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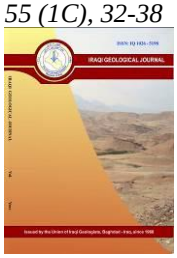

Reconnaissance Study of Gypsum from the Fatha Formation as Raw Material for Production of Gypsum Powder in Shaqlawa Area, Erbil, Kurdistan Region, Iraq

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Abstract

The quality of gypsum rock as raw material from the Fatha Formation in Talajar Village in the Shaqlawa area for ground gypsum production was assessed. A total of three samples of gypsum were collected from different locations of the same horizon in the outcrop for comparing the chemical and physical properties according to the Iraqi Standard Specification 26-1988 and American Standard for Testing and Materials C471-16. The analyses of major oxides for the bulk gypsum samples especially the main components for gypsum (SO_3, CaO, and combined water) showed good results and good purity. The apparent specific gravity and absorption of water were performed according to Iraqi Standard Specification 27-1988 at room temperature. These obtained data from chemical analyses and physical tests results revealed that the gypsum quality is in conformance with Iraqi Standard Specification requirements. The quality assessments from the study area show that the gypsum in the selected area is suitable as raw material for ground gypsum production.

Keywords: Gypsum; Plaster; Fatha Formation; Talajar; Kurdistan Region; Iraq

1. Introduction

Gypsum (hydrated calcium sulfate $CaSO_4.2H_2O$) is also known as alabaster, is the most common naturally occurring sulfate mineral (Van Drissche et al., 2019). It is utilized in many industries and constructional applications such as a raw material in the production of cement and gypsum plaster. Several processes are available to calcine gypsum into plaster of Paris. We can distinguish two categories. The first is calcination under atmospheric pressure to manufacture Beta plaster and the second is calcination under elevated pressure to manufacture Alpha plaster.

The most important characteristic which makes gypsum useful in the construction and building industry is the fast-setting time and hardening. Gypsum products (Stucco) can be classified according to Iraqi standard (IQS 28-1988) into, ordinary gypsum, technical gypsum, and plaster of Paris, which all types of gypsum are half-hydrated gypsum or hemihydrate calcined gypsum, but they have different physical and chemical properties due to the presence of impurities in their structures. The major

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application of gypsum is as a binder, finishing materials, precast units, gypsum boards, partitions, and sound isolations in various buildings (Duggal, 2008). There are numerous researches studied the Fatha Formation, and several researches studied the utilization of gypsum as raw material for the production of gypsum powder used in plaster and construction industries. Sissakian et al. (2016) studied the Miocene Sequence in Iraq and they mentioned that the very wide use for gypsum of the Fatha Formation in the plaster industry in different parts of Iraq, which is used as cementing material in construction. Gypsum of primary and secondary origins is widely used in Iraq as a building material in various applications (Jassim, 2019). Al-hadadi and Al-khafaji (2020) stated that gypsum deposits are of wide distribution in eastern Iraq especially in the Fatha Formation, and have been known as suitable materials for the gypsum plaster industry. The ever-growing need for ground gypsum nationwide requires a continuous supply of raw material of which gypsum is the most important. The gypsum from the Fatha Formation has been studied for this purpose. The aim of studying this formation outcrop at Talajar Village is to determine the quality of gypsum/anhydrite as raw material for production of gypsum powder.

2. Geological Setting

The proposed area is located nearly 800 m far from the northeast of the Talajar Village, about 15 km to the northwest of Shaqlawa Town (Fig. 1). The suggested location is 495 m high above sea level with coordinates 36° 32′ 43″ N and 44° 07′ 31″ E. In the selected locality, the gypsum occurs within the Fatha Formation and has the suitable geomorphologic conditions that can easily be excavated and transferred to the site of ground gypsum production (undercoat and finishing works).

The gypsum beds faced dissolution. The dissolution is not a constant; it increases in areas that surface water from rains and stream seep to undergrounds (Othman et al., 2020). However, the resistivity survey result for the site near Erbil-Kirkuk border in general, did not show any indication of subsurface cavitation of size more than 1.0 meter in diameter (Al-Saadi et al., 2021).

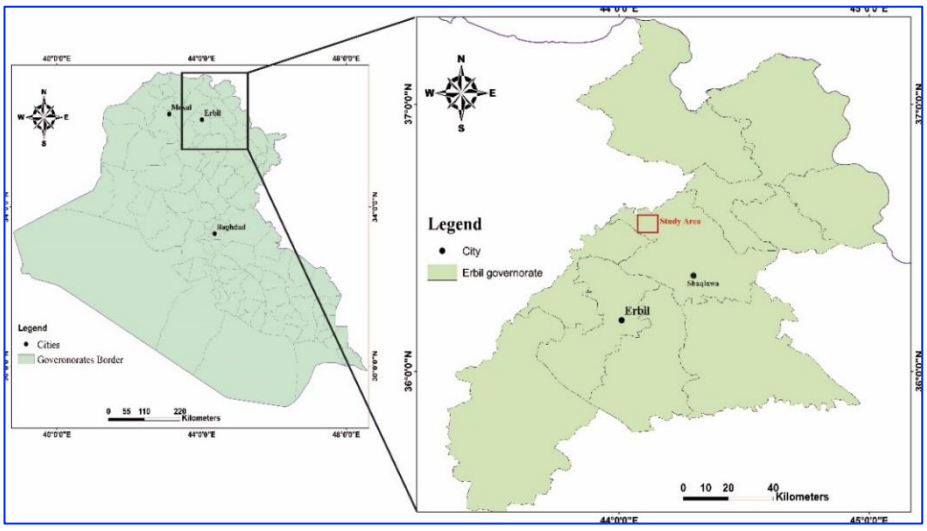

Fig. 1. Index map shows the studied location

The Fatha Formation (previously Lower Fars Formation) was first defined in the Fars area in Iran (Bellen et al., 1959). The type-section for the Fatha Formation in Iraq is located in Al Fatha Gorge (10 km north of Baiji Town, where the Tigris River crosses the Makhul-Hamrin Range). In the study area, the Fatha Formation unconformably overlies the Pila Spi Formation and underlies the Injana (Upper Fars) Formation (Fig. 2). In Talajar Village (Fig. 3), the apparent thickness of the Fatha Formation is about 250 m. The claystone, limestone, and gypsum/anhydrite beds are obvious and the upper parts are covered by soil. Therefore, the comprehensive exploration by drilling of boreholes to estimate the

preliminary reserve, then to do drilling in second stage with decreasing the drilling spacing to 50 m are highly recommended. The outcrop is located within the southwestern limb of the Safeen Anticline. Several geomorphological forms were formed by erosion, deposition, mass movement, and solution, such as karst and rock-fall. The effect of gully erosion; freezing and thawing; gravitational erosion and mass movement can be observed.

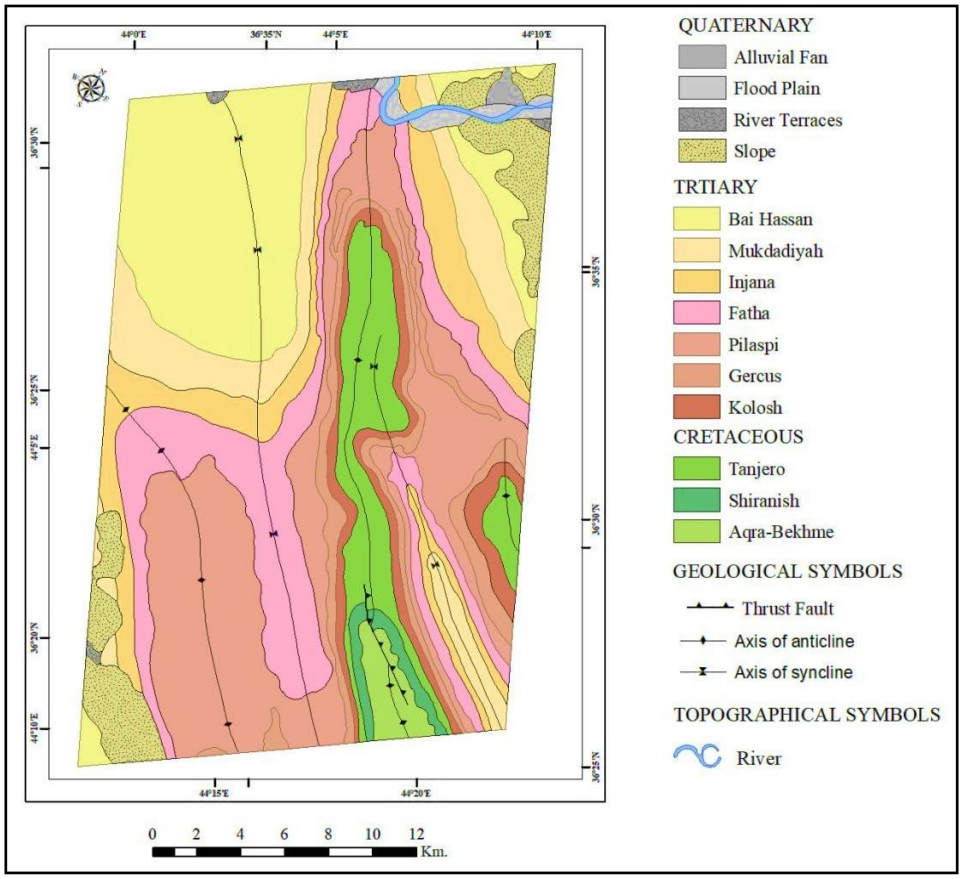

Fig. 2. Geological map of the studied area

Fig. 3. The gypsum beds within the Fatha Formation in Talajar Village

3. Materials and Methods

3.1. Chemical and Physical Tests

The chemical and physical requirement tests for the samples are carried out according to the Iraqi standard specifications which include: (1) the chemical requirements of gypsum samples as raw material that are examined according to the IQS-26-1988 (Table 1). For chemical analysis of gypsum used as plaster for civil construction purposes; (2) the physical requirement tests for the samples that are examined according to the IQS 27-1988 (Table 2). For physical analysis of gypsum used as plaster for civil construction purposes. The physical tests were performed by the National Center of Construction Laboratories, Erbil according to IQS 27-1988 at room temperature and chemical tests were performed according to IQS 26-1988 (COSQCI, 1988) and ASTM C471-16 (ASTM, 2002). The results were evaluated according to IQS 28-1988 and the samples are confirmed.

Table 1. Iraqi standard chemical properties of gypsum types based on IQS 26-1988 (IBB 311, 2017)

Required Property		Normal Gypsum	Borax	Technical Gypsum
Sulfur Trioxide (SO_3)	%	≥ 40	≥ 40	≥ 35
Calcium Oxide (CaO)	%		≥ 2/3 (SO_3)	
Total Soluble Salts and Magnesium Salts	%	≤ 0.25	≤ 0.25	≤ 0.25
Combined Water	%	≤ 9	≥ 4 and ≤ 9	≤ 9
Loss on Ignition	%	≤ 9	-	≤ 9
Impurities	%	-	≤ 5	-

Table 2. Physical properties of gypsum types based on IQS 27-1988 (IBB 311, 2017)

Required Property		Normal Gypsum	Borax	Technical Gypsum
Fineness	%	8	0	8
Setting time (S_t)	Min.	≥ 8 and ≤ 25	≥ 8 and ≤ 25	≥ 12 and ≤ 20
Compressive strength (Newton/mm^2)	MPa	3	5	6
Apparent Sp. Gr.		-	-	-
Absorption	%	-	≤ 5	-
Fraction module (Newton/mm^2)	-	-	1.5	2
Hardness strength (N/mm^2) (indention diameter of drop ball (dia. 12.8 mm))	-	-	5	5

3.2. Chemical and Physical Analyses

A total of three samples of gypsum were collected from the Fatha Formation in the studied area. Samples were taken from different locations within the same horizon to observe the lateral change. The chemical analyses were carried out in the National Center of Construction Laboratories, Erbil, to determine the percentages of major oxides in the bulk samples. The 20-gram dried rock samples were analyzed using Oxford Instruments X-Supreme 8000.

4. Results and Discussion

The Fatha consists of several gypsum horizons 3-5 meters thick, claystone, and limestone which can be used as aggregate in construction.

4.1. Correlation with Iraqi Standards

The results of chemical and physical analyses for the selected samples are shown in Tables 3 and 4, respectively. The percentages of SO_3 content of three samples were within the range of the IQS-86. The SO_3 content for three samples were more than 40% (range between 43.53% and 46.14%), while the percentage of CaO content for three samples were more than $⅔SO_3$ content (range between 30.47% and 32.30%). The high ratio of CaO in gypsum within the Fatha Formation reflects the presence of chemical factors that affecting the precipitation of gypsum rock (Liu et al., 2007). These concentrations of SO_3 clarify the quality of gypsum deposits which is in accordance with Iraqi Standard value (Fig. 4). The percentage of combined water from the analyses was more than twice of Iraqi Standard value, also the percentage of Lost on Ignition results was more than twice of proposed Iraqi Standard value, and the total soluble salts and magnesium salts were recorded as 0.05% which reflects a low amount of magnesium oxide (MgO) due to limited dolomitization (Fig. 5). The absorption result of three samples higher than the IQS value may indicate the possibility of more porosity and availability of micro-fractures within the gypsum structure (Fig. 6).

4.2. Water Supply

The site is located nearly 300 m to the North of Rubat Kargh River and about the same distance from the main Qandil-Shaqlawa, and Qandil-Salahadin water supply pipeline. The springs also exist in the area and getting water by drilling wells is another option.

Table 3. The results of chemical analyses for the selected samples.

Item	Requirements		Test Results			Specifications
			Sample 1	Sample 2	Sample 3	IQS 28-1988
1	Sulfur Trioxide (SO_3)	%	43.53	46.14	45.98	≥ 35
2	Calcium Oxide (CaO)	%	30.47	32.30	32.18	$\geq {}^{2}/_{3}\ SO_3$
3	Total Soluble Salts and Magnesium Salts	%	0.05	0.05	0.05	≤ 0.25
4	Combined Water	%	19.28	19.59	19.41	≤ 9
5	Loss on Ignition	%	19.46	19.87	19.64	≤ 9
6	Impurities	%	-	-	-	-

Table 4. The results of physical analyses for selected samples.

Item	Requirements		Test Results			Specifications
			Sample 1	Sample 2	Sample 3	IQS 28-1988
1	Fineness	%	-	-	-	≤ 8
2	Setting Time (S_t)	Min.	-	-	-	$8 \leq S_t \leq 25$
3	Compressional strength	Mpa	-	-	-	≥ 3.0
4	Apparent Sp. Gr.	-	-	2.49	-	2.32
5	Absorption of Water	%	-	19.50	-	≤ 9

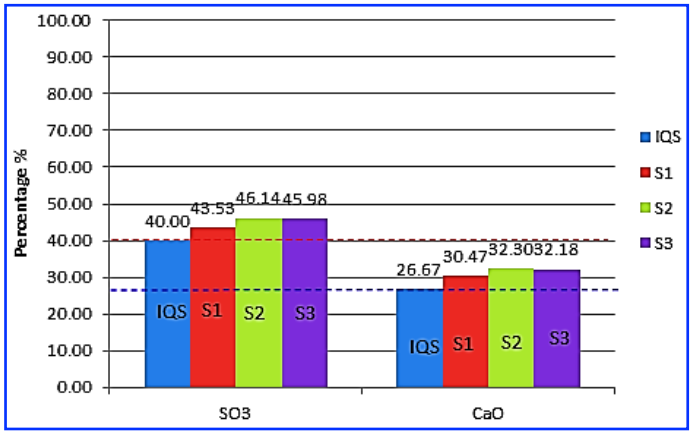

Fig. 4. Correlation of Chemical Requirement with IQS – 86

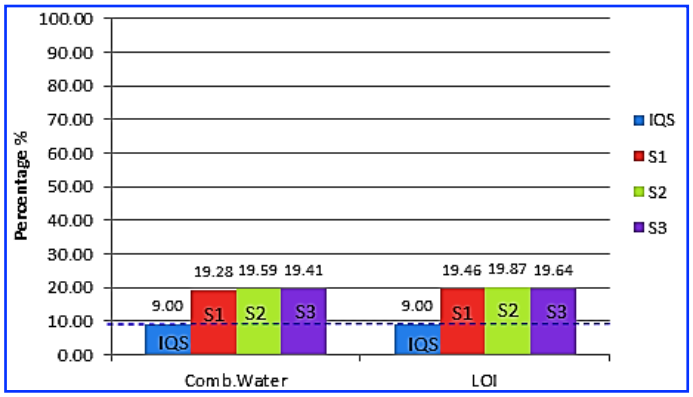

Fig. 5. Correlation of Combined Water and Lost on Ignition with IQS – 86

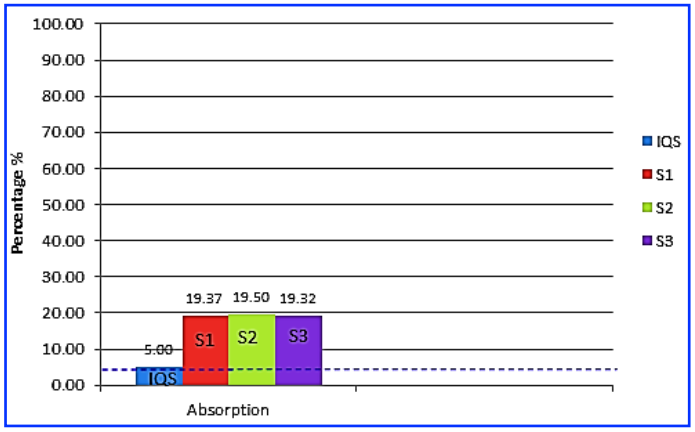

Fig. 6. Correlation of Absorption Property with IQS – 87

5. Conclusions

The obtained data from chemical analyses and the study area shows that the selected area is suitable qualitatively for ground gypsum production as:

- The correlation of data with the Iraqi Qualitative Standards for gypsum, shows that all three samples have SO_3 content percentages of more than %40, and CaO content for each sample more than ⅔ of SO_3 percentage, hence their chemical component suitable for gypsum production.
- The chemical analyses showed that the combined water percentage was more than twice of Iraqi Standards value (%9), but this can be related to samples high absorption values that also was more

than three times of Iraqi Standard value (%5) for absorption, which indicates for more porosity and availability of micro-fractures within the gypsum rock structure.

- The apparent specific gravity test showed 2.49, which is a bit above the normal pure gypsum value, which may be due to the presence of iron and some impurities.
- Because the gypsum rocks were not converted into gypsum plaster in this work, these physical parameters (Fineness, setting time (S_t), compressive strength (Newton/mm^2), hardness strength (Newton/mm^2), and fraction module) were not tested.
- The detailed exploration by drilling of boreholes to estimate the preliminary reserve is recommended.

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