

A COMPARATIVE GEOLOGICAL STUDY OF GYPSUM ORES IN SELECTED AREAS IN LIBYA AND THEIR ECONOMIC IMPORTANCE

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المخلص

تقدم هذه الدراسة تقييمًا جيولوجيًا واقتصاديًا شاملاً لرواسب الجبس والأنهدريت في أربع مناطق رئيسية في ليبيا: بئر الغنم، والسدرة، والرجمة (بنغازي)، وهون. باستخدام التحليل الطبقي، وبيانات التركيب الكيميائي، وتقييمات الخصائص الفيزيائية، يُسلط البحث الضوء على الاختلافات في جودة الخام والإمكانات الصناعية عبر المواقع. تشير النتائج إلى أن رواسب الجبس الليبية، وخاصة في السدرة وبئر الغنم، تُلبي أو تتجاوز المعايير الصناعية الدولية، مما يجعلها مناسبة لمجموعة واسعة من التطبيقات، بما في ذلك البناء والسيراميك والاستخدامات الطبية. كما تؤكد الدراسة على قاعدة الاحتياطي الكبيرة في ليبيا - من بين الأكبر في المنطقتين العربية والإفريقية - وإمكاناتها غير المستغلة للاستخدام المحلي والتصدير. وتقدم الدراسة توصيات استراتيجية لتعزيز الاستكشاف، وتوسيع الاستخدام الصناعي، وجذب الاستثمار في قطاع الجبس.

ABSTRACT

This study presents a comprehensive geological and economic evaluation of gypsum and anhydrite deposits in four key regions of Libya: Bir Al-Ghanam, Al-Sidra, Al-Rajma (Benghazi), and Hun. Using stratigraphic analysis, chemical composition data, and physical property assessments, the research highlights the variations in ore quality and industrial potential across the sites. The findings indicate that Libyan gypsum deposits, particularly in Al-Sidra and Bir Al-Ghanam, meet or exceed international industrial standards, making them suitable for a wide range of applications including construction, ceramics, and medical uses. The study also emphasizes Libya's significant reserve base—among the largest in the Arab and African regions—and its untapped potential for domestic utilization and export. Strategic recommendations are offered to enhance exploration, expand industrial use, and attract investment in the gypsum sector.

KEYWORDS: Gypsum ores, Anhydrite, Mineral reserves, Bir Al-Ghanam, Al-Sidra, Hun, Benghazi.

INTRODUCTION

Gypsum is one of the most common minerals on the surface of the earth, as it is found in sedimentary rocks in thick layers. It has been known since ancient times and has not lost its economic importance to this day, because it has properties and features that always make it at the forefront of the basic materials used in the manufacture of building

materials. Other properties of gypsum include its ease of use and shaping due to its rapid hardening and low price, as it is considered one of the cheap building materials. However, despite scientific development, no alternative to gypsum has been found. The use of gypsum (alabaster) in ancient civilizations to make statues, whiten the walls of tombs, cover the interior surfaces and designs of churches and other historical buildings. Gypsum deposits of various types are spread throughout different parts of Libya, numbering 18 sites, Figure (1).

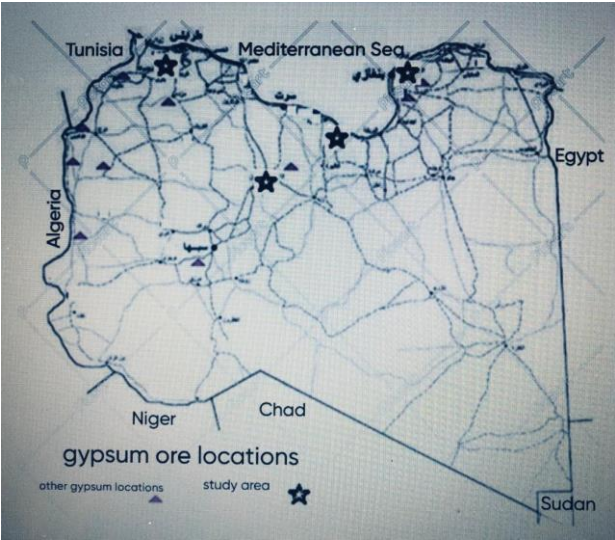


Figure 1: The most important gypsum deposit sites in Libya [1].

The work aims to conduct a comparative economic study of the most important sites of gypsum and anhydrite rocks and ores in Libya and their industrial uses. The four most important sites containing large quantities of ores were studied: Bir al-Ghanam, al-Sidra, al-Rajma, and Hun. Table (1) shows the locations of these ores.

Table (1): The locations of the most important gypsum deposits in Libya [2].

	Gypsum Deposit	Area	Location	Coordinates	
				Easting	Nording
1	Bir Elgnam	Zawia	80 km southwest of Tripoli	12° 25' 00"	32° 05' 00"
2	El-Sidra	Gulf of El-Sidra	200 km west of Benghazi and 180 km east of Sirte	18° 37' 22"	30° 17' 23"
3	El-Rajma	Benghazi	35km East Benghazi	20° 21' 00"	32° 04' 35"
4	Jufra	Hun	1-2km North East of Hun city	15° 56' 25"	29° 33' 38"

STRATIGRAPHIC SEQUENCE OF THE STUDY AREAS

The stratigraphic sequence of the study areas was determined through the geological maps of the four selected areas in the study, whose geological age extends from the Mesozoic (Triassic) to the modern (Quaternary) period. What distinguishes these areas is that they consist of sedimentary rocks, most of which are marine, the oldest of which lie directly on the basement rocks and were exposed to some subsequent tectonic

processes. A simplified explanation of the stratigraphy of gypsum ores in each of them will also be provided, as shown in Figure (2).

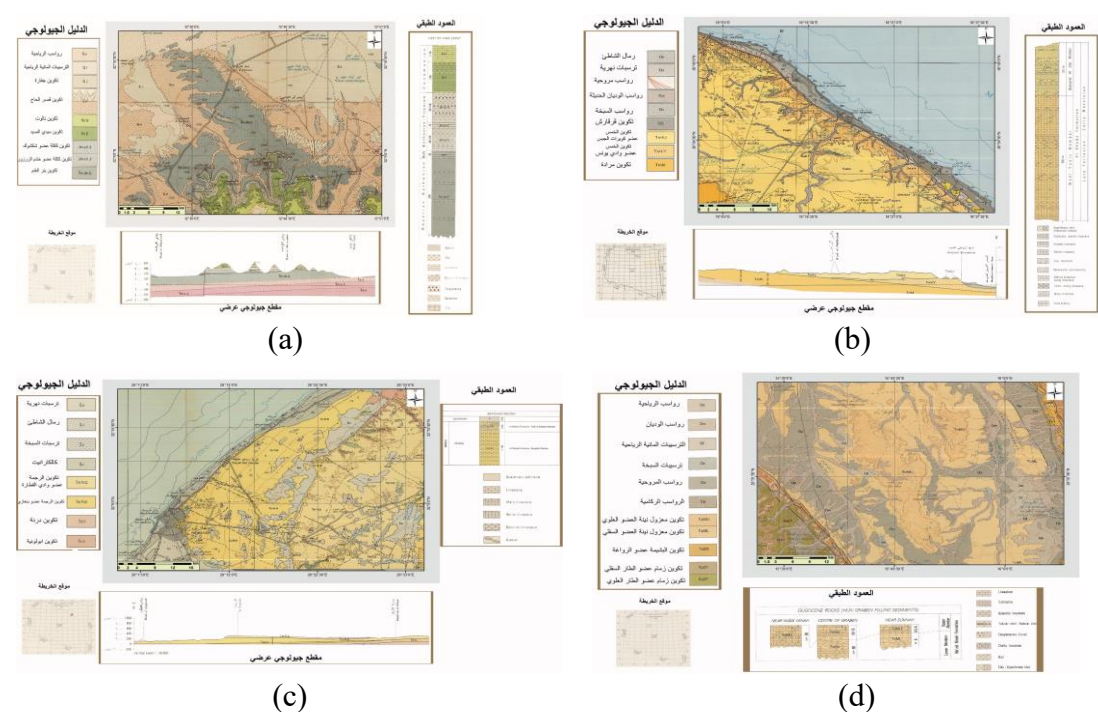


Figure (2): Geological map (a) Bir Al-Ghanam (b) Al-Sidra (c) Benghazi (d) Hun (Industrial Research Center).

Gypsum geology (its properties, types, uses, Arab reserves)

Gypsum is (CaSO₄.2H₂O) hydrated calcium sulfate with impurities of Ba, Sr, Mg, and anhydrite is usually found with it within sedimentary rocks in thick layers, and in volcanic areas as a result of the reaction of rising sulfur vapors with limestone as well as in metallic hydrothermal veins, and the percentage of oxides forming the two minerals is as shown in Table (2) and varies from one site to another according to the method of formation and its location.

Table (2): The proportions of oxides that make up gypsum and anhydrite.

Chemical composition	Chemical formula	%	
		Gypsum	Anhydrite
Sulphur trioxide	SO ₃	46.51	56.82
Calcium oxide	CaO	32.56	41.61
Water	H ₂ O	20.93	-

SPECIFICATIONS AND INDUSTRIAL PROPERTIES OF GYPSUM

There are some physical, chemical and technical properties that are taken into consideration when determining the geological-industrial importance of gypsum, to determine the industrial uses, the most important of which are shown in Table (3).

Table (3): The most important industrial properties (physical, chemical and technical) of gypsum [5].

	Gypsum property	The operator (the guide)
1	Whiteness	Up to 99-100
2	Thermal conductivity (kJ/h)	0.259 >
3	Amount of electric charge resistance (ohm/meter)	10 ⁴ >
4	Velocity of propagation of expansion waves (m/s)	4
5	Magnetism (magnetic susceptibility)	10 ⁻⁵ (0-5)
6	PH	6.5 - 7
7	solubility in water	Partially dissolved
8	Solubility in water of CaSo ₄ (g/L at 20°C)	2.05
9	Maximum solubility in water at a temperature between 32 - 41 °C	2.7
10	Solubility in HCL, HNO ₃	melts with difficulty
11	Density of burnt gypsum (for construction and ceramics) g/cm ³	2.6 - 3.0
12	Its density in bulk (for construction and ceramics) kg/m ³ : in the loose state in the bulk state (cohesive)	650 – 850 1250 – 1400
13	Porosity (for ceramic construction) %	55 – 60

ARAB GYPSUM RESERVES

Most Arab countries contain large quantities of gypsum ores, the most important of which are: Jordan in the areas of Sabil Zarqa, Wadi Mujib, Tafilah, and Azraq with confirmed reserve of 45 million tons, Emirates has large geological reserves in areas including Jebel Hafeet, Jebel Ali, Jebel Dhanna, Bani Yas Islands, Tunisia has also confirmed reserves of up to 32 million tons in the areas of Maknasi, Mustawa, northern Tunisia and others, and Algeria also has reserve of 32 million tons in the sites of Oran, Chlef, Ghardaia, Biskra, and Saudi Arabia in Al-Qassim (Ain Bin Fahid) both have large geological reserves, Sudan has a confirmed reserve of 150 million tons on the shores of the Red Sea and, Syria has a confirmed reserve is 160 million tons in Latakia, Rif Dimashq, Raqqa, Hasakah and Iraq has a confirmed reserve of 130 million tons from the southeast to the northwest, and the Sultanate of Oman has a large geological reserve in the far south of Oman, in Dhofar, and Libya has proven reserves exceeding 450 million tons in Bir Al-Ghanam, Sidra, Jafra, Benghazi, Egypt has a proven reserves of 300 million tons along the coast of the Gulf of Suez and the Red Sea, and has large geological reserves in Safi, Youssoufia, Sidi Tiji, and in Mauritania, Nouakchott area has a proven reserves of 100 million tons, Yemen has large reserves in Taazife, Hodeidah, Marib, Shabwa, Hadramaut, and Abyan and the geological reserves are large [3].

EVALUATION OF LIBYAN GYPSUM AND ITS INDUSTRIAL USES

Gypsum deposits are spread in different regions, and are exploited to a very limited extent, in the cement industry and two small gypsum plaster factories, and this stock is distributed over eighteen sites Table (4), and the calculated reserve for only eight sites with this material is approximately 8.5 billion tons.

The following is a comparison between the four most important sites: Bir al-Ghanam, al-Sidra, al-Rajma, and Hun.

Table (4): The most important gypsum sites, their reserves and their economic importance in Libya [4].

Area	Location	Reserves (M ton)	economic importance	Mining situation
Bir Al-Ghanam	Kaf Al-Kalaya and Bir Ayyad	8.403 confirmed 80 probable	Cement, gypsum and chalk industry	Very suitable for mining
Ghadames	West of Wadi Al-Awal	8.9 probable	Cement and gypsum plaster industry	thick cover
Wadi Al-Shati	Aleatshan mountain	100 probable	Cement industry and construction purposes	Very suitable for mining
Mezdah	Mezdah	Big deposit	Cement industry and construction purposes	Very suitable for mining
Wadi Al-Hayat	Wadi Tanhur	100 probable	Cement and gypsum plaster industry	Very suitable for mining
	Godwa	Small deposit	Cement industry	Very suitable for mining
Sirte	Sidrah	23 confirmed	Cement industry and construction purposes	Very suitable for mining
Jufra	Hun	18 probable	Cement industry	Very suitable for mining
Benghazi	El-Rajma Hawa al-Baraq Sidi Al-Mabrouk(1) Sidi Al-Mabrouk (2)	0.2 confirmed 0.69 confirmed 3.5 probable 4.9 confirmed	Cement industry and construction purposes	Very suitable for mining

BIR AL-GHANAM GYPSUM DEPOSITS

Gypsum and anhydrite deposits are spread in the Bir Al-Ghanam area in the form of highlands, characterized by a light brown, grayish-white color, sometimes layered to lenticular, wavy with layers of anhydrite, limestone and shale, and the thickness of its layers reaches 180 meters. According to the results of chemical analyses conducted on samples (Table 5), it is clear that the percentage of SO_3 in sample 6 reaches 41.01%, the percentage of CaO in sample 8 reaches 35.08%, and the percentage of SiO_2 in sample 5 reaches 9.22%. This means that the Bir Al-Ghanam gypsum ores are pure and do not contain a high percentage of SiO_2 to be used as an aid to smelting. The results of studies and tests conducted by the Industrial Research Center confirmed that the percentage of gypsum in the rocks reaches 75 - 99.5%, and the highest percentage of anhydrite is 8.82%. The gypsum deposits in Bir Al-Ghanam are spread over an area of about 60 km and a width of 25 km, with an unproven reserve estimated at about 80 million tons.

According to the results and to the British and Russian standard specifications, it is suitable for use in the following industries and purposes: cement industry, gypsum plaster strips, ceiling and packaging products, mold products.

Table (5): Chemical composition of samples of Bir al-Ghanam gypsum [1].

Oxides	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
SiO ₂	2.49	5.12	1.96	2.57	9.22	0.50	4.00	0.74
MgO	1.36	0.59	1.05	1.24	1.20	0.54	0.43	5.47
Fe ₂ O ₃	1.32	1.45	1.50	0.12	0.47	1.72	0.76	0.23
TiO ₂	0.01	0.02	0.08	0.03	0.03	0.01	0.01	0.01
Al ₂ O ₃	0.31	0.48	0.23	0.41	0.67	0.19	0.50	0.14
SO ₃	40.87	38.62	37.97	40.29	31.45	41.01	37.95	37.65
CaO	33.49	32.00	34.11	31.9	30.39	33.78	33.75	35.08
Na ₂ O	0.04	0.05	0.10	0.12	0.16	0.03	0.05	0.027
CO ₂	3.45	3.56	4.76	5.09	4.09	3.87	2.78	1.89
K ₂ O	0.08	0.11	0.036	0.064	0.19	0.04	0.1	0.04

SIDRA GYPSUM DEPOSITS

1. The deposits are located near the Sidra area and are characterized by their rectangular crystals of light lead gypsum with chalky limestone, and according to the results of chemical analyses (Industrial Research Center) shown in Table (6), it is clear from the chemical composition of gypsum that the percentage of SO₃ averages to 43.37% and the percentage of CaO averages to 33.3% and the percentage of SiO₂ averages to 0.6%, which means that Sidra gypsum ores are very pure and contain a low percentage of SiO₂, which gives them the advantage of use in the manufacture of medical materials. The mineral composition of these raw materials was determined, and it was found to be of very pure quality. Sidra gypsum is not only suitable for the cement industry, but also for various industrial purposes, as it can be considered a good material in the manufacture of gypsum plaster. The reserve was estimated at about 16.1 million tons as confirmed reserves and about 6.9 million tons as potential reserves, meaning that the total reserve is about 23.0 million tons [4].

Table (6): Chemical composition of Sidra gypsum [4].

Oxides	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
SiO ₂	0.58	0.62	0.63	0.60	0.62	0.62	0.64	0.52
MgO	0.32	0.42	0.32	0.25	0.25	0.30	0.25	0.52
Fe ₂ O ₃	0.017	0.017	0.017	0.015	0.016	0.013	0.013	0.020
TiO ₂	0.03	0.07	0.02	0.02	0.02	0.01	0.02	0.17
Al ₂ O ₃	0.47	0.87	0.25	0.37	0.38	0.14	0.39	1.35
SO ₃	43.24	43.44	43.62	43.29	43.70	43.18	43.10	43.40
CaO	33.58	32.95	32.91	33.50	33.02	33.51	33.44	33.47
Na ₂ O	0.21	0.23	<0.01	<0.01	<0.01	<0.01	0.03	0.14
CO ₂	4.40	4.05	4.36	4.46	4.20	4.26	4.17	3.60
K ₂ O	0.09	0.16	0.05	0.06	0.06	0.02	0.11	0.36

GYPSUM DEPOSITS IN BENGHAZI

Gypsum deposits in Benghazi are distributed in many locations, including: (Al-Rujma, Hawa Al-Baraq, Abu Maryam, Sidi Al-Mabrouk), gypsum crystals from centimeters to large, light lead to brown, layered to lenticular, with interferences of chalk sandstone, lobes and flint. According to the results of the chemical analyses conducted on the samples (Industrial Research Center) and shown in Table (7), it is clear from the

chemical composition of gypsum that the percentage of SO_3 averages to 34.88%, the percentage of CaO averages to 30.89%, and the percentage of SiO_2 averages to 3.57%. The results of the studies and tests conducted confirmed that it is generally considered to be of high quality, as the percentage of gypsum averages to about 95 - 99%. It is a high-quality raw material and can be used in some other industries, not limited to the cement industry only, the most important of which are: paint, ceramics, and as a filler, as well as in the manufacturing of plaster. The reserve is distributed in the studied sites as follows: Sidi Al-Baruk amounts to the reserve of about 3.5 million tons, Al-Buraq, where its proven reserves are estimated at about 689,000 tons, in addition to the existence of potential reserves of about 200,000 tons, Al-Rajma, has its proven reserves estimated at about 201,800 tons [5].

Table (7): Chemical composition of Benghazi gypsum [1].

Oxides	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
SiO_2	1.40	5.44	3.35	0.54	3.65	7.05	1.70
MgO	0.92	2.87	2.43	1.56	1.34	4.06	0.33
Fe_2O_3	0.14	0.60	0.33	0.10	0.80	1.08	0.57
Al_2O_3	0.59	2.04	1.08	0.48	0.21	0.76	0.59
SO_3	41.69	35.89	34.37	42.56	32.24	22.54	32.22
CaO	31.81	27.59	30.17	31.15	33.66	30.98	0.14
Na_2O	0.66	1.63	1.95	1.19	1.14	2.84	0.07
K_2O	Tr	Tr	Tr	Tr	Tr	Tr	0.33

HUN GYPSUM DEPOSITS

Gypsum deposits are located near the city of Hun, in the form of gypsum with lenses of clay and flint, and according to the results of chemical analyses conducted on samples of Hun Gypsum (Industrial Research Center) and shown in Table (8), it is clear from the chemical composition of gypsum that the percentage of SO_3 averages to 40.8% and the percentage of CaO averages to 27.3% and the percentage of SiO_2 averages to 4.8%, which means that Hun gypsum raw materials are of high quality and their content of SiO_2 is low, a potential reserve was estimated at about 17.5 million tons, as well as an inferred reserve of about 30 million tons, which can be used in various industries such as cement and as a filler material, as well as in the manufacture of plaster [6].

Table (8): Chemical composition of Hun Gypsum [1].

Oxides	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
SiO_2	7.76	23.80	1.70	2.74	19.47	7.34	1.11	0.92
MgO	0.45	2.57	0.33	0.38	2.57	0.86	-	-
Fe_2O_3	0.23	0.98	0.57	0.40	0.06	0.03	0.04	0.05
TiO_2	0.03	0.07	0.02	0.01	0.03	0.07	0.02	0.02
Al_2O_3	1.05	5.84	0.59	0.98	5.94	1.57	1.72	1.03
SO_3	40.87	26.20	43.14	41.00	26.37	35.12	47.00	47.60
CaO	28.69	18.34	32.22	32.25	22.77	29.10	36.16	36.47
Na_2O	0.25	0.73	0.14	0.11	0.25	0.17	0.13	0.14
CO_2	1.70	7.76	8.47	1.70	13.80	19.47	7.34	2.74
K_2O	0.12	0.73	0.07	0.09	0.65	0.16	0.13	0.12

In general, and by referring to the previous data above, the extent of the variation in the average chemical composition of the studied raw materials becomes clear, Table (9), which shows that the highest percentages of oxides, the main elements necessary for

the industry according to the specifications, are in Sidra gypsum, followed by Hun and then Bir al-Ghanam.

Table (9): Average concentration of the main oxides in the four regions.

Oxides	Bir Elganam	Sedra	Hun	Benghazi
SiO ₂	3.32	0.62	4.8	3.57
SO ₃	36.97	43.37	40.8	34.88
CaO	33.06	33.28	27.3	30.89
Al ₂ O ₃	0.36	0.56	2.66	0.92
Fe ₂ O	0.94	0.016	0.37	0.48
Na ₂ O	0.072	0.01	0.275	1.56
H ₂ O	-	19.43	18.08	15.34

RESULTS AND DISCUSSION

Gypsum raw materials in Libya meet all industrial requirements in terms of chemical and mineral composition, and can be used in various fields, and when compared with the specifications required in Germany and Japan, as shown in Table (10).

Table (10): Comparison of the composition of the studied gypsum stones with the required specifications in Germany and Japan [7].

Index%	Libyan gypsum				Japanese gypsum		German Gypsum		Comparison
	Hun	Benghazi	Gulf of Sidra	Bir Elganam	Second-class	First-class	Grey	White	
Total content of CaSO ₄ .2H ₂ O	82.00	97.00	97.50	93.40	91.00	94.00	98.50	96.76	All of them are first-class gray, except for the second-class white materials here.
Total impurity concentration	Less than 3.3	Less than 2.7	0.6>	1.37>	Less than 9	Less than 6	1.5	3.26	
stone humidity	-	-	-	-	Less than 4	Less than 2	-	-	-
wet water	18.08	15.34	19.43	-	19.00	20.00	20.84	20.83	All of them are first-class gray, except for the second-class white materials here.
carbonic acid	-	-	-	-	Less than 3	Less than 2.5	-	-	All of them are first-class gray, except for the second-class white materials here.
Iron oxide	0.37	0.48	0.016	0.94	0.3	0.2	-	-	Iron oxide
insoluble silica	4.8	3.57	0.62	3.32	Less than 5	Less than 4	0.1	0.06	Above specifications
Calcium oxide	27.3	30.89	33.28	33.06	29.5	31.0	32.0	33.8	All of them are first-class gray, except for the second-class white materials here.
Magnesium oxide	0.92	1.58	0.07	3.17	4.0	3.0	0.1	0.08	
Sulfur anhydrite	40.8	34.88	43.35	36.97	42.0	44.0	45.8	45.0	
Sulfur and its unions	-	-	-	-	0.2	0.1	-	-	-

We have found that they are first-class raw materials, with the exception of Hun raw materials, (which are second-class raw materials), and are considered to be of high

quality with huge reserves and suitable from a mining point of view, and their geographical location allows for the establishment of many factories on them that are sufficient for consumption and export abroad.

Through the above, Libyan gypsum can be used in many industries, uncalcined gypsum (natural), calcined gypsum or treated gypsum. Natural gypsum is used for the following purposes: cement industry, fertilizer to increase soil fertility, an aid to loosen clay soil and increase its permeability, glass industry, a carrier for pesticides, a filler in industries including textiles, paper and paints, and the manufacture of drilling fluid for oil wells. Calcined gypsum is used for: construction and urban purposes such as painting interior walls in buildings and making partitions, ceilings and wall panels and in decoration works, medical and pharmaceutical uses such as splinting and dental molds, ceramic industry, mold industry.

CONCLUSIONS

This study underscores the significant geological and economic value of Libya's gypsum and anhydrite deposits. The investigated sites—Bir Al-Ghanam, Al-Sidra, Al-Rajma, and Hun—demonstrate considerable variation in chemical composition and industrial suitability, yet all possess characteristics that meet or exceed international standards for multiple applications. The deposits are widely distributed, often surface-exposed, and require minimal mining operations, making them economically attractive.

Notably, Libya holds one of the largest confirmed gypsum reserves in the Arab and African regions, positioning it as a potential global player in the gypsum market. Despite this vast potential, current utilization remains limited. Therefore, harnessing these resources through targeted investment, industrial diversification, and further scientific assessment could greatly contribute to national economic development and reduce reliance on imports of construction and industrial materials.

By bridging geological insight with industrial needs, this study advocates for a strategic, sustainable approach to the development of Libya's mineral wealth—an approach that transforms abundant natural reserves into tangible economic opportunity.

The importance of these raw materials was clarified in terms of their quantity, location, age and surface spread of the raw material, especially since these raw materials are exposed on the surface, either in the form of domes or at shallow depths below the surface, and thus do not require complex mining operations, and what distinguishes them on the other hand is the difference in their types and thus the use can be diversified.

RECOMMENDATIONS

1. Conduct more geological and geochemical studies on the remaining existing gypsum sites.
2. The necessity of expanding studies related to the possibility of using these raw materials in industry.
3. Providing the opportunity for private and public companies to exploit these raw materials.

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