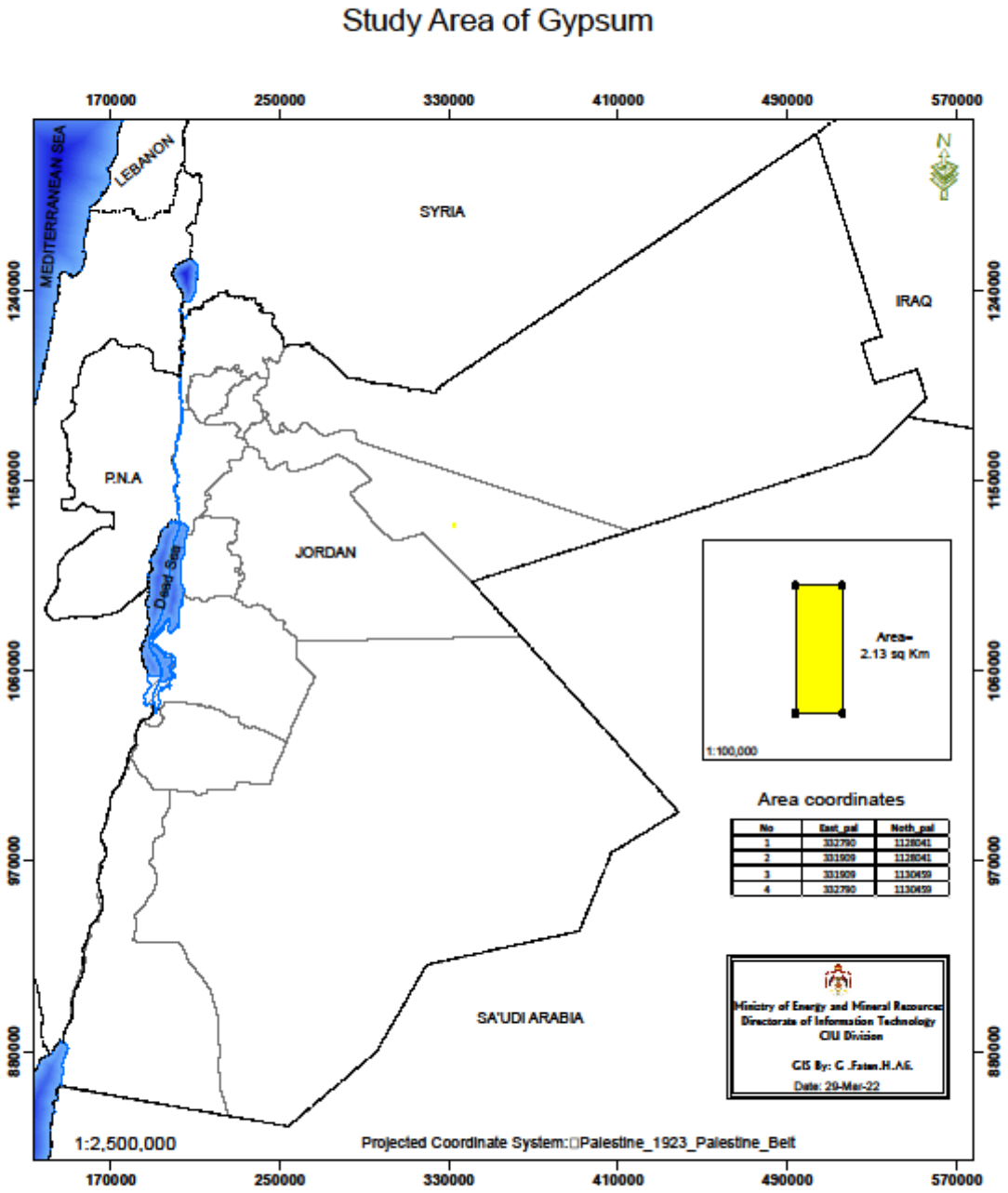



***Figure (1.2) The study area of the gypsum project in Azraq***

## 1.9 Geological situation of gypsum in the study area

Gypsum is found in the salt pans area in form of alternating layers with layers of clay, and in form of fresh sediments mixed with soil in the nearby areas towards Wadi Al-Ghadf. In (1975), Salamah studied the gypsum sediment in Al azraq salt pans between two main layers

which mixed with rock salt and clay. Gypsum exists in the salt pans area as large crystals of pure size of selenite and characterized by twinning. Gypsum seems have been deposited in a large closed saline lake, at the end of the Ice Age.

The gypsum deposits formed in the modern era as figure (1.3) in Al Azraq area & Wadi Al-Ghadaf. A detailed study resulted by Abu Jiyab (2001) on these sediments and showed that the gypsum exists in association with layers of quartz/mixed ilite/smectite, montmorillonite, palligorskite, kaolinite and mica. The gypsum mineral is the main component of surface sediments.

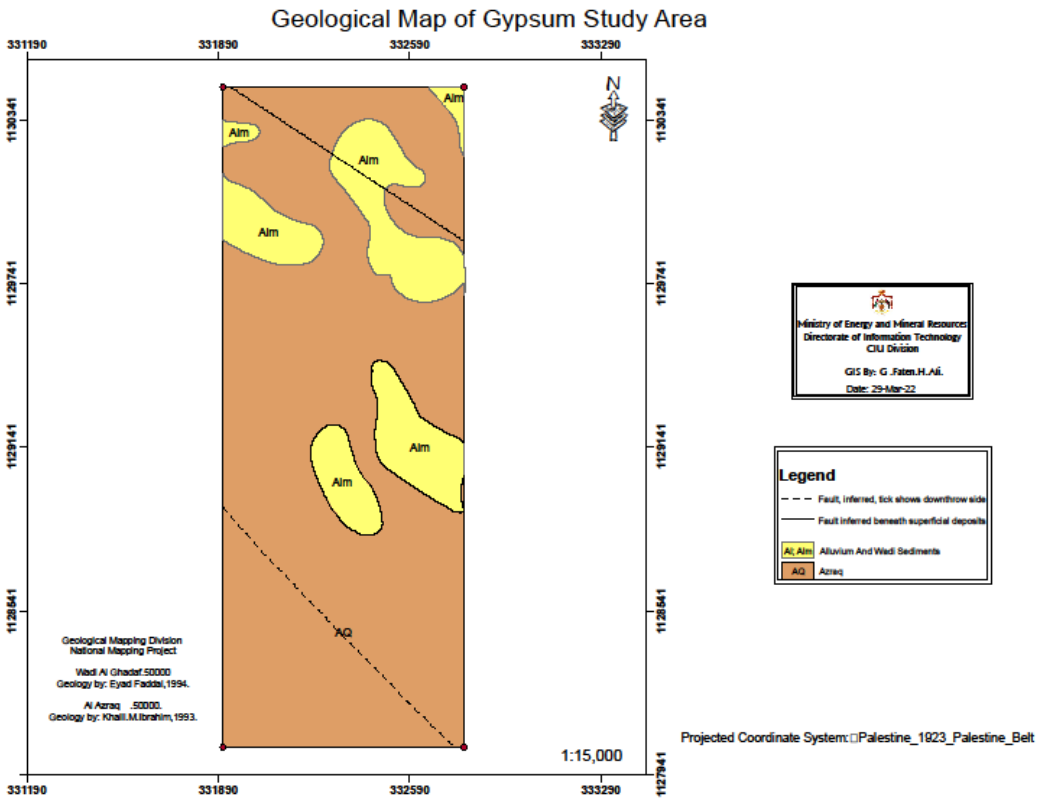



***Figure (1.3) the geology of the gypsum project study area in Azraq***

## 1.10 The sequence stratigraphy in the study area

The main formations of gypsum are Qarma & Azraq:

**Qarma Formation** (Miocene), consists of four main deposits which are fine white & loose sands, sandy limestones, and brown to beige rocks of hard mikritite limestones with a high percentage of porosity. the sedimentation environment of these rocks is a continental environment/lakes, and thicknesses ranges between 10 &15 m with thin layers of gypsum. This formation outcrops completely near Tell Qurma, in the northeast of the map of Wadi Al-Ghadf, and the thickness of this formation is about 40 m.

**Azraq Formation** (Pleistocene) consists of five different deposits; clay/brown clay, layers of gypsum, soft white sand attached to gypsum that characterized by absence of fossils and covering large areas around the northern and western part of Qaa Al-Omari, limestone lead, and a layer of Hard myrtic limestone. The five parts of this formation are located in a unconformity with Qurma formation and its thickness is about 10 m.

## 1.11 Structural geology of the study area

The study area is affected by the major normal faults; Sirhan and Falaq, and parallel secondary faults as shown in Figure (1.4).

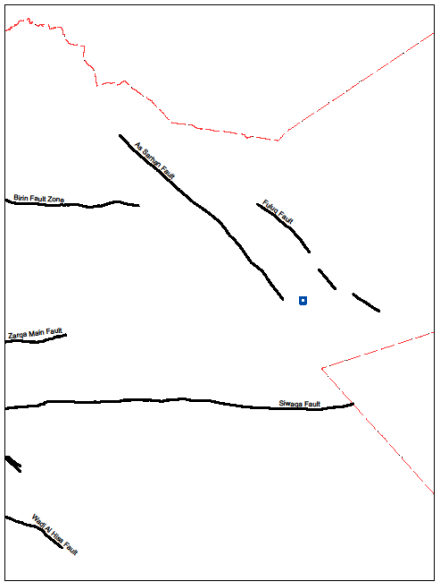



*Figure (1.4) The structure of the gypsum project study area in Azraq*

# (2) Drilling works and rock studies

## 2.1 Introduction

The gypsum exploration project began in Al-Azraq region in 2017. The project determined the study of gypsum deposits through Azraq geological formation which outcrops in Al-Azraq area, 120 km south of the capital Amman. The study started by collecting superficial samples and conducting chemical analyses on this samples. Chemical results proved the existence of good percentages of gypsum in the study area.

## 2.2 Location

60 boreholes were drilled in study area within coordinates (in Palestinian square) which shown in Table (2.1) and elevations in Figure (2.1), where the height above sea level is limited between 504.6 m and 524.1 m.

*Table (2.1): The coordinates of the Azraq gypsum area and the height above sea level*

| BH No. | E | N | Elevation (m) | BH No. | E | N | Elevation (m) |
|---|---|---|---|---|---|---|---|
| GP-1 | 331950 | 1128150 | 515.2 | GP-31 | 332350 | 1129350 | 508.9 |
| GP-2 | 331950 | 1128350 | 510.5 | GP-32 | 332350 | 1129550 | 515.8 |
| GP-3 | 331950 | 1128550 | 520.7 | GP-33 | 332350 | 1129750 | 511.9 |
| GP-4 | 331950 | 1128750 | 512.8 | GP-34 | 332350 | 1129950 | 518.9 |
| GP-5 | 331950 | 1128950 | 514.4 | GP-35 | 332350 | 1130150 | 509.6 |
| GP-6 | 331950 | 1129150 | 515.2 | GP-36 | 332350 | 1130350 | 510.7 |
| GP-7 | 331950 | 1129350 | 516.9 | GP-37 | 332550 | 1130350 | 511.2 |
| GP-8 | 331950 | 1129550 | 513 | GP-38 | 332550 | 1130150 | 506.9 |
| GP-9 | 331950 | 1129750 | 511 | GP-39 | 332550 | 1129950 | 504.6 |
| GP-10 | 331950 | 1129950 | 507.4 | GP-40 | 332550 | 1129750 | 514.8 |
| GP-11 | 331950 | 1130150 | 510 | GP-41 | 332550 | 1129550 | 514.3 |
| GP-12 | 331950 | 1130350 | 508.8 | GP-42 | 332550 | 1129350 | 506 |
| GP-13 | 332150 | 1130350 | 507.6 | GP-43 | 332550 | 1129150 | 509.9 |
| GP-14 | 332150 | 1130150 | 518.5 | GP-44 | 332550 | 1128950 | 509.2 |
| GP-15 | 332150 | 1129950 | 506.1 | GP-45 | 332550 | 1128750 | 509.7 |
| GP-16 | 332150 | 1129750 | 512 | GP-46 | 332550 | 1128550 | 508.4 |
| GP-17 | 332150 | 1129550 | 520.1 | GP-47 | 332550 | 1128350 | 505.7 |
| GP-18 | 332150 | 1129350 | 524.1 | GP-48 | 332550 | 1128150 | 505.5 |
| GP-19 | 332150 | 1129150 | 511.6 | GP-49 | 332749.9 | 1128150 | 515 |
| GP-20 | 332150 | 1128950 | 516.2 | GP-50 | 332749.9 | 1128350 | 518.6 |
| GP-21 | 332150 | 1128750 | 516.2 | GP-51 | 332749.9 | 1128550 | 514 |
| GP-22 | 332150 | 1128550 | 512.1 | GP-52 | 332749.9 | 1128750 | 511.5 |
| GP-23 | 332150 | 1128350 | 519.6 | GP-53 | 332749.9 | 1128950 | 510.9 |
| GP-24 | 332150 | 1128150 | 509.2 | GP-54 | 332749.9 | 1129150 | 513.4 |
| GP-25 | 332350 | 1128150 | 509.3 | GP-55 | 332749.9 | 1129350 | 513.7 |
| GP-26 | 332350 | 1128350 | 511.5 | GP-56 | 332749.9 | 1129550 | 511 |
| GP-27 | 332350 | 1128550 | 512 | GP-57 | 332749.9 | 1129750 | 510.6 |
| GP-28 | 332350 | 1128750 | 516.2 | GP-58 | 332749.9 | 1129950 | 507.1 |
| GP-29 | 332350 | 1128950 | 513.2 | GP-59 | 332749.9 | 1130150 | 509.2 |
| GP-30 | 332350 | 1129150 | 512.1 | GP-60 | 332749.9 | 1130350 | 516.7 |

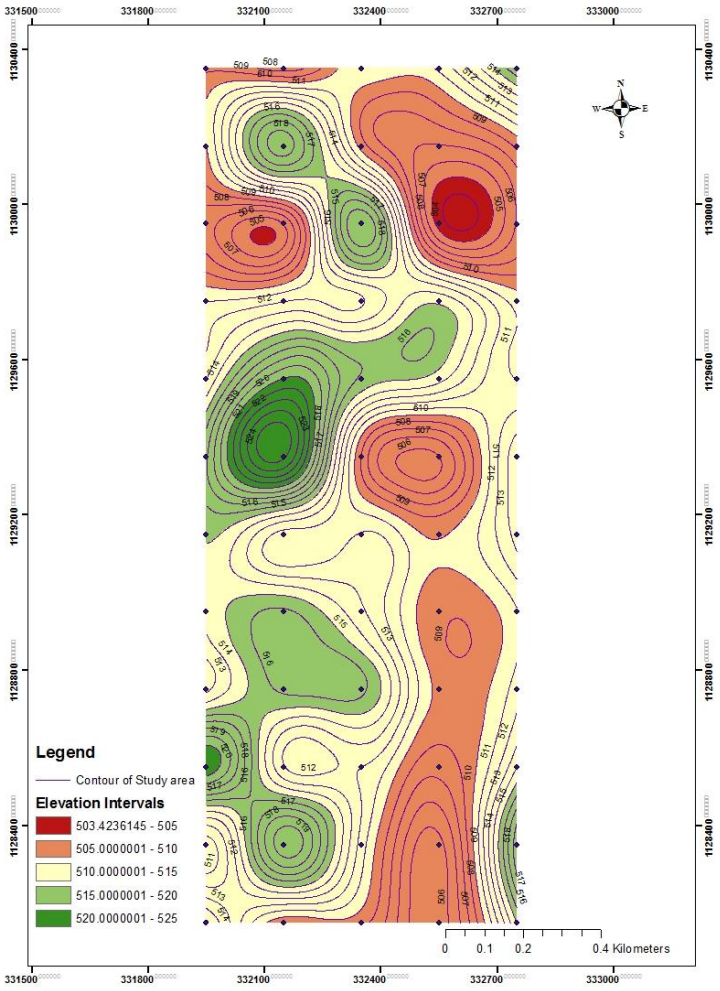



*Figure (2.1) A contour map of the elevation in the study area of the gypsum project in Azraq*

## 2.3 Field work and field trips

The field work included three stages:

**First stage:** exploration tours, surface sample collection and analysis.

**Second stage:** Exploration Vertical boreholes drilling.

**Third stage:** Samples analysis and evaluation of drilling results.

### Field trips

The surface samples have been collected from the study area, and the chemical analysis conducted of them, the results showed the presence good proportions of pure gypsum suitable for industrial uses.

**Drilling works**

Drilling began in the study area in7/26/2017, and 60 boreholes were dug as a first stage by Rig type SD300 of Ministry of Energy and Mineral Resources with a total depths of 327 meters , including 11 meters for cutting samples and 316 meters for coring samples, as shown in table (2.1) and figures (2.2 ) and (2.3) This stage was completed on 12/14/2017.

*Table (2.2): Type of the taken samples, thicknesses of gypsum, and the overburden in Azraq area*

| Sample ID | Core (m) | Cutting (m) | Total Depth (m) | Gypsum Thickness (m) | Overburden Thickness (m) |
|---|---|---|---|---|---|
| GP-1-01 | 8 | 3 | 11 | 3 | 0 |
| GP-2-01 | 8 | | 8 | 3 | 0 |
| GP-3-01 | 8 | | 8 | 0 | 0 |
| GP-4-01 | 6 | | 6 | 2 | 1 |
| GP-5-01 | 4 | | 4 | 2 | 0 |
| GP-6-01 | 11 | | 11 | 1 | 0 |
| GP-7-01 | 10.5 | | 10.5 | 2 | 0 |
| GP-8-01 | 7 | | 7 | 1 | 0 |
| GP-9-02 | 4 | | 4 | 1 | 1.5 |
| GP-10-02 | 6.5 | | 6.5 | 2 | 0 |
| GP-11-02 | 5 | | 5 | 2 | 1 |
| GP-12-02 | 9 | | 9 | 2 | 0 |
| GP-13-01 | 9 | | 9 | 1 | 0 |
| GP-14-1 | 10 | | 10 | 2 | 0 |
| GP-15-2 | 8 | | 8 | 1 | 0 |
| GP-16-1 | 6 | | 6 | 1 | 0 |
| GP-17-2 | 8 | | 8 | 3 | 0 |
| GP-18-1 | 8 | | 8 | 3 | 0 |
| GP-19 | 4.5 | 2 | 6.5 | 3 | 0 |
| GP-20-1 | 4 | 2 | 6 | 3 | 0 |
| GP-21-2 | 3 | 3 | 6 | 2 | 0 |
| GP-22-1 | 3 | 1 | 4 | 2 | 0 |
| GP-23-1 | 8 | | 8 | 3 | 0 |
| GP-24-1 | 4 | | 4 | 1 | 0 |
| GP-25-1 | 6 | | 6 | 1 | 0 |
| GP-26-1 | 4.5 | | 4.5 | 1 | 0 |
| GP-27-1 | 4.5 | | 4.5 | 1 | 0 |
| GP-28-1 | 5 | | 5 | 1 | 0 |
| GP-29-1 | 5 | | 5 | 1 | 0 |
| GP-30-1 | 4 | | 4 | 2 | 0 |
| GP-31-1 | 4.5 | | 4.5 | 1 | 0 |
| GP-32-1 | 6 | | 6 | 1 | 0 |
| GP-33-1 | 6 | | 6 | 1 | 0 |
| GP-34-1 | 4.5 | | 4.5 | 2 | 0 |
| GP-35-1 | 4.5 | | 4.5 | 2 | 0 |
| GP-36-1 | 4.5 | | 4.5 | 1 | 0 |
| GP-37-1 | 4 | | 4 | 1 | 0 |
| GP-38-1 | 3 | | 3 | 1 | 0 |
| GP-39-2 | 4 | | 4 | 1 | 0 |
| GP-40-1 | 4 | | 4 | 1 | 1 |

| Sample ID | Core (m) | Cutting (m) | Total Depth (m) | Gypsum Thickness (m) | Overburden Thickness (m) |
|---|---|---|---|---|---|
| GP-41-1 | 3 | | 3 | 1 | 1 |
| GP-42-1 | 4 | | 4 | 1 | 0 |
| GP-43 | 3 | | 3 | 0 | 0 |
| GP-44-1 | 4 | | 4 | 1 | 1 |
| GP-45-1 | 4 | | 4 | 1 | 0 |
| GP-46-1 | 4 | | 4 | 1 | 0 |
| GP-47-1 | 4.5 | | 4.5 | 1 | 0 |
| GP-48 | 4.5 | | 4.5 | 1 | 0 |
| GP-49 | 4 | | 4 | 0 | 0 |
| GP-50 | 3 | | 3 | 0 | 0 |
| Gp-51-1 | 3 | | 3 | 1 | 0 |
| Gp-52 | 3 | | 3 | 0 | 0 |
| Gp-53 | 6 | | 6 | 0 | 0 |
| Gp-54-1 | 6 | | 6 | 1 | 0 |
| Gp-55-1 | 4 | | 4 | 1 | 0 |
| Gp-56-1 | 4 | | 4 | 1 | 0 |
| Gp-57 | 3.5 | | 3.5 | 1 | 0 |
| Gp-58-1 | 4 | | 4 | 1 | 0 |
| Gp-59-1 | 4 | | 4 | 1 | 1 |
| Gp-60-1 | 4 | | 4 | 1 | 1 |
| Total | | | 327 | | |

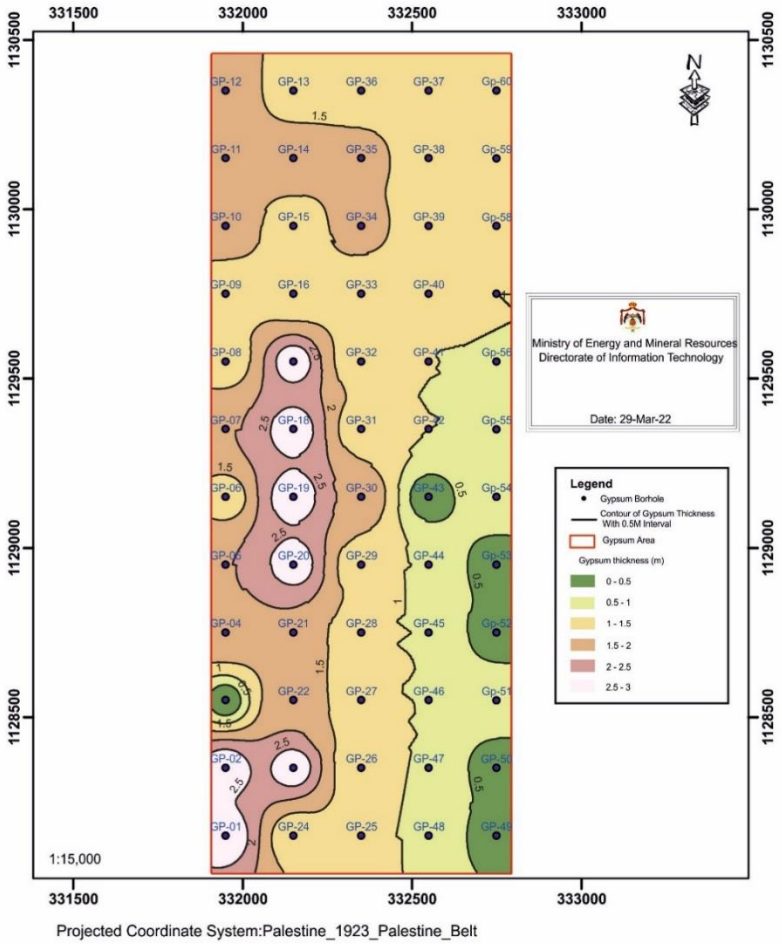



*Figure (2.2) A contour map of the gypsum thickness in the study area of the gypsum project in Azraq*

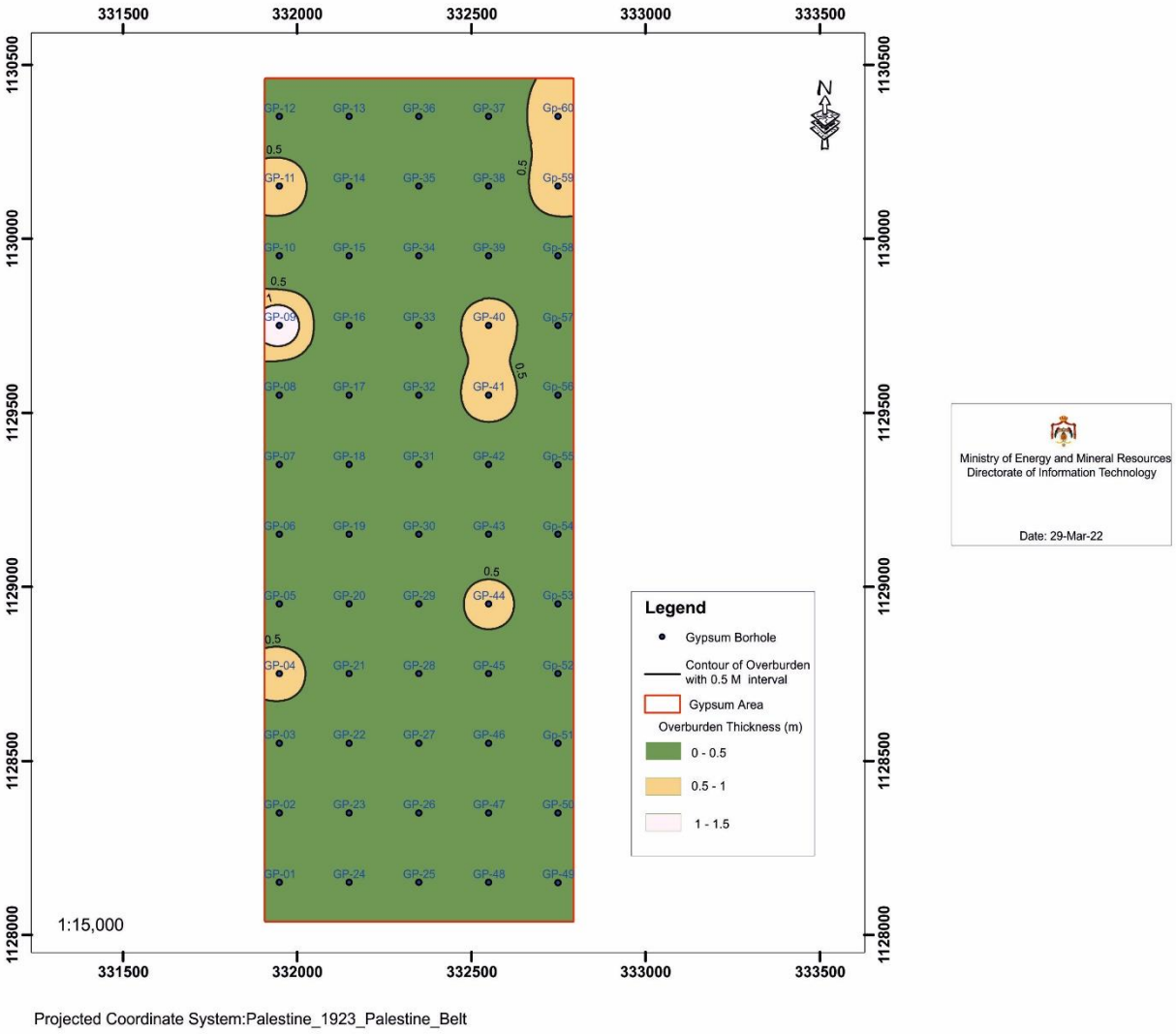



***Figure (2.3): Contour map of the thickness of the gypsum overburden in the study area of the gypsum project in Azraq***

**Sample analysis and evaluation of drilling results**

A total of 79 samples were prepared for the necessary analyzes. The results of the chemical analyzes showed the availability of hopeful percentages of gypsum in the study area.

## 2.4 Gypsum thickness and Overburden

The overburden in the study areas is almost non-existent and closed to zero and does not represent a burden in mining operations due to the unfolding of gypsum beds in many areas near the surface of the earth, as shown in Table (2.3) which illustrated the thickness of gypsum and overburden in the studied boreholes.

## 2.5 The rock description of boreholes

- Gypsum unfolds in layers close to the Earth's surface within the Azraq geological formation from the Quaternary era of the Cenozoic Era.
- It was found that there are overlaps of fine sand and clay with gypsum and which formed in the lacustrine environment, which is characterized by the sediments formed in the bottoms of ancient lakes, with gypsum, there are fresh sediments that have accumulated at the bottoms of valleys and rivers that have accumulated, the table (2.3) mentioned below shows a simplified rocky description of the rock samples taken from the Azraq gypsum boreholes.

*Table (2.3) a simplified rock description of gypsum samples in the Azraq area*

| Sample ID | Description | Sample ID | Description |
|---|---|---|---|
| GP-01 | Gypsum silty | GP-31-1 | Gypsum sandy |
| GP-02-01 | Gypsum Dirty | GP-32-1 | Gypsum white |
| GP-03-01 | Gypsum sandy | GP-33-1 | Gypsum mixed |
| GP-04-01 | Gypsum white and Dirty | GP-34-1 | Gypsum white (0.5 m) |
| GP-05-01 | Gypsum white in upper part sandy in lower part | GP-35-1 | Gypsum white (0.5 m) |
| GP-06-01 | Gypsum silty and sandy | GP-36-1 | Gypsum sandy |
| GP-07-01 | Gypsum silty and sandy | GP-37-1 | Gypsum silty |
| GP-08-01 | Gypsum silty and sandy | GP-38-1 | Gypsum sandy |
| GP-09-02 | Gypsum silty and sandy | GP-39-2 | Gypsum with clay |
| GP-10 | Gypsum sandy | GP-40-1 | Gypsum sandy |
| GP-11-02 | Gypsum whitish gray | GP-41-1 | Gypsum sandy |
| GP-12-02 | Gypsum sandy | GP-42-1 | Gypsum sandy |
| GP-13-01 | Gypsum white | GP-43 | No Gypsum |
| GP-14-1 | Gypsum white | GP-44-1 | Gypsum with clay |
| GP-15-2 | Gypsum with clay | GP-45-1 | Gypsum with clay |
| GP-16-1 | Gypsum with clay | GP-46-1 | Gypsum with clay |
| GP-17-2 | Gypsum with clay | GP-47-1 | Gypsum with clay |
| GP-18-1 | Gypsum with clay | GP-48 | Gypsum with clay |
| GP-19 | Gypsum white | GP-49 | Gypsum with clay and sand |
| GP-20-1 | Gypsum white | GP-50 | Gypsum sandy |
| GP-21-2 | Gypsum white | Gp-51-1 | Gypsum sandy |
| GP-22-1 | Gypsum with clay | Gp-52 | Gypsum sandy |
| GP-23-1 | Gypsum sandy | Gp-53 | Gypsum sandy |
| GP-24-1 | Gypsum sandy | Gp-54-1 | Gypsum sandy |

| Sample ID | Description | Sample ID | Description |
|---|---|---|---|
| GP-25-1 | Gypsum sandy | Gp-55-1 | Gypsum white (0.5m) |
| GP-26-1 | Gypsum sandy | Gp-56-1 | Gypsum white (0.5m) |
| GP-27-1 | Gypsum sandy | Gp-57 | Gypsum silty and sandy |
| GP-28-1 | Gypsum sandy | Gp-58-1 | Gypsum silty and sandy |
| GP-29-1 | Gypsum with clay | Gp-59-1 | Gypsum silty and sandy |
| GP-30-1 | Gypsum white | Gp-60-1 | Gypsum silty and sandy |

# (3) Laboratory analyzes

## 3.1Introduction

The laboratory analyzes included conducting XRF, XRD chemical and mineral analyses of samples that were taken from boreholes. The total number of analyzed samples was 80 samples on the XRF device and 10 samples on XRD.

## 3.2Test results

The chemical results of XRF and XRD are shown in Tables No. (3.1) and (3.2) and Figures (3.1), (3.2) and (3.3).

The results of the chemical analysis showed that the percentage of CaO is ranged between 12.20 & 51.00%. The percentages of $SO_3$ ranged between 1.30 & 47.9%. It is noticed from results, the LOI values increase in some samples and decrease in others. This gives an indication that the samples contain more proportions of LOI have better gypsum mineral ($CaSO_4.2H_2O$) results. Gypsum rocks mostly consist of 32.6% CaO, 46.5% $SO_3$, 20.9% $H_2O$ and some small percentage of bassanite mineral ($CaSO_4.(1/2)H_2O$). Bassanite mineral contains a small percentage of water less than what is contained in gypsum mineral and it is formed as a result of gypsum losing 75% of water. It is clear from Figure (2.4) that the most percentage of gypsum mineral is concentrated in the southwestern region of study area.

Based on XRD analysis, it was found that there were low values of calcite mineral, as for the existence of slightly high values of silicon oxides, they are due to quartz mineral, and low values of magnesium and aluminum oxides are due to the existence of Palygorskite mineral.

The whiteness degree of some samples 6 has been studied, as in table 3.3 and the highest degree of whiteness reached 82.10 with sample Gp-60-1, and total density of some samples reached about 7 g/cm$^3$ with average 2.06 g/cm$^3$.

*Table (3.1) XRF analysis of some boreholes samples in the study area*

| Sample ID | $Fe_2O_3$ | MnO | $TiO_2$ | CaO | $K_2O$ | $P_2O_5$ | $SiO_2$ | $Al_2O_3$ | MgO | $Na_2O$ | $SO_3$ | SrO | LOI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GY-1 | 0.48 | 0.03 | 0.06 | 49.90 | 0.11 | 0.65 | 4.38 | 0.65 | 1.51 | 0.88 | 15.50 | 0.84 | 24.70 |
| GP-1-01 | 0.46 | 0.00 | 0.06 | 26.20 | 0.16 | 0.00 | 18.20 | 0.81 | 2.77 | 0.39 | 40.10 | 0.20 | 10.20 |
| GP-1-02 | 0.42 | 0.00 | 0.07 | 31.50 | 0.16 | 0.00 | 7.93 | 0.91 | 1.31 | 0.17 | 47.90 | 0.36 | 8.60 |
| GP-1-03 | 0.53 | 0.00 | 0.07 | 24.70 | 0.22 | 0.00 | 42.90 | 1.03 | 1.02 | 0.17 | 19.30 | 0.23 | 9.40 |
| GP-2-01 | 0.44 | 0.00 | 0.06 | 37.70 | 0.14 | 0.00 | 4.95 | 0.85 | 0.85 | 0.10 | 45.10 | 0.18 | 9.50 |
| GP-2-02 | 0.73 | 0.00 | 0.12 | 19.40 | 0.35 | 0.00 | 59.50 | 1.40 | 1.00 | 0.04 | 1.30 | 0.03 | 16.00 |
| GP-4-01 | 2.10 | 0.00 | 0.30 | 21.80 | 0.66 | 0.00 | 21.60 | 3.96 | 3.66 | 0.07 | 33.60 | 0.26 | 11.70 |
| GP-3-01 | 0.94 | | 0.21 | 25.90 | 0.31 | | 8.35 | 1.29 | 1.40 | 0.05 | 39.90 | 1.37 | 19.40 |
| GP-5-01 | 1.04 | | 0.13 | 27.30 | 0.25 | | 5.14 | 1.48 | 0.62 | 0.05 | 41.10 | 0.62 | 21.30 |
| GP-5-02 | 0.56 | | 0.07 | 28.80 | 0.14 | | 6.56 | 1.02 | 1.45 | 0.04 | 40.20 | 0.10 | 20.00 |
| GP-6-01 | 1.14 | | 0.15 | 24.70 | 0.34 | | 8.95 | 1.82 | 1.52 | 0.10 | 38.30 | 0.76 | 21.20 |
| GP-7-01 | 1.35 | | 0.18 | 25.20 | 0.38 | | 9.14 | 2.00 | 1.64 | 0.05 | 38.40 | 0.82 | 20.80 |
| GP-7-02 | 1.05 | | 0.14 | 27.60 | 0.30 | | 7.93 | 1.32 | 2.04 | 0.05 | 38.30 | 0.92 | 20.40 |
| GP-8-01 | 2.56 | | 0.40 | 22.00 | 0.72 | | 17.40 | 3.57 | 2.86 | 0.19 | 29.30 | 1.13 | 19.80 |
| GP-8-02 | 1.93 | | 0.32 | 28.10 | 0.64 | | 14.90 | 2.79 | 3.12 | 0.12 | 25.50 | 0.62 | 22.00 |
| GP-9-01 | 2.40 | | 0.35 | 22.60 | 0.64 | | 13.20 | 3.65 | 1.20 | 0.11 | 32.80 | 0.90 | 21.10 |
| GP-9-02 | 1.28 | | 0.17 | 24.40 | 0.46 | | 12.50 | 2.45 | 2.37 | 0.08 | 34.60 | 1.04 | 20.70 |
| GP-10-01 | 4.36 | | 0.51 | 15.60 | 1.16 | | 24.20 | 7.24 | 2.35 | 0.21 | 23.50 | 0.73 | 20.10 |
| GP-10-02 | 1.23 | | 0.23 | 27.00 | 0.45 | | 12.60 | 2.06 | 2.81 | 0.10 | 31.50 | 0.84 | 21.20 |
| GP-10-03 | 1.57 | | 0.19 | 29.30 | 0.48 | | 14.60 | 2.46 | 2.70 | 0.09 | 24.70 | 0.51 | 23.50 |
| GP-10-04 | 1.14 | | 0.19 | 33.60 | 0.47 | | 12.80 | 2.48 | 2.36 | 0.09 | 19.90 | 1.46 | 24.30 |
| GP-11-01 | 1.84 | | 0.24 | 21.80 | 0.54 | | 13.40 | 3.35 | 2.22 | 0.09 | 33.00 | 0.41 | 22.10 |
| GP-11-02 | 0.67 | | 0.09 | 27.20 | 0.20 | | 6.83 | 1.13 | 1.49 | 0.06 | 39.00 | 0.47 | 21.80 |
| GP-11-03 | 0.61 | | 0.08 | 33.50 | 0.21 | | 5.87 | 1.02 | 1.36 | 0.06 | 32.40 | 1.22 | 22.70 |
| GP-12-01 | 1.13 | | 0.18 | 23.40 | 0.42 | | 10.70 | 2.46 | 1.97 | 0.07 | 33.70 | 0.34 | 24.60 |
| GP-12-02 | 0.83 | | 0.12 | 25.00 | 0.27 | | 8.00 | 1.56 | 1.69 | 0.06 | 40.00 | 0.24 | 21.20 |
| GP-13-01 | 1.00 | | 0.14 | 26.60 | 0.31 | | 7.26 | 1.83 | 1.35 | 0.07 | 38.00 | 0.51 | 22.00 |
| GP-14-1 | 0.51 | | 0.06 | 34.4 | 0.14 | | 6.14 | 0.94 | 1.82 | 0.05 | 30.30 | 0.75 | 23.90 |
| GP-14-2 | 0.95 | | 0.12 | 43.6 | 0.28 | | 7.42 | 1.44 | 1.59 | 0.05 | 14.70 | 0.17 | 28.70 |
| GP-15-1 | 1.75 | | 0.27 | 26.9 | 0.52 | | 11.5 | 2.49 | 1.89 | 0.08 | 21.20 | 0.72 | 20.70 |
| GP-15-2 | 2.03 | | 0.35 | 25.2 | 0.64 | | 14.7 | 3.24 | 2.45 | 0.1 | 29.20 | 0.76 | 20.20 |
| GP-16-1 | 0.48 | | 0.06 | 30.7 | 0.13 | | 4.61 | 0.71 | 1.23 | 0.06 | 39.40 | 0.86 | 20.80 |
| GP-17-1 | 3.63 | | 0.44 | 22.2 | 0.81 | | 16.1 | 4.32 | 2.52 | 0.1 | 26.50 | 1.64 | 20.70 |
| GP-17-2 | 0.5 | | 0.08 | 28.9 | 0.13 | | 6.23 | 0.68 | 2.25 | 0.08 | 38.70 | 0.89 | 20.60 |
| GP-18-1 | 0.8 | | 0.13 | 27.8 | 0.22 | | 8.6 | 1.63 | 1.83 | 0.05 | 36.8 | 0.45 | 21.70 |
| GP-18-2 | 1.06 | | 0.17 | 24.3 | 0.26 | | 12.1 | 1.75 | 3.09 | 0.05 | 35.7 | 1.36 | 20.20 |
| GP-20-1 | 1.04 | | 0.14 | 23.9 | 0.31 | | 10.6 | 1.71 | 2.59 | 0.06 | 37.1 | 0.13 | 22.50 |

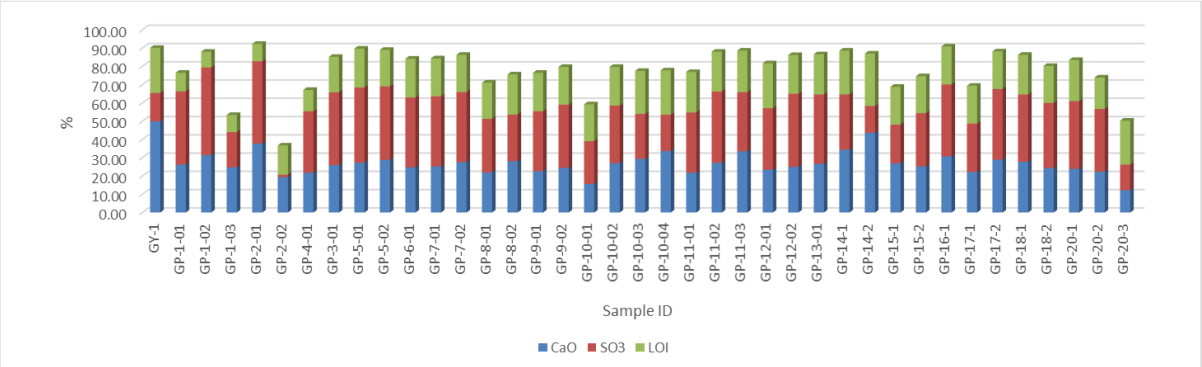
| Sample ID | $Fe_2O_3$ | MnO | $TiO_2$ | CaO | $K_2O$ | $P_2O_5$ | $SiO_2$ | $Al_2O_3$ | MgO | $Na_2O$ | $SO_3$ | SrO | LOI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GP-20-2 | 1.93 | | 0.26 | 22.3 | 0.53 | | 15.8 | 2.76 | 3.1 | 0.07 | 34.4 | 0.66 | 17.20 |
| GP-20-3 | 3.11 | | 0.44 | 12.2 | 1.22 | | 32.9 | 7.11 | 3.63 | 0.21 | 14 | 0.23 | 24.10 |
| GP-21-1 | 1.87 | | 0.21 | 19.6 | 0.71 | | 20.9 | 4.06 | 2.27 | 0.013 | 22.7 | 0.68 | 26.50 |
| GP-21-2 | 1.17 | | 0.25 | 31.4 | 0.31 | | 11.8 | 1.8 | 2.76 | 0.09 | 24.7 | 1.21 | 24.60 |
| GP-22-1 | 0.59 | | 0.07 | 29.3 | 0.19 | | 5.38 | 0.91 | 1.23 | 0.06 | 39.8 | 1.19 | 21.30 |
| GP-23-1 | 0.53 | | 0.07 | 29.3 | 0.15 | | 3.47 | 0.86 | 0.59 | 0.05 | 44.8 | 0.61 | 18.60 |
| GP-23-2 | 0.91 | | 0.12 | 23.6 | 0.26 | | 9.61 | 1.76 | 2.15 | 0.06 | 37.8 | 0.73 | 22.00 |
| GP-23-3 | 1.54 | | 0.19 | 30.9 | 0.43 | | 14.3 | 2.38 | 3.18 | 0.07 | 23.1 | 0.71 | 22.10 |
| GP-24-1 | 2.31 | | 0.3 | 20.2 | 0.69 | | 18 | 4.14 | 1.85 | 0.09 | 30.8 | 0.55 | 21.10 |
| GP-25-1 | 0.93 | | 0.12 | 25.4 | 0.28 | | 9.12 | 1.42 | 2.26 | 0.07 | 37.7 | 1.20 | 21.50 |
| GP-26-1 | 0.93 | | 0.12 | 26.8 | 0.28 | | 6.89 | 1.36 | 1.57 | 0.05 | 39.1 | 1.36 | 20.50 |
| GP-27-1 | 1.08 | | 0.15 | 31.6 | 0.42 | | 10.3 | 1.67 | 2.03 | 0.1 | 27.6 | 1.03 | 23.00 |
| GP-28-1 | 0.64 | | 0.08 | 26.7 | 0.19 | | 5.58 | 1.1 | 0.99 | 0.06 | 40.4 | 1.03 | 22.20 |
| GP-28-2 | 1.82 | | 0.21 | 21.2 | 0.46 | | 12.8 | 2.3 | 2.4 | 0.07 | 34.1 | 1.61 | 23.10 |
| GP-29-1 | 0.74 | | 0.11 | 30.1 | 0.21 | | 4.93 | 1.21 | 0.84 | 0.07 | 38.6 | 0.52 | 21.70 |
| GP-30-1 | 1.77 | | 0.25 | 24.5 | 0.51 | | 13.5 | 2.2 | 3.18 | 0.1 | 31.8 | 0.17 | 21.00 |
| GP-31-1 | 0.51 | | 0.07 | 30.1 | 0.15 | | 4.38 | 0.93 | 0.87 | 0.06 | 40 | 0.40 | 21.60 |
| GP-32-1 | 1.28 | | 0.22 | 26.7 | 0.43 | | 11.4 | 2.23 | 2.43 | 0.12 | 29.4 | 1.32 | 23.50 |
| GP-33-1 | 1.03 | | 0.2 | 27.3 | 0.32 | | 9.82 | 1.57 | 2.26 | 0.07 | 33.6 | 0.41 | 22.40 |
| GP-34-1 | 0.7 | | 0.09 | 29.2 | 0.19 | | 7.61 | 1.09 | 2.01 | 0.05 | 34.3 | 0.42 | 23.30 |
| GP-35-1 | 1.24 | | 0.16 | 29.1 | 0.41 | | 10.4 | 1.77 | 2.16 | 0.06 | 24.6 | 1.76 | 27.40 |
| GP-36-1 | 0.62 | | 0.11 | 35.6 | 0.21 | | 6.07 | 1.16 | 1.4 | 0.053 | 29.6 | 0.67 | 23.80 |
| GP-37-1 | 1.83 | | 0.25 | 25.2 | 0.58 | | 10.9 | 3.06 | 1.58 | 0.052 | 33.8 | 0.89 | 21.30 |
| GP-38-1 | 1.33 | | 0.21 | 27.8 | 0.48 | | 9.2 | 2.42 | 1.37 | 0.094 | 35.1 | 0.44 | 21.00 |
| GP-39-1 | 1.19 | | 0.16 | 27.8 | 0.34 | | 8.03 | 2.12 | 1.27 | 0.068 | 36.6 | 0.42 | 21.50 |
| GP-39-2 | 0.72 | | 0.09 | 29.6 | 0.24 | | 6.71 | 1.27 | 1.43 | 0.059 | 37.3 | 1.15 | 21.00 |
| GP-40-1 | 0.52 | | 0.07 | 30.4 | 0.15 | | 3.57 | 1.02 | 0.61 | 0.058 | 40.9 | 0.32 | 21.90 |
| GP-40-2 | 1.19 | | 0.17 | 28.6 | 0.35 | | 8.59 | 1.91 | 1.57 | 0.074 | 35.2 | 0.44 | 21.40 |
| GP-41-1 | 0.79 | | 0.11 | 28.7 | 0.2 | | 8.09 | 1.28 | 1.95 | 0.065 | 36 | 0.40 | 21.90 |
| GP-42-1 | 0.47 | | 0.07 | 30.7 | 0.16 | | 3.78 | 0.79 | 0.62 | 0.061 | 40.3 | 0.90 | 21.60 |
| GP-44-1 | 1.79 | | 0.28 | 27.2 | 0.59 | | 13.6 | 2.64 | 2.42 | 0.107 | 28.3 | 1.06 | 21.50 |
| GP-45-1 | 0.51 | | 0.07 | 30.8 | 0.14 | | 4.87 | 0.92 | 0.77 | 0.057 | 39 | 1.73 | 20.60 |
| GP-45-2 | 0.92 | | 0.12 | 35.1 | 0.27 | | 10.5 | 1.55 | 2.37 | 0.067 | 23.5 | 0.10 | 25.00 |
| GP-45-3 | 1.73 | | 0.23 | 31.6 | 0.59 | | 16 | 2.88 | 2.96 | 0.084 | 14.1 | 1.76 | 27.60 |
| GP-46-1 | 1.28 | | 0.18 | 25.7 | 0.49 | | 12.6 | 1.97 | 2.83 | 0.184 | 30.1 | 0.08 | 24.10 |
| GP-47-1 | 0.54 | | 0.08 | 28.4 | 0.22 | | 6.25 | 1.12 | 1.35 | 0.063 | 38.6 | 0.72 | 22.10 |
| Gp-51-1 | 0.67 | | 0.09 | 35.6 | 0.26 | | 7.83 | 1.46 | 1.67 | 0.09 | 26.8 | 0.31 | 24.80 |
| Gp-54-1 | 1.29 | | 0.16 | 25.7 | 0.35 | | 8.74 | 2.35 | 1.38 | 0.06 | 36.3 | 0.59 | 22.70 |
| Gp-55-1 | 0.26 | | 0.02 | 30.7 | 0.07 | | 1.74 | 0.42 | 0.45 | 0.07 | 43.7 | 0.49 | 21.70 |
| Gp-56-1 | 0.28 | | 0.03 | 30.2 | 0.08 | | 2.08 | 0.43 | 0.57 | 0.06 | 43.6 | 0.70 | 21.60 |
| Gp-58-1 | 0.84 | | 0.13 | 25.7 | 0.29 | | 8.12 | 1.81 | 1.69 | 0.08 | 36.6 | 0.88 | 23.50 |
| Gp-59-1 | 1.54 | | 0.19 | 36.5 | 0.57 | | 15.5 | 2.72 | 2.36 | 0.1 | 12.6 | 0.18 | 27.30 |
| Gp-60-1 | 0.62 | | 0.09 | 51 | 0.23 | | 5.98 | 1.11 | 1.36 | 0.06 | 6.74 | 0.61 | 31.80 |

*Table (3.2) XRD analysis of some boreholes samples in the study area*

| SAMPLE ID | GYPSUM | PALYGORSKTE | CALCITE | QUARTZ |
|---|---|---|---|---|
| GP-9-2 | *** | * | | |
| GP-17-2 | *** | | | |
| GP-20-1 | *** | ** | | |
| GP-34-2 | *** | * | * | NEGATIVE |
| GP-35-2 | *** | * | ** | ** |
| GP-37-1 | *** | NEGATIVE | NEGATIVE | |
| GP-39-1 | *** | NEGATIVE | NEGATIVE | |
| GP-40-2 | *** | NEGATIVE | NEGATIVE | |
| GP-42-1 | *** | NEGATIVE | NEGATIVE | |
| GP-45-2 | *** | * | * | |
| *** | MAJOR | | | |
| ** | MINOR | | | |
| * | TRACE | | | |

*Table (3.3) Analysis of whiteness and density bulk for some samples of boreholes in the study area*

| Sample ID | Whiteness | Bulk Density |
|---|---|---|
| GP-37-1 | 53.20 | |
| GP-40-2 | 59.10 | |
| GP-45-2 | 73.60 | |
| Gp-51-1 | | 2.07 |
| Gp-54-1 | | 2.09 |
| Gp-55-1 | | 2.15 |
| Gp-56-1 | | 2.02 |
| Gp-58-1 | 74.50 | 2.14 |
| Gp-59-1 | 77.50 | 1.90 |
| Gp-60-1 | 82.10 | 2.03 |
| | **An average** | **2.06** |



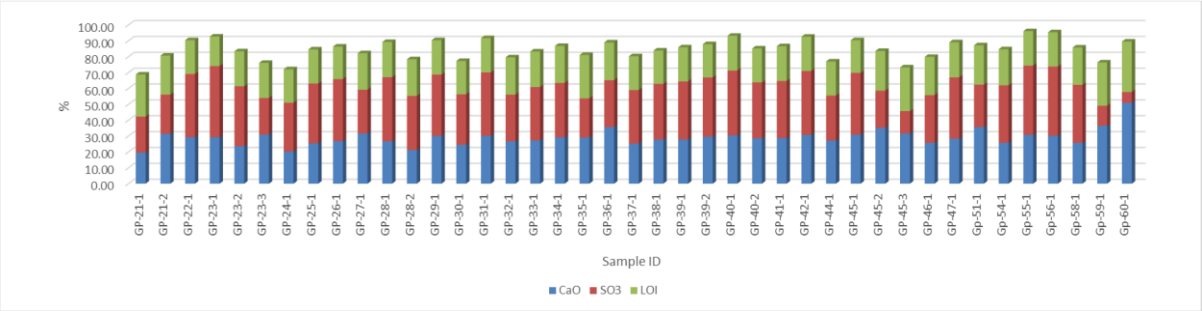
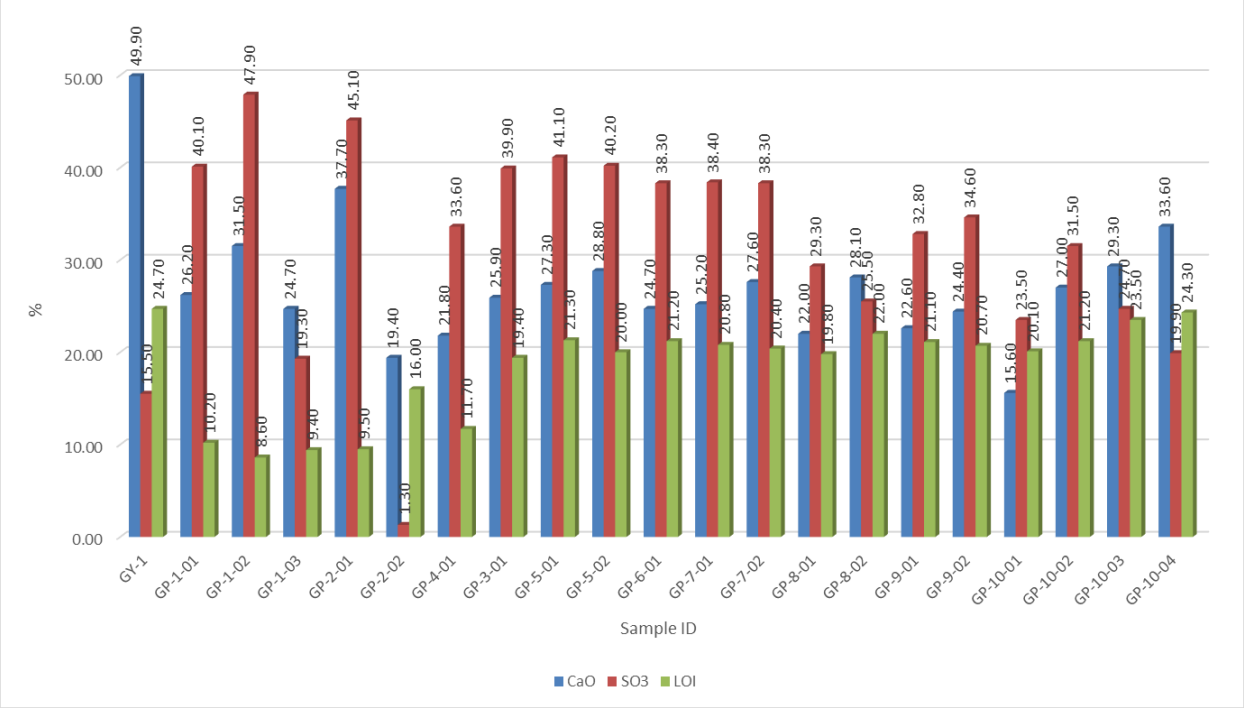



*Figure (3.1) The ratio of gypsum components in the study area*



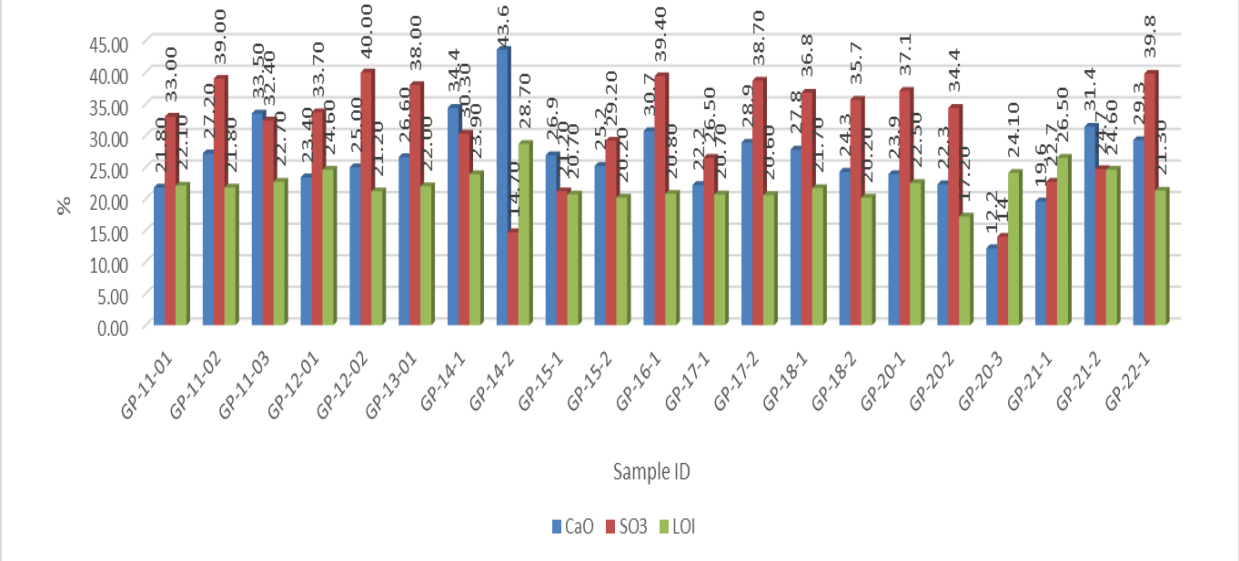
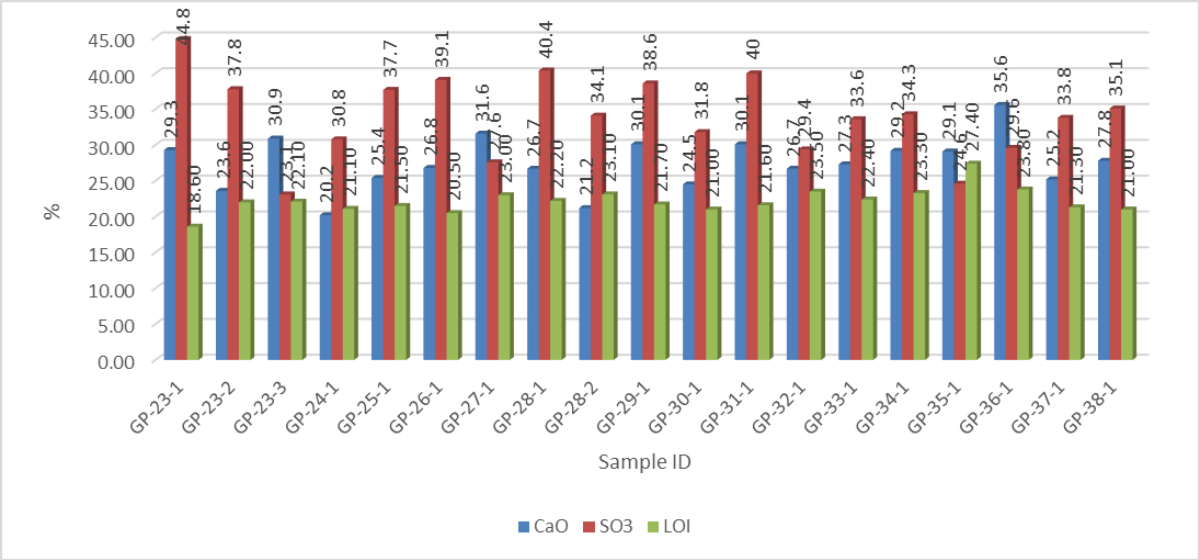



*Figure (3.2) The ratio of gypsum components in the study area*



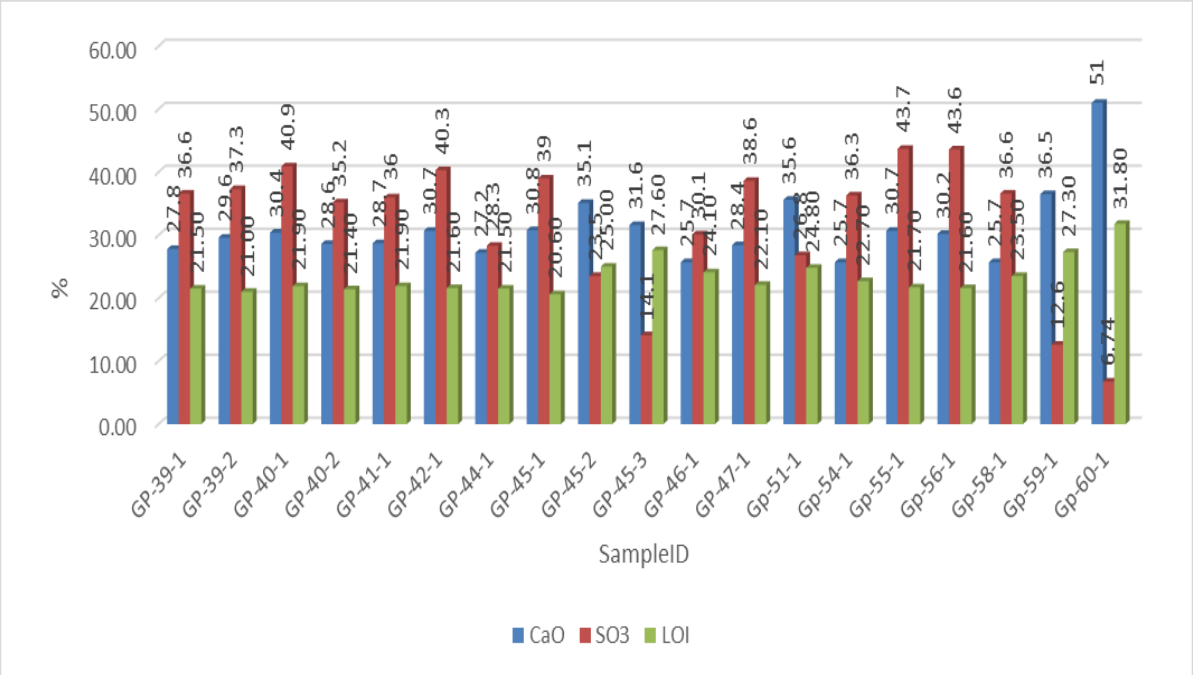




*Figure (3.3) The ratio of gypsum components in the study area*

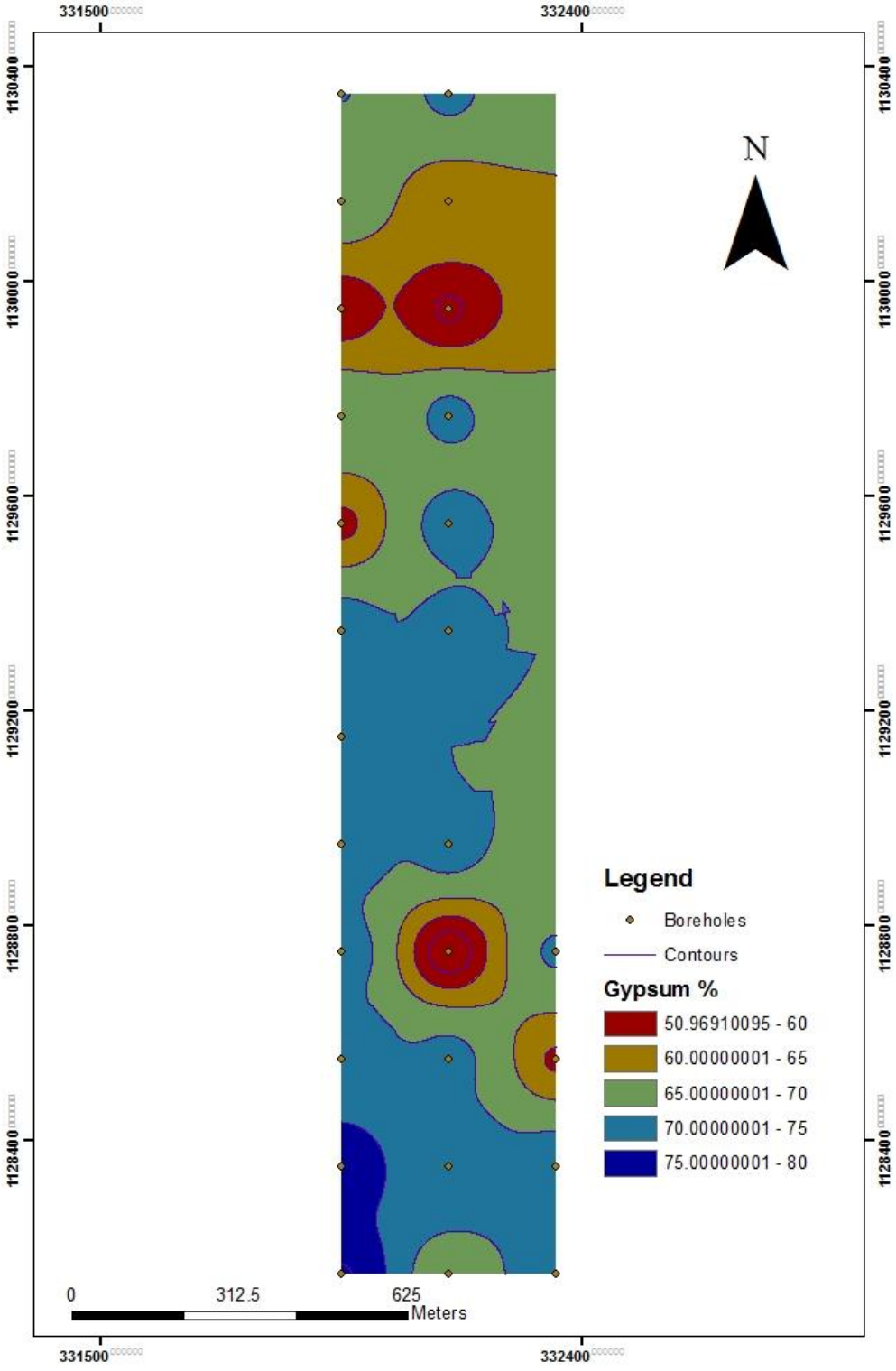



*Figure (3.4) A contour map of gypsum ratio in the study area*

# (4) The reserve

## Primary estimates of reserve

The thickness of the exposure in the Azraq area was estimated to be approximately three meters, with horizontal extension about 2500 meter, Gypsum is characterized by its high purity and ease of access, and it is revealed on the surface in most of the boreholes with the presence of a thin rocky cover sometimes. The primary reserves of gypsum in the study area appropriate for mining about 6 million metric tons, which were calculated according to the Tyson equation as follows:

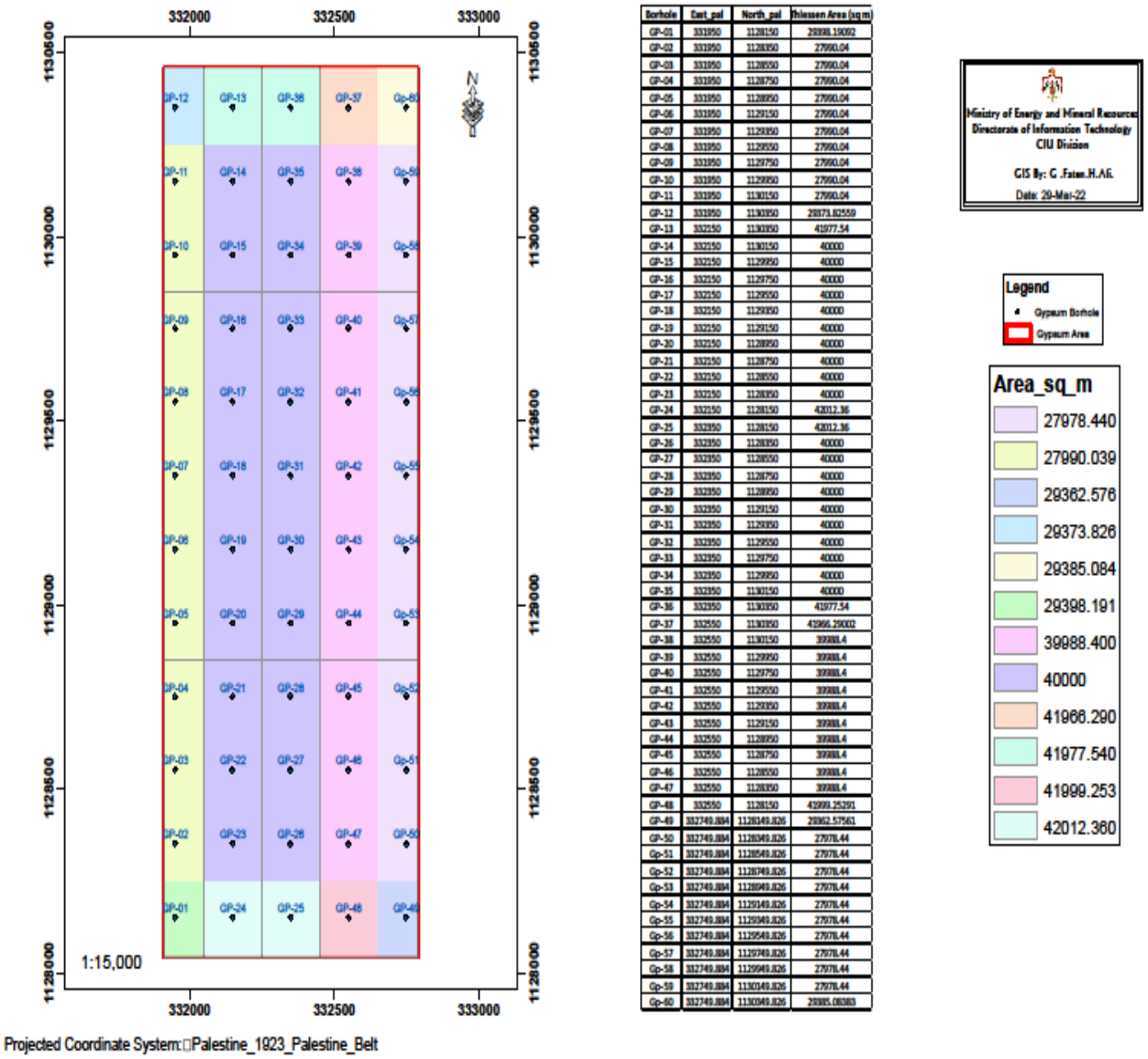
R= T*A* B

R: reserve

A: the area covered by each of the boreholes

T: the gypsum thickness

B: Specific Density (2.06) g/cm3




| Borhole | East_pal | North_pal | Thiessen Area (sq m) |
|---|---|---|---|
| GP-01 | 331950 | 1128150 | 29398.19092 |
| GP-02 | 331950 | 1128350 | 27990.04 |
| GP-03 | 331950 | 1128550 | 27990.04 |
| GP-04 | 331950 | 1128750 | 27990.04 |
| GP-05 | 331950 | 1128950 | 27990.04 |
| GP-06 | 331950 | 1129150 | 27990.04 |
| GP-07 | 331950 | 1129350 | 27990.04 |
| GP-08 | 331950 | 1129550 | 27990.04 |
| GP-09 | 331950 | 1129750 | 27990.04 |
| GP-10 | 331950 | 1129950 | 27990.04 |
| GP-11 | 331950 | 1130150 | 27990.04 |
| GP-12 | 331950 | 1130350 | 29373.82559 |
| GP-13 | 332150 | 1130350 | 41977.54 |
| GP-14 | 332150 | 1130150 | 40000 |
| GP-15 | 332150 | 1129950 | 40000 |
| GP-16 | 332150 | 1129750 | 40000 |
| GP-17 | 332150 | 1129550 | 40000 |
| GP-18 | 332150 | 1129350 | 40000 |
| GP-19 | 332150 | 1129150 | 40000 |
| GP-20 | 332150 | 1128950 | 40000 |
| GP-21 | 332150 | 1128750 | 40000 |
| GP-22 | 332150 | 1128550 | 40000 |
| GP-23 | 332150 | 1128350 | 40000 |
| GP-24 | 332150 | 1128150 | 42012.36 |
| GP-25 | 332350 | 1128150 | 42012.36 |
| GP-26 | 332350 | 1128350 | 40000 |
| GP-27 | 332350 | 1128550 | 40000 |
| GP-28 | 332350 | 1128750 | 40000 |
| GP-29 | 332350 | 1128950 | 40000 |
| GP-30 | 332350 | 1129150 | 40000 |
| GP-31 | 332350 | 1129350 | 40000 |
| GP-32 | 332350 | 1129550 | 40000 |
| GP-33 | 332350 | 1129750 | 40000 |
| GP-34 | 332350 | 1129950 | 40000 |
| GP-35 | 332350 | 1130150 | 40000 |
| GP-36 | 332350 | 1130350 | 41977.54 |
| GP-37 | 332550 | 1130350 | 41966.29002 |
| GP-38 | 332550 | 1130150 | 39988.4 |
| GP-39 | 332550 | 1129950 | 39988.4 |
| GP-40 | 332550 | 1129750 | 39988.4 |
| GP-41 | 332550 | 1129550 | 39988.4 |
| GP-42 | 332550 | 1129350 | 39988.4 |
| GP-43 | 332550 | 1129150 | 39988.4 |
| GP-44 | 332550 | 1128950 | 39988.4 |
| GP-45 | 332550 | 1128750 | 39988.4 |
| GP-46 | 332550 | 1128550 | 39988.4 |
| GP-47 | 332550 | 1128350 | 39988.4 |
| GP-48 | 332550 | 1128150 | 41999.25291 |
| GP-49 | 332749.884 | 1128349.826 | 28962.57561 |
| GP-50 | 332749.884 | 1128349.826 | 27978.44 |
| Gp-51 | 332749.884 | 1128549.826 | 27978.44 |
| Gp-52 | 332749.884 | 1128749.826 | 27978.44 |
| Gp-53 | 332749.884 | 1128949.826 | 27978.44 |
| Gp-54 | 332749.884 | 1129149.826 | 27978.44 |
| Gp-55 | 332749.884 | 1129349.826 | 27978.44 |
| Gp-56 | 332749.884 | 1129549.826 | 27978.44 |
| Gp-57 | 332749.884 | 1129749.826 | 27978.44 |
| Gp-58 | 332749.884 | 1129949.826 | 27978.44 |
| Gp-59 | 332749.884 | 1130149.826 | 27978.44 |
| Gp-60 | 332749.884 | 1130349.826 | 29385.08383 |

*Figure (4.1) Map of the influence area of each borehole in the study area to calculate the reserve*

*Table (4.1) Reserve calculation for each borehole in the study area*

| Borhole ID | Gypsum Thickness (m) | Influence Area ($m^2$) | Volume ($m^3$) | Metric Ton |
|---|---|---|---|---|
| GP-01 | 3 | 29398.19092 | 88194.57276 | 181844.4799 |
| GP-02 | 3 | 27990.04 | 83970.12 | 173134.268 |
| GP-03 | 0 | 27990.04 | 0 | 0 |
| GP-04 | 2 | 27990.04 | 55980.08 | 115422.8454 |
| GP-05 | 2 | 27990.04 | 55980.08 | 115422.8454 |
| GP-06 | 1 | 27990.04 | 27990.04 | 57711.42268 |
| GP-07 | 2 | 27990.04 | 55980.08 | 115422.8454 |
| GP-08 | 1 | 27990.04 | 27990.04 | 57711.42268 |
| GP-09 | 1 | 27990.04 | 27990.04 | 57711.42268 |

| Borhole ID | Gypsum Thickness (m) | Influence Area ($m^2$) | Volume ($m^3$) | Metric Ton |
|---|---|---|---|---|
| GP-10 | 2 | 27990.04 | 55980.08 | 115422.8454 |
| GP-11 | 2 | 27990.04 | 55980.08 | 115422.8454 |
| GP-12 | 2 | 29373.82559 | 58747.65118 | 121129.1777 |
| GP-13 | 1 | 41977.54 | 41977.54 | 86551.62887 |
| GP-14 | 2 | 40000 | 80000 | 164948.4536 |
| GP-15 | 1 | 40000 | 40000 | 82474.2268 |
| GP-16 | 1 | 40000 | 40000 | 82474.2268 |
| GP-17 | 3 | 40000 | 120000 | 247422.6804 |
| GP-18 | 3 | 40000 | 120000 | 247422.6804 |
| GP-19 | 3 | 40000 | 120000 | 247422.6804 |
| GP-20 | 3 | 40000 | 120000 | 247422.6804 |
| GP-21 | 2 | 40000 | 80000 | 164948.4536 |
| GP-22 | 2 | 40000 | 80000 | 164948.4536 |
| GP-23 | 3 | 40000 | 120000 | 247422.6804 |
| GP-24 | 1 | 42012.36 | 42012.36 | 86623.42268 |
| GP-25 | 1 | 42012.36 | 42012.36 | 86623.42268 |
| GP-26 | 1 | 40000 | 40000 | 82474.2268 |
| GP-27 | 1 | 40000 | 40000 | 82474.2268 |
| GP-28 | 1 | 40000 | 40000 | 82474.2268 |
| GP-29 | 1 | 40000 | 40000 | 82474.2268 |
| GP-30 | 2 | 40000 | 80000 | 164948.4536 |
| GP-31 | 1 | 40000 | 40000 | 82474.2268 |
| GP-32 | 1 | 40000 | 40000 | 82474.2268 |
| GP-33 | 1 | 40000 | 40000 | 82474.2268 |
| GP-34 | 2 | 40000 | 80000 | 164948.4536 |
| GP-35 | 2 | 40000 | 80000 | 164948.4536 |
| GP-36 | 1 | 41977.54 | 41977.54 | 86551.62887 |
| GP-37 | 1 | 41966.29002 | 41966.29002 | 86528.43303 |
| GP-38 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-39 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-40 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-41 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-42 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-43 | 0 | 39988.4 | 0 | 0 |
| GP-44 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-45 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-46 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-47 | 1 | 39988.4 | 39988.4 | 82450.30928 |
| GP-48 | 1 | 41999.25291 | 41999.25291 | 86596.39775 |
| GP-49 | 0 | 29362.57561 | 0 | 0 |
| GP-50 | 0 | 27978.44 | 0 | 0 |
| Gp-51 | 1 | 27978.44 | 27978.44 | 57687.50515 |
| Gp-52 | 0 | 27978.44 | 0 | 0 |
| Gp-53 | 0 | 27978.44 | 0 | 0 |
| Gp-54 | 1 | 27978.44 | 27978.44 | 57687.50515 |

| Borhole ID | Gypsum Thickness (m) | Influence Area ($m^2$) | Volume ($m^3$) | Metric Ton |
|---|---|---|---|---|
| Gp-55 | 1 | 27978.44 | 27978.44 | 57687.50515 |
| Gp-56 | 1 | 27978.44 | 27978.44 | 57687.50515 |
| Gp-57 | 1 | 27978.44 | 27978.44 | 57687.50515 |
| Gp-58 | 1 | 27978.44 | 27978.44 | 57687.50515 |
| Gp-59 | 1 | 27978.44 | 27978.44 | 57687.50515 |
| Gp-60 | 1 | 29385.08383 | 29385.08383 | 60587.80171 |
| | | | Reserve (Tons) | 5921356.641 |
| | | | Million tons | 5.921356641 |

# (5) Results and Recommendations

## 5.1 Results

- Boreholes GP1 to GP60 were drilled in Azraq, where the gypsum thickness reached three meters. The thickness of gypsum increases in the south and southwest of the study area, and starts decreasing as we head towards the north and northwest of the study area.
- The rock overburden thickness over the gypsum layer ranged between 0 to 1.5 meters.
- The gypsum bed is located within the Azraq geological formation, which dates back to the Pliocene-Pleistocene geological age, and covers most layers of the study area.
- There are white and gray layers of gypsum, which are mostly pure and sometimes mixed with small percentages of impurities such as greenish-gray clay with small percentages of fine sand, silt and calcite.
- The results of mineral analysis showed that the main component of most samples is gypsum with presence of some other minerals in small percentages such as quartz and calcite.
- The results of chemical analysis showed that the average percentage of gypsum of all samples ranged between 60 & 80%.
- The total primary reserves of gypsum in the study area about 6 million metric tons.

## 5.2 Recommendations

The necessity of continuing research and exploration gypsum in the Azraq area, especially the southern and southwestern suburbs of the study area, noting that the gypsum project is within the first phase of exploration studies, as 60 boreholes were drilled out of 130 boreholes were identified in the Azraq area.

# (6)References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- www.eurogypsum.org

# (7)Appendix

## Rocky description of boreholes

| | |
|---|---|
| **Borehole No.: GP-01** | **Start Drilling: 26/7/2017**<br>**Stop Drilling: 1/ 8 /2017** |
| **Coordinates ( Palestine Belt)**<br>**E : 331950**<br>**N: 1128150**<br>**Elevation: 515.2m** | **Total depth:11 m**<br>**Rig: SD-300** |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | 0 | Gypsum, silty, dirty grey with limestone and chert fragments, medium to hard. |
| 1 | 2 | core | 0 | As above, with marl and chert fragments. |
| 2 | 3 | core | 0 | Gypsum, silty, grey to light grey, with limestone fragments, medium to hard. |
| 3 | 4 | core | 0 | Sandstone, conglomerate texture, limestone as cement, brown to light brown, medium to hard. |
| 4 | 5 | core | 0 | As above, coarse texture. |
| 5 | 6 | core | 0 | As above, fine grain texture, clay and limestone as cement. |
| 6 | 7 | core | 0 | Sandstone, silty, grey, medium to hard. |
| 7 | 8 | core | 0 | As above. |
| 8 | 9 | core | 0 | As above, more silty, intercalate with marl. |
| 9 | 9.5 | core | 75 | Clay, silty, calcareous, soft, light brown, medium hard. |
| 9.5 | 10 | core | 90 | Chalk, veins filled with marl, white, medium hard. |
| 10 | 11 | core | 80 | Clay, silty, brown to reddish, medium hard. |

| | |
|---|---|
| **Borehole No.: GP-02** | **Start Drilling: 2/8/ 2017**<br>**Stop Drilling: 2/ 8 / 2017** |
| **Coordinates ( Palestine Belt)**<br>**E : 331950**<br>**N: 1128350**<br>**Elevation: 510.5m** | **Total depth: 8 m**<br>**Rig: SD-300** |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | 30 | Gypsiferous, white to grey, with vugs, dirty, medium to hard. |
| 1 | 2 | core | 0 | Gypsum, with limestone and chert fragments, white to light grey, medium to hard. |
| 2 | 3 | core | 0 | As above. |
| 3 | 4 | core | 0 | Clay, silty, light brown, soft. |
| 4 | 5 | core | 70 | As above. |
| 5 | 6 | core | 0 | Sandstone, silty, limestone as cement, hard. |
| 6 | 7 | core | 0 | As above. |
| 7 | 8 | core | 30 | Clay, silty, light brown, soft. |

| Borehole No.: GP-03 | Start Drilling: 17/8/ 2017 |
|---|---|
| | Stop Drilling: 17/ 8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1128550<br>Elevation: 520.7m | Total depth: 8 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Gypsum, sandy, brownish white, with vugs and intraclasts. |
| 1 | 2 | core | | Sandstone, whitish grey, silty clay, grey green. |
| 2 | 3 | core | | Clay and siltstone, grey green. |
| 3 | 4 | cutting | | Sandstone, fine to coarse grains, with nodules of chert, claystone, and intraclasts. |
| 4 | 5 | cutting | | As above. |
| 5 | 6 | cutting | | Sandstone, whitish grey, medium to coarse grains. |
| 6 | 8 | cutting | | Clay and claystone, grey green, with sandstone, medium grains. |

| Borehole No.: GP-04 | Start Drilling: 7/8/ 2017 |
|---|---|
| | Stop Drilling: 8/ 8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1128550<br>Elevation: 512.8m | Total depth: 6 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | 0 | Soil, mixed, chert fragments. |
| 1 | 2 | core | 10 | Gypsum, white-dirty, with vugs filled with marl, hard. |
| 2 | 3 | core | 0 | As above, with limestone fragments. |
| 3 | 4 | core | 0 | Sandstone, conglomerate texture, with limestone as cement, medium to hard. |
| 4 | 5 | core | 0 | As above, medium hard, crushed. |
| 5 | 6 | core | 0 | No sample, stuck. |

| Borehole No.: GP-05 | Start Drilling: 10/8/ 2017 |
|---|---|
| | Stop Drilling: 14/ 8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1128950<br>Elevation: 514.4m | Total depth: 4 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1.5 | core | | Gypsum, whitish grey, with vugs, sandy in parts and silty sand with intraclasts. |
| 1.5 | 3 | core | | The first 60 cm gypsum, grey to whitish grey, with vugs, after that 30 cm of chalky clay, white to whitish grey, after that 60 cm of gypsum as above. |
| 3 | 4 | core | | Clay, silty, grey green, with intraclasts. |

| Borehole No.: GP-06 | Start Drilling: 15/8/ 2017 |
|---|---|
| | Stop Drilling: 15/8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1129150<br>Elevation: 515.2m | Total depth: 11 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Gypsum, sandy and silty sand, whitish grey, with intraclasts. |
| 1 | 3 | cutting | | Alluvium sediments |
| 3 | 4 | cutting | | Sandstone, chert, clay and clayey chalk, grey white. |
| 4 | 5 | | | Sandstone and silty sandstone, friable, with nodules of chert |
| 5 | 6.5 | | | As above. |
| 6.5 | 7 | | | Sandstone, grey. |
| 7 | 9 | | | Sandstone, with clay and siltstone, grey green, with intraclasts. |
| 9 | 10 | | | As above. |
| 10 | 11 | | | Clay, green, with sand, whitish grey. |

| Borehole No.: GP-07 | Start Drilling: 16/8/ 2017 |
|---|---|
| | Stop Drilling: 16/ 8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1129350<br>Elevation: 516.9m | Total depth: 10.5 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Gypsum, sandy, grey to brownish grey, with vugs and nodules of chert, with intraclasts. |
| 1 | 2 | core | | As above. |
| 2 | 2.5 | cutting | | Sand and silt with chert nodules. |
| 2.5 | 3 | cutting | | Clay, grey to green, and silt. |
| 3 | 3.5 | cutting | | As above. |
| 3.5 | 4 | cutting | | As above. |
| 4 | 5 | cutting | | Siltstone and clay, grey green |
| 5 | 6.5 | cutting | | As above. |
| 6.5 | 8 | cutting | | Sandstone, buff, fine to medium grains. |
| 8 | 9 | cutting | | Clay, grey green. |
| 9 | 10.5 | cutting | | As above. |

| Borehole No.: GP-08 | Start Drilling: 21/8/ 2017 |
|---|---|
| | Stop Drilling: 22/ 8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1129550<br>Elevation: 513m | Total depth: 7 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Gypsum, sandy, grey to whitish grey, with intraclasts and vugs. |
| 1 | 2 | | | Clay, green, gypsum, sandy, whitish grey. |
| 2 | 3 | | | Clay, grey green, with gypsum fragments. |
| 3 | 4 | | | As above. |
| 4 | 5 | | | As above. |
| 5 | 7 | cutting | | Sandstone, whitish grey, medium to coarse grains, with chert and siltstone. |

| Borehole No.: GP-09 | | | | Start Drilling: 23/8/ 2017<br>Stop Drilling: 23/8 / 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1129750<br>Elevation: 511m | | | | Total depth: 5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 0.5 | core | | Top soil |
| 0.5 | 1.5 | core | | Sandstone to silty sand, brown, and gypsum, sandy, grey and reddish brown, with nodules of chert and limestone, grey. |
| 1.5 | 3 | | | Gypsum, sandy, grey, with intraclasts and nodules of brown grey chert. |
| 3 | 5 | cutting | | Sandstone, whitish grey, medium grains, with siltstone and chert. |

| Borehole No.: GP-10 | | | | Start Drilling: 24/ 8/ 2017<br>Stop Drilling: 24/ 8 / 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1129950<br>Elevation: 507.4m | | | | Total depth: 6.5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1.5 | core | | The top 70 cm soil, the last gypsum, sandy, grey white, with intraclasts. |
| 1.5 | 3 | core | | Gypsum, sandy, grey to whitish grey, with vugs and intraclasts. |
| 3 | 4 | core | | Gypsum, sandy, grey with chert nodules. |
| 4 | 5 | | | As above. |
| 5 | 6 | | | As above. |
| 6 | 6.5 | | | Clay and chalky clay, white. |

| Borehole No.: GP-11 | Start Drilling: 28/8/ 2017 |
|---|---|
| | Stop Drilling: 28/ 8 / 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1130150<br>Elevation: 510m | Total depth: 5 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Silty sand, reddish brown, with intraclasts. |
| 1 | 2 | core | | Gypsum, grey to whitish grey, with silt and intraclasts. |
| 2 | 3 | | | Gypsum, sand, whitish grey, with vugs and intraclasts, and chert nodules. |
| 3 | 4 | | | As above. |
| 4 | 5 | | | Clay and limestone, chalky, with chert nodules. |

| Borehole No.: GP-12 | Start Drilling: 6/9/ 2017 |
|---|---|
| | Stop Drilling: 12/9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 331950<br>N: 1130350<br>Elevation: 508.8m | Total depth: 9 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Gypsum, sandy, whitish grey and buff white, with vugs and intraclasts. |
| 1 | 2 | | | As above. |
| 2 | 3 | | | Sandstone, whitish grey, medium to coarse grains, with chert nodules and intraclasts. |
| 3 | 4.5 | | | As above. |
| 4.5 | 5 | | | Chalky limestone, white. |
| 5 | 7 | cutting | | Sandstone, friable, buff. |
| 7 | 9 | | | Clay and silty clay, grey green |

| Borehole No.: GP-13 | Start Drilling: 12/9/ 2017 |
|---|---|
| | Stop Drilling: 12/ 9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1130350<br>Elevation: 507.6m | Total depth: 9 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | core | | Gypsum, buff to white, medium hard, with intraclasts. |
| 1 | 2 | | | Limestone, chalky and sandy limestone, whitish grey. |
| 2 | 3 | | | As above. |
| 3 | 4 | | | Clay and siltstone, grey green. |
| 4 | 5 | cutting | | Sandstone, friable, fine to medium grains, yellowish white. |
| 5 | 6 | | | Silty clay, grey green. |
| 6 | 7 | | | As above. |
| 7 | 8 | | | As above. |
| 8 | 9 | | | Sandstone, fine to medium grains, friable, white. |

| Borehole No.: GP-14 | Start Drilling: 13/9/ 2017 |
|---|---|
| | Stop Drilling: 13/9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1130150<br>Elevation: 518.5m | Total depth: 10m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 95 | Gypsum, buff to white, with limestone fragments, medium to hard. |
| 1 | 2 | Core | 95 | Gypsum, white, medium to hard (1-1.25)<br>clay with silty clay, brown (1.25-2) |
| 2 | 3 | Core | 90 | Clay, soft, medium hard (2-2.20)<br>silty clay, soft, grey, medium to soft (2.20-3) |
| 3 | 4 | Core | 60 | Chalky limestone, white, medium to hard. |
| 4 | 5 | Core | 0 | Sandstone, friable, fine to medium grains. |
| 5 | 6 | Core | 0 | Silty clay, green to light grey, hard. |
| 6 | 7 | Core | 0 | Silty clay, green to light grey. |
| 7 | 8 | Core | 0 | As above. |
| 8 | 10 | Core | 0 | As above. |

| Borehole No.: GP-15 | Start Drilling: 13/9/ 2017 |
|---|---|
| | Stop Drilling: 13 / 9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1129950<br>Elevation: 506.1m | Total depth: 8 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 90 | Gypsum, dirty, with vugs and veins, grey to light grey, medium hard, intercalated with clay. |
| 1 | 2 | Core | 80 | As above. |
| 2 | 3 | Core | 10 | Sandstone, friable, green, hard, fine to medium grains. |
| 3 | 4 | Core | 80 | As above. |
| 4 | 5 | Core | 85 | Chalky limestone, white to grey, medium to hard. |
| 5 | 6 | Core | 0 | Sandstone, silty, medium to coarse grains. |
| 6 | 7 | Core | 0 | As above. |
| 7 | 8 | Core | 0 | As above. |

| Borehole No.: GP-16 | Start Drilling:18 /9/ 2017 |
|---|---|
| | Stop Drilling:18 /9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1129750<br>Elevation: 512m | Total depth: 6 m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 30 | Gypsum,white,dirty, vugs , medium to hard |
| 1 | 2 | Core | 20 | As above interclated with clays |
| 2 | 3 | Core | 20 | Clay and siltstone, light brown , soft |
| 3 | 4 | Core | 30 | Chalky limestone ,white , medium to hard |
| 4 | 5 | Core | 0 | Sandstone, silty , fine to coarse grains , hard |
| 5 | 6 | Core | 0 | As above |

| Borehole No.: GP-17 | Start Drilling:20 /9/ 2017 |
|---|---|
| | Stop Drilling:20 /9/ 2017 |
| Coordinates ( Palestine Belt)<br>E: 332150<br>N: 1129950<br>Elevation: 520.1m | Total depth: 8m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 90 | Gypsy ferous, brown to dark brown , vugs , interclated with clay (0-80 cm) , gypsum , white vugs (80-100cm) |
| 1 | 2 | Core | 95 | Gypsum , white ,vugs , medium to hard |
| 2 | 3 | Core | 10 | As above , with chert hard |
| 3 | 4 | Core | 0 | Gypsum , crashed with siltstone and chert fragment , fine to coarse grains ,light gray , medium to hard |
| 4 | 5 | Core | 0 | As above |
| 5 | 6 | Core | 10 | Sandstone , silty , fine grain ,light gray |
| 6 | 7 | Core | 10 | As above |
| 7 | 8 | Core | 20 | As above , fine grains, interclated with silty |

| Borehole No.: GP-18 | Start Drilling: 21/9/ 2017 |
|---|---|
| | Stop Drilling: 21/9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1129350<br>Elevation: 524.1m | Total depth: 10m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 95 | Gypsum, brown to dark brown vugs |
| 1 | 2 | Core | 95 | Gypsum, white vugs , medium to hard . Intercalated with clay. |
| 2 | 3 | Core | 80 | (40 cm) gypsum white vugs, medium to hard .Intercalated with clay .<br>(42-31 cm) silt clay white , medium to hard. |
| 3 | 4 | Core | 50 | Clay. White medium to hard . |
| 4 | 5.6 | Core | 0 | Sandstone, silty fine grain |
| 5.5 | 8 | Core | 0 | As above . |

| Borehole No.: GP-19 | Start Drilling: 25/9/ 2017 |
|---|---|
| | Stop Drilling: 25/9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1129150<br>Elevation: 511.6m | Total depth: 10m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 20 | Gypsum, brown medium to hard |
| 1 | 2 | Core | 0 | Gypsum of white fine grain |
| 2 | 3 | Core | 0 | Intercalated with chert as above |
| 3 | 4.5 | Core | 80 | Gypsum white intercalated with silt clay and chert (3-3.5).<br>(3.5-4.5) clay white to off white . |
| 4.5 | 5.5 | Core | 0 | Clay off white fine grain with chert . |
| 5.5 | 6.5 | Core | 0 | Sandstone fine grain . |

| Borehole No.: GP-20 | Start Drilling: 26/9/ 2017 |
|---|---|
| | Stop Drilling: 26/9/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1128950<br>Elevation: 516.2m | Total depth: 10m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 90 | Gypsum white medium hard with chalk . |
| 1 | 2 | Core | 90 | Gypsum white medium hard with clay off white |
| 2 | 3 | Core | 80 | Clay Intercalated with gypsum |
| 3 | 4 | Core | 0 | Off white , medium clay yellowish fine grain |
| 4 | 5 | Core | 0 | Sandstone with chert . |
| 5 | 6 | Core | 0 | With clay sandstone off white . |

| Borehole No.: GP-21 | | | | Start Drilling: 27/9/ 2017<br>Stop Drilling: 27/9/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1128750<br>Elevation: 516.2m | | | | Total depth: 10m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 70 | Gypsum white medium hard with clay off white . |
| 1 | 2 | Core | 70 | As above |
| 2 | 3 | Core | 70 | (30 cm) as above . (230-3) silt clay white with chert |
| 3 | 4 | Core | 0 | Sand stone, white , fine grain . |
| 4 | 6 | Core | 0 | As above . |

| Borehole No.: GP-22 | | | | Start Drilling: 27/9/ 2017<br>Stop Drilling: 27/9/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1128550<br>Elevation: 512.1m | | | | Total depth: 10m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 95 | (40 cm) gypsum browm medium hard . (40-1) gypsum with clay with chert . |
| 1 | 2 | Core | 60 | Gypsum with clay with chert . |
| 2 | 3 | Core | 60 | Gypsum intercalated with siltclay off white |
| 3 | 4 | Core | 0 | Sand stone, white , fine grain . |

| Borehole No.: GP-23 | Start Drilling: 2/10/ 2017 |
|---|---|
| | Stop Drilling: 2/10/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1128350<br>Elevation: 519.6m | Total depth: 10m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 0 | Gypsum sandy whitish gray +bulk medium hard with intercalation . |
| 1 | 2 | Core | 0 | As above . |
| 2 | 3 | Core | 0 | As above . |
| 3 | 4.5 | Core | 0 | Clay to silt clay intercalated sandstone friable . |
| 4.5 | 6 | Core | 0 | As above . |

| Borehole No.: GP-24 | Start Drilling: 3/10/ 2017 |
|---|---|
| | Stop Drilling: 3/10/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332150<br>N: 1128150<br>Elevation: 509.2m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1.5 | Core | 0 | Gypsum sandy , bulk and gray ,white , medium hard with intercalation . |
| 1.5 | 3 | Core | 0 | Sandstone whitish gray with nodules |
| 3 | 4 | Core | 0 | As above . |

| Borehole No.: GP-25 | | | | Start Drilling: 3/10/ 2017<br>Stop Drilling: 3/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1128150<br>Elevation: 509.3m | | | | Total depth: 6m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 0 | Gypsum sandy whitish gray,medium hard with interclation . |
| 1 | 2 | Core | 0 | Silty clay , whitish gray , medium hard . |
| 2 | 3 | Core | 0 | Clay silty with gypsum and sandstone soft , coarse grain. |
| 3 | 4.5 | Core | 0 | Sandstone with silt stone and clay gray . |
| 4.5 | 6 | Core | 0 | As above . |

| Borehole No.: GP-26 | | | | Start Drilling: 4/10/ 2017<br>Stop Drilling: 4 / 10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1128350<br>Elevation: 511.5m | | | | Total depth: 4.5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1.5 | | | Gypsum sandy (first 40 cm) bulk and the last part gray white to whitsh gray , medium to hard with intraclasts. |
| 1.5 | 2.5 | | | Sandy silt , clayey , gray , soft . |
| 2.5 | 3 | | | Clay , gray , with nodules of chert . |
| 3 | 4.5 | | | Sandy silt , gray with nodules of chert and intraclasts . |

| Borehole No.: GP-27 | | | | Start Drilling:4 /10/ 2017<br>Stop Drilling:4 /10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1128550<br>Elevation: 512m | | | | Total depth: 4.5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1.5 | | | Gypsum sandy , silty in parts whitish gray , medium to hard with intercalated . |
| 1.5 | 3 | | | Silty clay , gray with intraclasts. |
| 3 | 4.5 | | | As above . |

| Borehole No.: GP-28 | | | | Start Drilling:10 /10/ 2017<br>Stop Drilling:10/10 / 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1128750<br>Elevation: 516.2m | | | | Total depth: 5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1.5 | | | Gypsum , sandy , whitish gray , medium to hard , with intraclasts . |
| 1.5 | 2.5 | | | As above . |
| 2.5 | 3 | | | Clay silty , and clay gray . |
| 3 | 4 | | | Sandstone , whitish yellow , friable . |
| 4 | 5 | | | As above. |

| Borehole No.: GP-29 | | | | Start Drilling:11/10/ 2017<br>Stop Drilling:11/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1128950<br>Elevation: 513.2m | | | | Total depth: 5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 2 | | 10 | Gypsum ferrous , dirty , yellowish , intercalated with marl , medium . |
| 2 | 3 | | 0 | Sandstone , silty , with chert fragments , medium grain size . |
| 3 | 5 | | 0 | As above . |

| Borehole No.: GP-30 | | | | Start Drilling:11/10/ 2017<br>Stop Drilling:11/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1129150<br>Elevation: 512.1m | | | | Total depth: 4 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 50 | Claly marl , with gypsum ferrous , yellowish , silty , medium . |
| 1 | 2 | Core | 50 | Gypsum , vugs, gray to white color , medium to hard . |
| 2 | 3 | Core | 5 | Silty clay , soft , gray color . |
| 3 | 4 | Core | 0 | Sandstone , fine grain , gray to greowish color , soft to medium . |

| Borehole No.: GP-31 | Start Drilling: 16 / 10 / 2017<br>Stop Drilling: 16 / 10 / 2017 |
|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N : 1129350<br>Elevation: 508.9 m | Total depth: 4.5 m<br>Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1.5 | core | 60 | First (40 cm) is clay stone, to siltstone dirty , brown , medium to hard .<br>(The rest of core)<br>(40-1.5) Gypsum<br>Vuges , Dirty color intercalated with sand medium-hard . |
| 1.5 | 3.0 | core | 50 | As above of (40-1.5) . |
| 3.0 | 4.5 | core | 50 | Sandstone, silty , gray , medium to hard . |

| Borehole No.: GP-32 | Start Drilling: 16 / 10 / 2017<br>Stop Drilling: 16 / 10 / 2017 |
|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N : 1129550<br>Elevation: 515.8m | Total depth: 6 m<br>Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 90% | Gypsyferrous , Dirty , color brown intercalated with clay , media to hard . |
| 1 | 1.5 | Core | 90% | Gypsum ,white to light gray , media to hard . |
| 1.5 | 3 | Core | 0% | As above intercalated with sandstone . |
| 3 | 4.5 | Core | 0% | As above . |
| 4.5 | 6 | Core | 0% | First (4.5-5.5) clay soft with ferrous chain , soft last (0.5 m) sandstone , small fine grain , gray , medium to hard . |

| Borehole No.: GP-33 | Start Drilling: 7 / 10 / 2017<br>Stop Drilling: 7 / 10 / 2017 |
|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N : 1129750<br>Elevation: 511.9 m | Total depth: 6 m<br>Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 90 | Gypsy ferrous dirty , reddish color , intercalated with clay , medium to hard . |
| 1 | 2 | Core | 90 | Fist (0.5 m) Gypsum , white , medium to hard<br>(0.5 m- 2.0 m) sandstone intercalated with clay ,Fine grain ,gray , medium to hard . |
| 2 | 3 | Core | 95 | Sandstone , Fine grain , gray , medium to hard . |
| 3 | 4.5 | Core | 40 | Gypsum intercalated with sandstone , gray , medium to hard . |
| 4.5 | 6 | Core | 30 | As above . |

| Borehole No.: GP-34 | Start Drilling:17 / 10 / 2017<br>Stop Drilling: 17 / 10 / 2017 |
|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N : 1129950<br>Elevation: 518.9 m | Total depth: 4.5 m<br>Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 95 | First (0.5 m) intercalated with clay , reddish color , hard<br>(0.5 -1.0m) gypsum, white , medium to hard . |
| 1 | 2 | Core | 95 | Gypsum, white ,vugs , medium to hard . |
| 2 | 3 | Core | 90 | Gypsum intercalated with sandstone , white to light gray , medium to hard . |
| 3 | 4.5 | Core | 50 | Clay silty , soft , gray . |

| Borehole No.: GP-35 | | | | Start Drilling:18 / 10 / 2017<br>Stop Drilling: 18 / 10 / 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N : 1130150<br>Elevation: 509.6 m | | | | Total depth: 4.5 m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 90 | First (0.5 m) intercalated with clay , reddish color ,medium to hard (0.5 -1.0m) gypsum, white , medium to hard . |
| 1 | 2 | Core | 90 | Gypsum, white , medium to hard . |
| 2 | 3 | Core | 90 | Gypsum intercalated with sandstone ,medium grain size, light gray to white , medium to hard . |
| 3 | 4.5 | Core | 30 | Clay silty , soft , gray to light gray . |

| Borehole No.: GP-36 | | | | Start Drilling:19/10/ 2017<br>Stop Drilling:19/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332350<br>N: 1130350<br>Elevation: 510.7 m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 60 | Gypsum sandy silt ,whitish grey ,medium hard to hard |
| 1 | 2 | Core | 50 | Clay silty and chalky clay , whitish grey with 30cm of gypsum sand silt , whitish grey |
| 2 | 3 | Core | 40 | Clay to chalky clay , medium hard , whitish grey |
| 3 | 4 | Core | 0 | As above |

| Borehole No.: GP-37 | Start Drilling:23/10/ 2017 |
|---|---|
| | Stop Drilling:23/10/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1130350<br>Elevation: 511.2m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 60 | The first 50cm gypsum sandy silt grey , The last 50cm clay and chalky clay medium hard to hard grey to whitish grey |
| 1 | 2 | Core | 50 | Clay and chalky clay whitish grey , medium hard |
| 2 | 3 | Core | 0 | As above |
| 3 | 4 | Core | 0 | As above |

| Borehole No.: GP-38 | Start Drilling:24/10/ 2017 |
|---|---|
| | Stop Drilling:24/10/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1130150<br>Elevation: 506.9m | Total depth: 3m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 70 | Gypsum sandy silt grey and buuf , medium hard |
| 1 | 2 | Core | 0 | Clay silty and chalky clay , whitish grey medium hard |
| 2 | 3 | Core | 0 | Sandstone with nodules of chert (Alluvial sediments) |

| Borehole No.: GP-39 | | | | Start Drilling:25/10/ 2017<br>Stop Drilling:25/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1129950<br>Elevation: 504.6 m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 40 | Gypsum clay to clay silty with silica in parts , whitish grey medium hard |
| 1 | 2 | Core | 30 | As above |
| 2 | 3 | Core | 0 | Clay and clay chalky and silty clay whitish grey medium hard |
| 3 | 4 | Core | 0 | Silty sand and sand |

| Borehole No.: GP-40 | | | | Start Drilling:26/10/ 2017<br>Stop Drilling:26/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1129750<br>Elevation: 514.8m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 60 | Clay and silt grey medium hard , Gypsum sandy to silty buff , medium hard |
| 1 | 2 | Core | 50 | Gypsum sandy and clayey whitish grey , medium hard |
| 2 | 3 | Core | 40 | Clay chalky and silt clay in parts ,grey , medium hard |
| 3 | 4 | Core | 0 | Alluvial sediments. |

| Borehole No.: GP-41 | | | | Start Drilling:30/10/ 2017<br>Stop Drilling:30/10/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1129550<br>Elevation: 514.3m | | | | Total depth: 3m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 40 | Silt sandy , buff and reddish brown , medium hard |
| 1 | 2 | Core | 50 | Gypsum sandy ,whitish grey medium hard |
| 2 | 3 | Core | 0 | Clay and silt grey to whitish grey medium hard . |

| Borehole No.: GP-42 | | | | Start Drilling:1/11/ 2017<br>Stop Drilling:1/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1129350<br>Elevation: 506m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 90 | Gypsum sandstone grey to whitish grey medium hard |
| 1 | 2 | Core | 70 | Clay and chalky clay grey to whitish grey , medium hard |
| 2 | 3 | Core | 0 | As above |
| 3 | 4 | Core | 0 | Alluvial sediments . |

| Borehole No.: GP-43 | | | | Start Drilling:2/11/ 2017<br>Stop Drilling:2/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1129150<br>Elevation: 509.9 m | | | | Total depth: 3m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 70 | Sandstone and siltstone whitish grey friable |
| 1 | 2 | Core | 60 | Silt and clay silty whitish grey |
| 2 | 3 | Core | 0 | As above |

| Borehole No.: GP-44 | Start Drilling:6/11/ 2017 |
|---|---|
| | Stop Drilling:6/11/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1128950<br>Elevation: 509.2m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 70 | Clay reddish brown ,medium hard |
| 1 | 2 | Core | 60 | As above |
| 2 | 3 | Core | 0 | Gypsum clay and clay stone reddish and whitish grey |
| 3 | 4 | Core | 0 | Alluvial sediments sandstone |

| Borehole No.: GP-45 | Start Drilling:6/11/ 2017 |
|---|---|
| | Stop Drilling:6/11/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1128750<br>Elevation: 509.7m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 70 | Gypsum clay and siltstone , sandy silt with nodules of chert |
| 1 | 2 | Core | 50 | As above |
| 2 | 3 | Core | 0 | Siltstone and silt sandstone with gypsum whitish grey medium hard |
| 3 | 4 | Core | 0 | Clay whitish grey to greenish grey medium hard |

| Borehole No.: GP-46 | Start Drilling:7/11/ 2017 |
|---|---|
| | Stop Drilling:7/11/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1128550<br>Elevation: 508.4m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1.5 | Core | 70 | Gypsum clay and siltstone grey green medium hard |
| 1.5 | 3 | Core | 50 | Clay yellowish green medium hard |
| 3 | 4 | Core | 0 | Sandstone whitish grey friable |

| Borehole No.: GP-47 | | | | Start Drilling:8/11/ 2017<br>Stop Drilling:8/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1128350<br>Elevation: 505.7m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1.5 | Core | 20 | Gypsum clay and siltstone sandstone grey green medium hard |
| 1.5 | 2 | Core | 60 | Clay grey green medium hard |
| 2 | 3 | Core | 0 | Clay and siltstone grey green medium hard |
| 3 | 4 | Core | 0 | Sandstone whitish grey friable |

| Borehole No.: GP-48 | | | | Start Drilling:9/11/ 2017<br>Stop Drilling:9/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332550<br>N: 1128150<br>Elevation: 505.5 m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 50 | Gypsum clay silty sandy texture grey medium hard |
| 1 | 2 | Core | 0 | Sandstone light grey , grey medium hard (medium grain size texture) with gypsum |
| 2 | 3 | Core | 0 | As above |
| 3 | 4 | Core | 0 | Sandstone grey color fine grain medium hard |

| Borehole No.: GP-49 | | | | Start Drilling:13/11/ 2017<br>Stop Drilling:13/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1128150<br>Elevation: 515m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 20 | Gypsum ferrous (0- 0.25) whitish light grey hard ,<br>(0.25 – 1) sandy with gypsum grey medium to hard |
| 1 | 2 | Core | 0 | Sandstone light grey to grey medium to hard |
| 2 | 3 | Core | 0 | As above |

| Borehole No.: GP-50 | | | | Start Drilling:13/11/ 2017<br>Stop Drilling:13/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1128350<br>Elevation: 518.6m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 30 | Silt clay intercalated with gypsum ferrous and clay vugs medium to hard |
| 1 | 2 | Core | 20 | As above |
| 2 | 3 | Core | 10 | Sandstone light grey medium to hard |
| 3 | 4 | Core | 0 | As above |

| Borehole No.: GP-51 | | | | Start Drilling:15/11/ 2017<br>Stop Drilling:15/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1128550<br>Elevation: 514m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 90 | Gypsoferrous vugs with silty clay brown hard |
| 1 | 2 | Core | 60 | First 10 cm is sandstone brownish hard , 20 cm clay soft grey , 30cm gypsum with vugs filled with clay hard |
| 2 | 3 | Core | 10 | Sandstone grey hard . |

| Borehole No.: GP-52 | | | | Start Drilling:15/11/ 2017<br>Stop Drilling:15/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1128750<br>Elevation: 511.5m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 75 | Gypsoferrous dark brown with vugs hard ( 0 -0.1m) from (0.1-1m) sandygypsum , sandy texture medium grain size hard |
| 1 | 2 | Core | 20 | Sandstone light grey , grey medium to hard |
| 2 | 3 | Core | 0 | As above . |

| Borehole No.: GP-53 | | | | Start Drilling:16/11/ 2017<br>Stop Drilling:16/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1128950<br>Elevation: 510.9m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 60 | Gypsoferreous dark - light brown with sandy texture medium hard |
| 1 | 2 | Core | 75 | Gypsum , sandy light grey hard |
| 2 | 3 | Core | 10 | As above |
| 3 | 4 | Core | 0 | Sandstone light grey , grey medium to hard |
| 4 | 5 | Core | 0 | As above |
| 5 | 6 | Core | 5 | As above |

| Borehole No.: GP-54 | | | | Start Drilling:25/11/ 2017<br>Stop Drilling:25/11/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1129150<br>Elevation: 513.4m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | 25 | Gypsoferreous brown to light brown vugs and vines (0-0.75) , (0.75-1) sandstone light grey hard |
| 1 | 2 | Core | 95 | Sandstone light grey medium to hard |
| 2 | 3 | Core | 80 | Sandstone silty intercalated with clay dark brown to light grey |
| 3 | 4 | Core | 80 | As above |
| 4 | 5 | Core | 50 | Sandstone light grey medium to hard |
| 5 | 6 | Core | 0 | As above |

| Borehole No.: GP-55 | Start Drilling:21/11/ 2017 |
|---|---|
| | Stop Drilling:21/11/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1129350<br>Elevation: 513.7m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 95 | Gypsum , first (0.5m) vugs and dirty color white to light brown , (the last 0.5m ) gypsum sandy texture light grey hard |
| 1 | 2 | Core | 80 | Sandstone whitish to light grey , fine – medium grain |
| 2 | 3 | Core | 0 | Sandstone with chert grey to light grey medium to hard |
| 3 | 4 | Core | 0 | As above with chalk fragment and gypsoferrous |

| Borehole No.: GP-56 | Start Drilling:21/11/ 2017 |
|---|---|
| | Stop Drilling:21/11/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1129550<br>Elevation: 511m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 95 | Gypsum vugs and viens dirty color crystalline whitish color (0-0.5) , Gypsum sandstone texture sandy light grey hard |
| 1 | 2 | Core | 80 | Sandstone light grey to whitish color medium to hard |
| 2 | 3 | Core | 0 | Sandstone with chert and chalky fragments grey medium to hard |
| 3 | 4 | Core | 0 | As above |

| Borehole No.: GP-57 | Start Drilling:27/11/ 2017 |
|---|---|
| | Stop Drilling:27/11/ 2017 |
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1129750<br>Elevation: 510.6m | Total depth: 4m |
| | Rig: SD-300 |

| From (m) | To (m) | D. Type | C.R. % | Lithological description |
|---|---|---|---|---|
| 0 | 1 | Core | 90 | Gypsoferreous brown to dark brown with silty clay hard |
| 1 | 2 | Core | 90 | Gypsoferreous sandy with medium to coarse grain grey to light grey hard |
| 2 | 3.5 | Core | 10 | Sandstone light grey to greenish color fine to medium grains , medium |

| Borehole No.: GP-58 | | | | Start Drilling:4/12/ 2017<br>Stop Drilling:4/12/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1129950<br>Elevation: 517.1 m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1.5 | Core | | Gypsoferreous sandy reddish brown medium hard the last 1m to gypsoferrous sandy silty and chalky whitish grey with vugs medium hard |
| 1.5 | 3 | Core | | Alluvial sediments |
| 3 | 4 | Core | | As above |

| Borehole No.: GP-59 | | | | Start Drilling:5/12/ 2017<br>Stop Drilling:5/12/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1130150<br>Elevation: 509.2m | | | | Total depth: 3m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 1 | Core | | Chalky limestone whitish grey with nodules of chert hard to medium hard |
| 1 | 2 | Core | | Gypsum chalky and sandy grey with vugs medium hard |
| 2 | 3 | Core | | Sandstone and siltstone grey green friable |

| Borehole No.: GP-60 | | | | Start Drilling:5/12/ 2017<br>Stop Drilling:5/12/ 2017 |
|---|---|---|---|---|
| Coordinates ( Palestine Belt)<br>E : 332749.9<br>N: 1130350<br>Elevation: 516.7m | | | | Total depth: 4m<br>Rig: SD-300 |
| **From (m)** | **To (m)** | **D. Type** | **C.R. %** | **Lithological description** |
| 0 | 0.5 | Core | | Sandstone reddish brown medium grained |
| 0.5 | 2 | Core | | Gypsum with clay ,sand and clay chalky whitish grey medium hard |
| 2 | 3 | Core | | Clay and chalky clay grey green medium hard with vugs contain gypsum |
| 3 | 4 | Core | | Sandstone grey green friable |