GEOLOGICAL SURVEY ADMINISTRATION
Mineral Status and Future Opportunity

GYPSUM

Prepared By

Bassam Tarawneh

Dr. Suha Yasin — **Geo. Marwan Madanat**

Geo. Nedal Mehyar — **Geo. Younes Al-Omari**

Edited By

Geo. Julia Sahawneh — **Geo. Marwan Madanat**

2014

CONTENTS

List of Figures

List of Tables

List of Appendices

Gypsum

1. Introduction

Gypsum is one of the non – metallic minerals, composed mainly of hydrated calcium sulfate ($CaSO_4$ $2H_2O$). It is usually formed by precipitation of $CaSO_4$ $2H_2O$ from solutions over saturated with respect to SO_4^{-2} and Ca^{+2} ions. Gypsum is associated with varying amount of carbonates, clays and other impurities. Naturally it can be found at many forms such as: selenite, satin spar (fibrous), gypsite and massive gypsum. Gypsum is used mainly for cement, ceramics industries and building construction.

2. Locations

Main localities of gypsum deposits found in eastern part of Jordan and in Azraq area west of Jordan [Table 1, Fig 1and Appendices- Plates (A) & (B)].

Table (1): Coordinates of main gypsum localities (Pal. Belt).

Area	Coordinates		Name of sheet
	East	North	
Zarqa River	217000–220800	1176500–1177500	Salt
Jabal Bani Hameda	207000-214000	1095000-1102000	Al-Rabba and Ma,in
Wadi Al-Mujib	226000–228500	1093700-1095800	Dhiban –Wadi El-Mujib
Wadi Ibn Hammad, and Wadi Al-Karak	211500-213500	1073500-1080000	Al-Rabba and Karak
North of Wadi Al Hasa and Jabal Mulayh	202000-210000	1038000-1044000	Tafila
Al-Azraq	352000-362000	1110000-1121000	Abar Al Hazim
Wadi Al Dahel	190000–196500	1023000-1028500	Fifa

3. Geological Setting

3.1. Zarqa River Area

This area is considered the most important locality for gypsum occurrences, due to the high thickness of gypsum bed. Gypsum deposit reaches 60m thick which consist of a massive successive layers of gypsum and thin layers of dolomite, clays and bitumen silty clay, overlain by soil and clays (2 – 14 m thick) in some places. Gypsum deposit occurs In Abu Ruwies Formation of Triassic age.

3.2. Jabal Bani Hameda Area

Gypsum deposit in this area refers to the Fuheis/Hummar/Shuayb undifferentiated Formation (F/H/S) of Upper Cretaceous age (Cenomanian) overlain by green to yellow clays (4 – 6m thick). There are five locations of gypsum present in this area. In three locations of them, gypsum occurs as a bed of (1 – 2m thick) overlain by soil up to 20m thick. The other two locations, gypsum consist of two layers, the first layer ranges in thickness from 0.6 – 0.8m, and the second layer is 1.2m thick.

3.3. Wadi Al-Mujib Area

Gypsum deposit of Wadi Al- Mujib area refers to the F/H/S Formation of Upper Cretaceous age (Cenomanian) it is sandwiched between limestone beds and underneath green to yellow clays, and shale and the colour of gypsum ranges from white to dark grey. The total thickness of the gypsum beds are 7.25m.

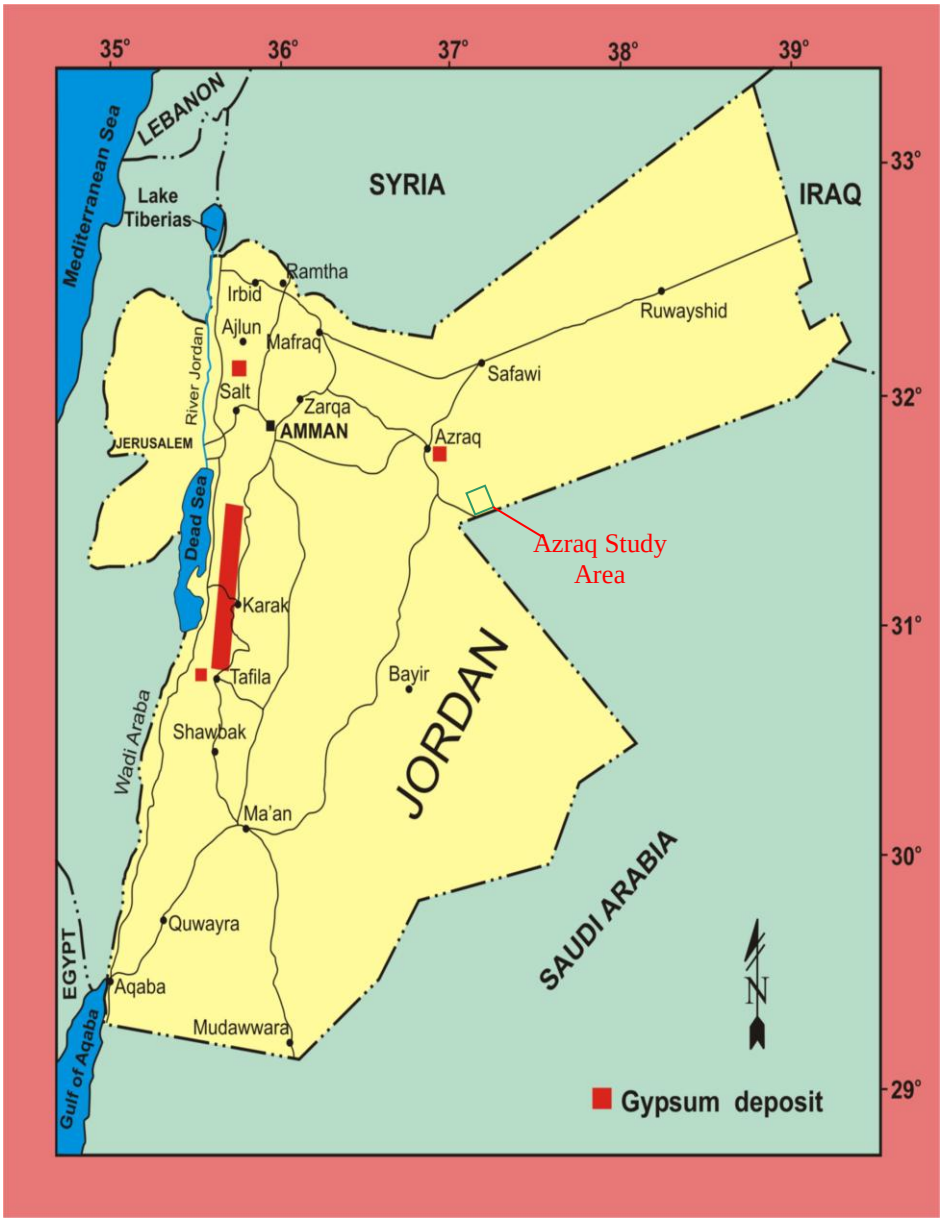


Fig (1): Gypsum deposit locations in Jordan.

3.4. Wadi Ibn Hammad Area

The gypsum beds lie in F/H/S Formation of upper Cretaceous age (Cenomanian). Gypsum deposit is associated with two beds of green to red clay in this area. It is occurring as two thin beds, the first bed is 0.8 – 1m thick, and the second is 1.2 – 2m thick.
North of Wadi Al Hasa Area

3.5 North of Wadi Al Hasa Area

The gypsum deposit of Wadi Al Hasa area refers to F/H/S Formation of Upper Cretaceous age (Cenomanian).It is present on both sides of Wadi Al-Hisa. The gypsum occurred, in Wadi Al-Hisa, consist of two beds with about two meter thick.

3.6. Al-Azraq Area

Gypsum deposit in this area occurs within the Azraq Formation of the Quaternary age. It looks like thin lamina, with a thickness ranges from 0.25 – 0.5m. Gypsum deposit in this area is known as Gypsite or Gypcrete and usually mixed with soil.

3.7. Wadi Al Dahel Area

Gypsum deposit in this area occurs within the F/H/S Formation of Upper Cretaceous age. Gypsum occurs as beds (1-3 beds with a thickness of about 1m for each bed), it is also occurs as thin layers (0.25 – 0.3m thick) separated by beds of vary coloured marl and clay. Gypsum deposit exposed on the surface in some places and covered by 10 -15 m of overburden in the other places.

4. Reserves

The geological reserves of Jordanian gypsum are estimated as follows:

Table (2): Gypsum deposits reserves.

Area	NRA reserves	Private companies	Exploited Company
Zarqa River	G. 10.000000 t Possible7.300000 t Proved 1.700000 t	450.000 t	Cement
Wadi Al qurr	167.000 t		
Namteh & Aimah /Tafila	165.000 t		
Wadi Al-Mujib	562.000 t	97960 t 172.000 t 80.000 t 206.030 t 45.000 t	Falahat Al-Naser Al-Noor Al- Mujib Al-Joud
Al-Azraq	3.000.000 t		
Wadi Al Dahel	284.000 t	200.000 t	Cement
North of Wadi Al Hasa & Jabal	1.400.000 t	1.500.000 t	Public mining
Wadi Hidan-Madaba		48.000 t	Abdul Majeed
Sa'eeda		658.000 t	Al- Mujib
Aqraba Madaba		8370 t	Al-Noor

5. Mineral Properties

5.1 Chemical Properties

The quality of gypsum depends on SO_3% and CaO% content. According to the geochemistry analysis Jordan gypsum considered to be a good quality (Table 3).

Table (3): Chemical analysis of gypsum in different localities.

Area	CaO %		SO_3%	
	From	To	From	To
Zarqa River	31.0	34.0	40.0	47.0
Wadi Al Hasa	31.3	32.4	39.4	45.1
Wadi Ibn Hammad	29.3		40.98	
Jabal Bani Hameda	32.0	36.3	45.3	50.9
Wadi Al-Mujib	28.1	32.5	37.3	44.7
Al-Azraq	32.0	35.0	42.0	45.0
Wadi Al Dahel	29.4	39.5	36.1	52.0

5.2 Mineralogical Properties

Wadi Al Dahel: The main minerals occur are gypsum and anhydrite with traces of quartz, dolomite and calcite.

Zarqa river: Technostone SpA estimated the mineralogical composition of a single sample of gypsum and they found it consist of 79.5% gypsum, 4.7% Anhydrite, 0.34% Sodium chloride with the reminder as dolomite and clay.

6. Background

Gypsum deposits of Jordan were first recorded in 1970, since that time many exploration and geological studies have been carried out to estimate the reserves and properties of these deposits. These studies include the following:

- In 1984, Teimeh, M. Studied the gypsum occurrences of Jabal Mulayh area / Tafila District, this study include mapping, drilling, trenching, pitting, many samples were collected and analyzed. And also measured the reserve of gypsum.

- In 1984 Technostone, S. P. A. Studied the gypsum of Wadi Zarqa area, the study includes geological investigation of the area, many samples were collected, and the results of analyses of these samples indicated that the gypsum of this area is pure and suitable for Portland cement production and plaster making.

- In 1986, Ajlouni, a. and Gharaybeh, M. studied the gypsum occurrences of Jabal Mulayh area. Many boreholes were drilled; samples were collected for chemical analyses, and reserve calculations.

- In 2000, Madanat, M., et al, studied the occurrences of gypsum in the area between Wadi Al-Dahl and Al-Rashdyah / Tafila District. Many trenches were dug and samples were collected for chemical analysis, and they calculated the gypsum reserve in this area.

7. Global Market

Domestic Production and Use: In 2012, domestic production of crude gypsum was estimated to be 9.9 million tons with a value of about $69.3 million. The leading crude gypsum-producing States were, in descending order, Oklahoma, Texas, Iowa, Nevada, and California, which together accounted for 58% of total output. Overall, 47 companies produced gypsum in the United States at 54 mines and plants in 34 States. Approximately 90% of domestic consumption, which totaled approximately 22 million tons, was accounted for by manufacturers of wallboard and plaster products. Approximately 1.5 million tons for cement production and agricultural applications and small amounts of high-purity gypsum for a wide range of industrial processes accounted for the remaining tonnage.

Events, Trends, and Issues: U.S. gypsum production increased 11% compared with that of 2011 as the housing and construction markets increased in activity. Apparent consumption increased by 4% compared with that of 2011. The world's leading gypsum producer, China, produced more than five times the amount produced in the United States, the world's fourth ranked producer. Iran is thought to rank second in world production and supplied much of the gypsum needed for construction in the Middle East. Spain, the leading European producer, ranked third in the world and supplied crude gypsum and gypsum products to much of Western Europe. An increased use of wallboard in Asia, coupled with new gypsum product plants, spurred increased production in that region. As more cultures recognize the economy and efficiency of wallboard use, worldwide production of gypsum is expected to increase.
Demand for gypsum depends principally on the strength of the construction industry, particularly in the United States, where about 95% of consumed gypsum is used for building plasters, the manufacture of portland cement, and wallboard products. If the construction of wallboard manufacturing plants designed to use synthetic gypsum from flue gas desulfurization (FGD) units as feedstock continues, this will result in less mining of natural gypsum. The availability of inexpensive natural gas, however, may limit the increase of future FGD units and, therefore, the production of synthetic gypsum. Gypsum imports increased slightly compared with those of 2011. Exports, although very low compared with imports and often subject to wide fluctuations, increased by 56%.

World Mine Production and Reserves: Reserves for Brazil, India, and Poland were revised based on information from those countries.

Table (4): World Mine Production and Reserves

Country	Mine production (Mt.)		Reserves6
	2011	2012	
United States	8.900	9.900	700.000
Algeria	1.650	1.650	NA
Argentina	1.340	1.200	NA
Australia	3.500	3.000	NA
Brazil	2.750	2.800	230.000
Canada	2.560	2.200	450.000
China	48.000	48.000	NA
France	2.300	2.300	NA
Germany	2.020	2.050	NA
India	2.700	2.750	69.000

Iran	13.000	14.000	NA
Italy	4.130	4.100	NA
Japan	5.600	5.700	NA
Mexico	3.840	3.850	NA
Poland	1.200	1.200	55.000
Russia	3.000	3.100	NA
Saudi Arabia	2.100	2.300	NA
Spain	11.500	11.500	NA
Thailand	9.900	10.000	NA
Turkey	3.200	3.000	NA
United Kingdom	1.700	1.700	NA
Other countries	14.500	14.900	NA
World total	149.000	150.000	Large

As a low-value, high-bulk commodity produced from deposits widely distributed throughout the world, gypsum tends to be consumed within the country in which it is mined. Less than 20% of the world's crude gypsum production was estimated to be an international trade. Canada, Mexico, Spain and Thailand are the major crude gypsum exporters in the world.

Worldwide, gypsum is used in producing Portland cement that used for construction (i.e. bridges, buildings, highways, and many other structures). Gypsum is extensively used as a soil conditioner on large tracts of land in suburban areas and in agricultural regions.

Gypsum output is classified as either calcined or uncalcined. Calcined gypsum produced domestically from crude gypsum to manufacture wallboard and plaster products, whereas uncalcined gypsum is used for producing Portland cement and agriculture, accounted almost for all remaining consumption during the year.

7.1. Synthetic Gypsum

Synthetic gypsum is generated as a byproduct in flue-gas desulphurization (FGD) systems and used to reduce sulfur dioxide emissions from coal-fired electric power plants. The FGD systems not only keep the air clean, but also they can provide a sustainable, ecologically sound source of very pure gypsum. Various other acid-neutralizing processes also generate synthetic gypsum.

The use of synthetic gypsum from FGD is expected to increase as more coal-fired power plants convert their desulphurization processes to produce commercial gypsum and as more wallboard plants are constructed near these power plants.

7.2. Phospho Gypsum

Phospho-gypsum (PG) has been used extensively in cement, wallboard and other building materials in Europe, Japan, and Australia. In some cases, PG has been used due to the absence of low-cost natural gypsum and/or scarcity of long-term storage space. In the

United States, the use of PG was very limited in the past and out of use at present. Largely because of the natural presence of radioactivity associated with this material.

7.3. Cement Industry

The leading use of gypsum, worldwide, is in the manufacture of cement and concrete, accounting for 50 % to 60 % of all consumption. In the developing countries, especially in the Middle East and Asia, most gypsum is used in the production of cement or as a plaster product.

7.4. Wallboard

Although the use of gypsum wallboard increased worldwide, only developed countries (i.e. United States) used gypsum primarily for wallboard products. In the United States, most gypsum is used to manufacture wallboard and plaster for homes, offices and commercial buildings. In average, new American home contains more than 7.31 metric tons (t) of gypsum or, in other terms, more than 571 square meters (6,144 square feet) of gypsum wallboard (Mineral Information Institute, 2001).

7.5. Prices

In 2003, the average cost (free on board, mine or plant) reported by U.S.A producers was $6.90 per metric ton for crude gypsum and about $ 20.00 per ton for calcined gypsum. The average value for plaster reported by domestic producers during the year was $15.13 per 100 kilograms ($ 6.86 per 100 pounds). In 2003, the average value of uncalcined gypsum used in agriculture and in cement production was about $17.40 per ton.

8. Investment Opportunities

- **Crude Gypsum**

Three cement factories are authorized for production in Jordan two currently in processes the third and may be two more will start production in few years later. So any new investment in crude gypsum production is required to be directed to supply these factories.

- **Phospho-gypsum**

Hundred thousands tons of phosphor - gypsum found at Aqaba port as a waste product arising from the manufacture of phosphoric acid. Nothing is known of the quality of the material although it could be appropriate for cement additive or other industries especially in view of its possible radioactive content.

- **Plaster of Paris and Wallboard**

The use of plaster board in the Middle East is still in its infancy. If Jordan has enough reserves of gypsum to enhance this industry it will be a good investment opportunity.

- **Potential Areas**

More areas of the F/H/S and Azraq Formation which are not surveyed; are recommended to be investigated (Plates A & B).

9. References

Ajlouni, A. and Gharaybeh, M. 1986. Gypsum Occurrences of Jable Mulayh Area, Tafila. *NRA.*

El-Hiyari, M. and Abed, A. 1987. Distribution and Geology of Gypsum Horizon in West-Central Jordan. In: Geology of Jordan and Adjacent Areas. Edt. Z. El Isa and et. al. *Proc. 2nd Jordanian Geol. Conf. 1985, Jordanian Geologists Association.*

Ibrahim, K. 1993. The Geology of Al-Azraq Map Sheet No. 3353. *NRA.*

Jawabreh, M., Kraisat, J. and Qarar'ah, M. 1996. Gypsum in Jordan. *NRA.* Report in Arabic.

Madanat, M., Mihyar, N., Abu Snober, A., and Rousan, A. 2000. Gypsum Deposits in Rashadieh and Dahl/ Tafila District. *NRA.* Report in Arabic.

Muneizel, S. and Khalil, B. 1993. The Geology of Al-Salt Map Sheet No. 3154-III. *NRA.*

Powell, J. 1988. The Geology of Karak Map Sheet No. 3152-III. *NRA, Bull. 8, 172p.*

Raba'a, I. and Tarawneh, B. 1999. Gypsum Deposits in Dhahkia area (in Arabic)

Salman, D. and Taimeh, M. 1975. Gypsum Occurrences of Wadi El-Huna-Wadi Azab, Zarqa River Area. *NRA, 8p.*

Tarwneh, B. 1992. The Geology of The Fifa Area, Map Sheet No. 3051-I. *Bull. 20, 46p. NRA.*

Tarwneh, B. 1988. The Geology of Al-Tafila Map Sheet No. 3151, scale 1:50 000. *Bulletin 12, NRA, 55p.*

Technostone S.P.A. 1984. Final Report on Gypsum, Wadi Zarqa Area. Study for the Exploitation of Deposits of Lithic Materials in Jordan. *Carrara, 74p. Rep. Prepared for the Public Mining Co.*

Teimeh, M. 1984. Gypsum Occurrences of Jable Mulayh Area, Tafila. *NRA, 10p.*

Teimeh, M. and Hiyari, M. 1978. Report on The Gypsum Occurrences in Southern Jordan. *NRA, 22p.*

Appendices

Plate (A): Main locations of Gypsum Deposits.
Plate (B): Main locations of Gypsum Deposits.

Plate (A) Gypsum Investment Areas

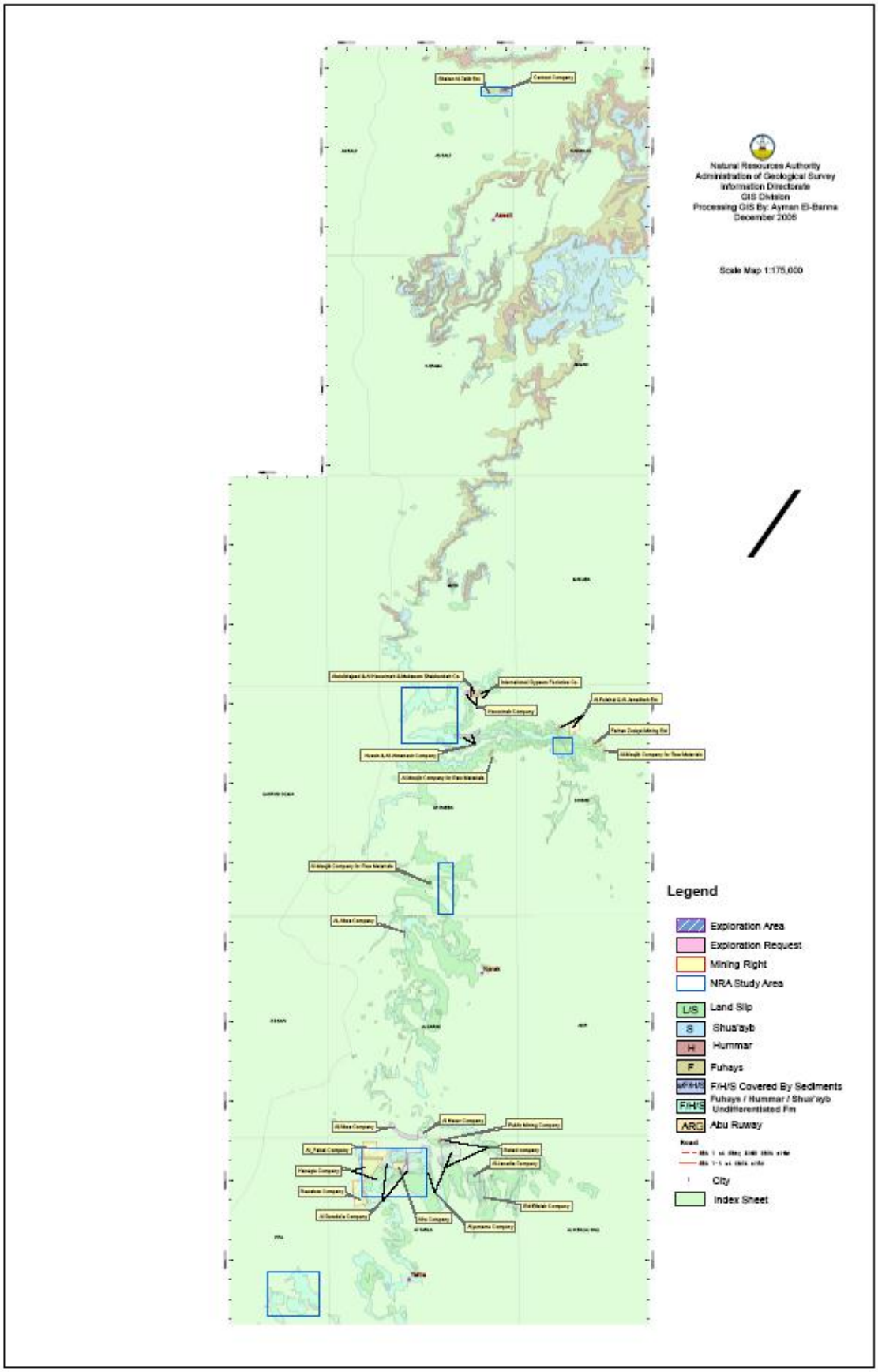
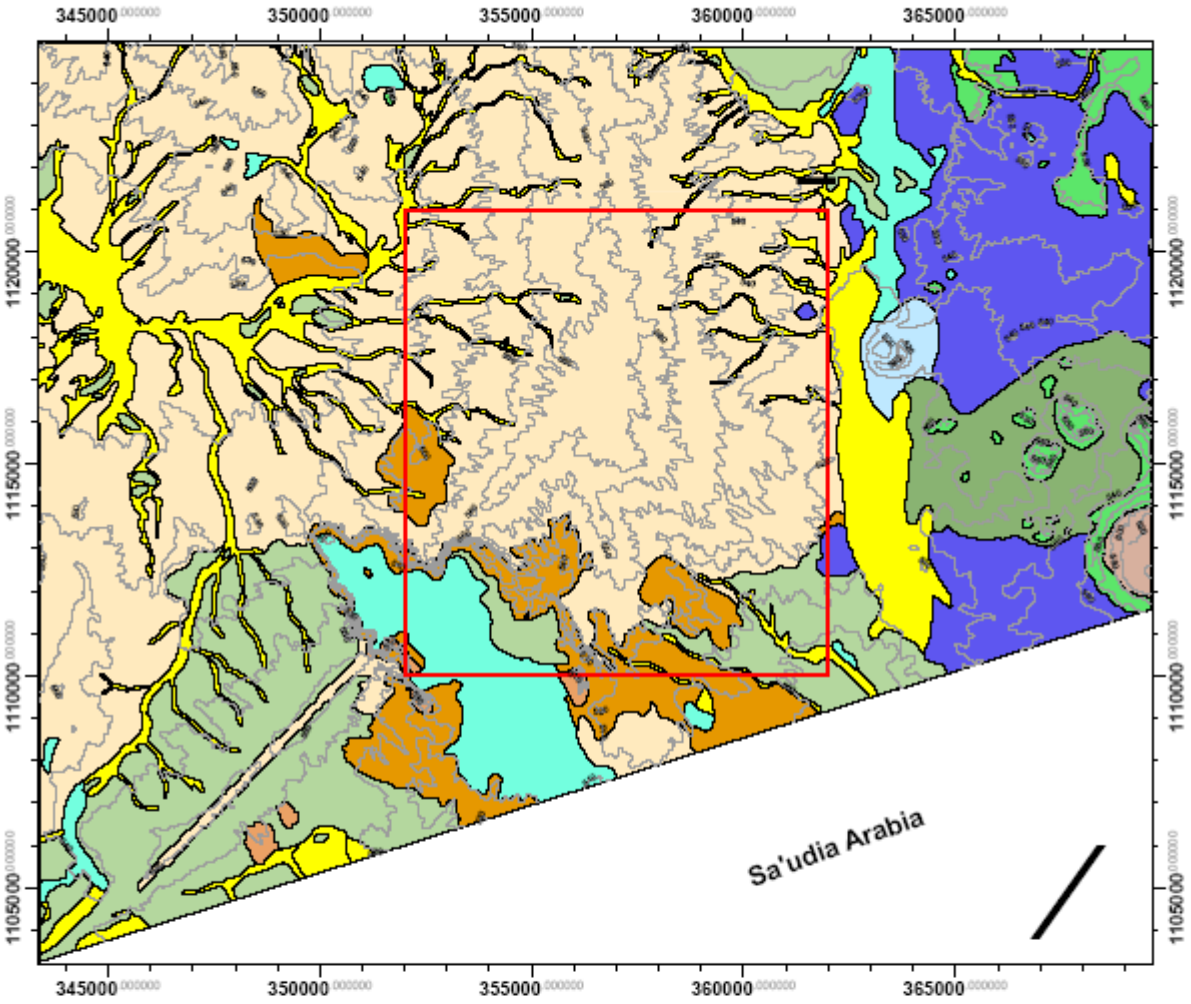


Plate B Gypsum Investment Terms



Scale Map 1:150000

Legend

DHS	Dahiklya Sandstone	HAB	Hashimya Basalt
AQ	Azraq	Plg	Plistocene conglomorate
AT	Aritayn Volcaniclastic	QCS	Qirma Calcareous Sandstone
Al	Alluvium Wadi Deposite	TT	Thulaythuwat chalk
Alm	Alluvium Mudflat	WD	Wisad
Als/QCS	Aeoline Sand Dune/Qirma		Al_Azraq/NRA Studied Area
			Contour

Natural Resources Authority
Administration Of Geological Survey
Information Diroctority
GIS Division
GIS Processing By: Ayman El-Banna
December 2006