Use of the Benghazi Formation in Aggregate Industry: A Case Study of Two Quarries in Northeastern Libya

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Abstract

This work aimed to evaluate the Benghazi Formation (i.e. dolomitic limestone) as aggregates for building. We selected two quarries located in northeastern Libya, namely the Al Huarry cement quarry and the Al Abyar quarry. Eight limestone samples were subjected to inductivity coupled plasma-mass spectrometry technique for major

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oxides. The main carbonate minerals in the studied samples are calcite and dolomite. The chemical classification of limestone samples are impure. This study revealed that dolomitic limestone in both quarries are suitable for aggregates.

Keywords: *Aggregates, Benghazi Formation, Al Huarry Cement Quarry, Al Abyar Quarry, Libya.*

1. Introduction

Limestone and dolomite are the common rock types and usually occur in thick beds in the Al Jabal Al Akhdar, which are structurally simple and easy to quarry. They are widely extracted for aggregate materials. In this work, two localities have been studied: Al Huarry cement quarry and Al Abyar quarry (Fig. 1). The studied quarries consist of the Benghazi Formation. The lithostratigraphic columns of the Benghazi Formation in the studied quarries are shown in (Figs. 2 and 3). The name was introduced [1] as Benghazi limestone for a sequence of massive fossiliferous limestone of Middle Miocene age.

[2] Divided Ar Rajmah Formation with in to two members the lower Benghazi Member and the upper Wadi-Al Qattarah Member [3] Is up ranked to Ar Rajmah Group by [4] and raised Benghazi Member to Benghazi Formation based on the recognized hard grounds and rock ground. [5] Reported that the ages derived from strontium isotope analysis of crystalline calcites are gave an age Late Burdigalian-Early Serravallian (13.24-17.45 Ma) for the Benghazi Formation. The goal of this study is to evaluate the Benghazi Formation (i.e. dolomitic limestone) as aggregates for building by studying the physical properties.

2. Methodology

Eight samples were collected from the studied quarries (Figs. 2 and 3). Bulk geochemical analysis for major oxides was performed using the inductively coupled plasma-mass spectrometry (ICP-MS) technique. The chemical analysis was done in the Nuclear Materials authority of Egypt. We determined the bulk density of the samples by the Mettler Toledo instrument (density meters). The density measurement was carried out in private company for constructional in Libya.

Fig. 1: Composite image showing (A) Satellite image of Libya showing the studied quarries (after [6]), (B) General view of the Al Huarry cement quarry and (C) General view of the Al Abyar quarry.

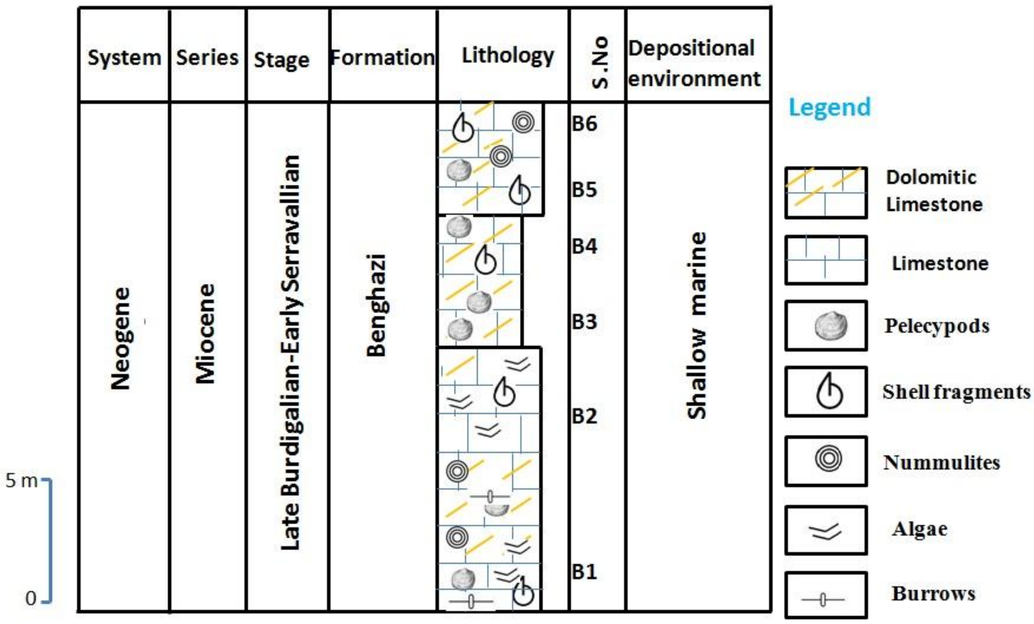

Fig.2: Lithostratigraphic column of the Benghazi Formation in Al Huarry cement quarry.

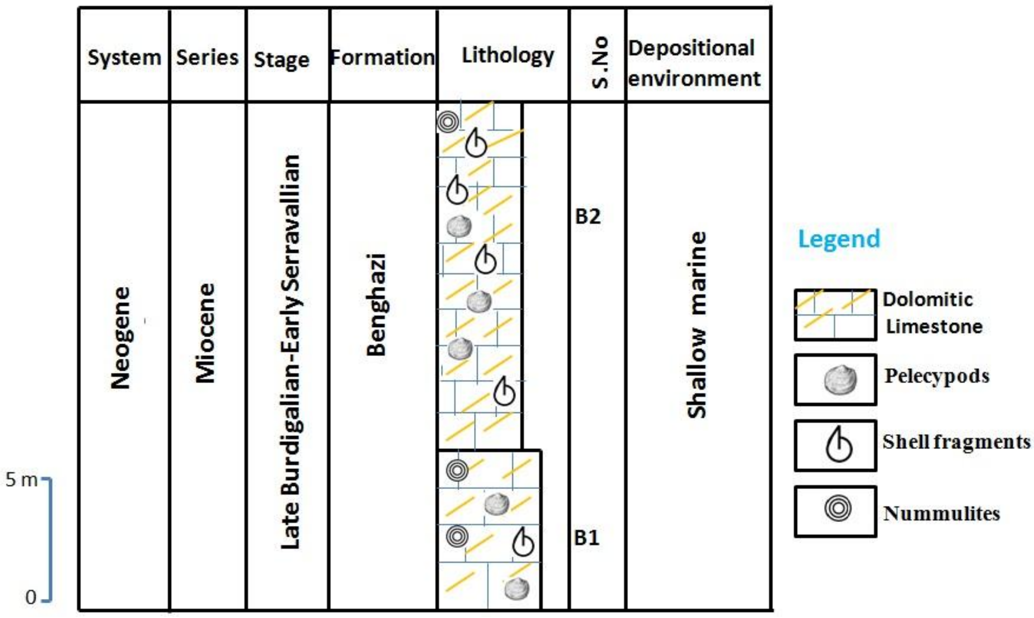

Fig.3: Lithostratigraphic column of the Benghazi Formation in Al Abyar quarry.

3. Results and Discussion

3.1. Geochemistry

The chemical analysis data are given in Table (1). The MgO/CaO ratio is about 0.27 in the Al Huarry cement quarry and 0.6 in the Al Abyar quarry; these values indicate that the studied samples are dolomitized [7]. The triplot of $FeCO_3$- $CaCO_3$-$MgCO_3$ indicates that calcite and dolomite are the main carbonate minerals in the studied samples.

Table 1: Chemical analysis data (major oxides in wt. %) of the studied samples

Sample No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	$CaCO_3$	$MgCO_3$	$FeCO_3$
B1	1.43	0.02	0.18	0.13	0.01	9.21	41.33	0.02	0.15	0.02	0.39	0.02	73.57	19.2489	0.21
B2	2.00	0.05	0.24	0.22	0.01	11.60	44.49	0.04	0.27	0.03	0.13	0.01	79.19	24.244	0.35
B3	1.05	0.01	0.15	0.08	0.02	8.23	40.93	0.01	0.12	0.02	0.26	0.01	72.86	17.2007	0.13
B4	1.91	0.03	0.21	0.05	0.01	12.59	45.52	0.03	0.19	0.01	0.34	0.02	81.03	26.3131	0.08
B5	1.20	0.02	0.16	0.08	0.03	7.76	41.00	0.01	0.10	0.01	0.36	0.03	72.98	16.2184	0.13
B6	1.18	0.01	0.13	0.14	0.01	13.73	46.42	0.01	0.09	0.01	0.25	0.02	82.63	28.6957	0.23
B7	0.81	0.01	0.33	0.16	0.01	20.79	30.75	0.02	0.06	0.02	0.19	0.01	54.74	43.4511	0.26
B8	1.22	0.01	0.40	0.23	0.01	20.86	31.12	0.02	0.09	0.03	0.21	0.01	55.39	43.5974	0.37

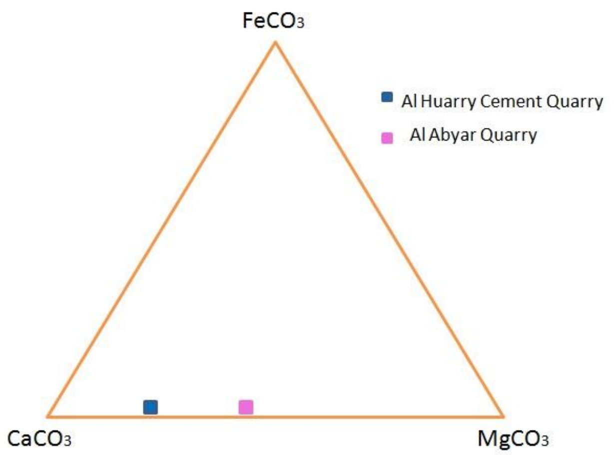

Fig.4: Triplot of $FeCO_3$- $CaCO_3$-$MgCO_3$ showing the carbonate minerals in the studied samples (fields after [8]).

3.2. Chemical Classification of Limestone

Table (2) shows the classification of limestone based on chemical composition. Clearly, the studied samples are classified as impure limestone. Impurities such as quartz, dolomite and clay are found in variable amounts.

Table 2: Chemical classification of limestone (after [9])

Categories of limestone	Chemical Composition ($CaCO_3$ in wt. %)
Very high purity	>98.5
High purity	97 – 98.5
Medium purity	93.5 – 97
Low purity	85 – 93.5
Impure	<85

3.3. Aggregates

The main impurity such as dolomite is considered as a good mineral for aggregates due to hardness and density. The density of dolomite should be in average 2.65-2.85 g/cm^3 for aggregates uses [9]. Aggregates are inert granular materials such as sand, gravel, or crushed stone, are essential ingredient in concrete [10]. Aggregates are used in nearly all residential commercial and industrial building construction and in most public-works projects such as roads and highways, bridges, railroad beds, dams, airports, tunnels, water and sewer systems [11]. There are three stages of aggregates: 1) Collection of raw material (Fig. 5), 2) Crushed of raw material (Fig. 6), and 3) Production of aggregates (Fig. 7).

Fig. 5: Field image showing the first stage (i.e. collection of raw material) in the Al Abyar quarry.

Fig. 6: Field image showing the second stage (i.e. crushed of raw material) in the Al Abyar quarry.

Fig. 7: Field image showing the third stage (i.e. production of aggregates) in the Al Abyar quarry.

3.3.1. Dimension Stones

According to [9] there are three sizes of aggregates in the Al Abyar quarry, namely fine aggregate (<5mm), medium aggregate (>5mm) and coarse aggregate (>10 mm) (Fig. 8). The dimension stone that mass using in building and consist mixture of three parts from aggregate, cement and sand (Fig. 9). This mixture produces three types of dimension stones (Fig. 10). Fine aggregates are also used to prevent the pore spaces between the aggregates to give strength (Fig .11).

Fig.8: Photographs showing the three aggregate sizes in the Al Abyar quarry. (A) Fine aggregates, (B) Medium aggregates, and (C) Coarse aggregates.

Fig. 9: Photograph showing the dimension stones in the Al Abyar quarry.

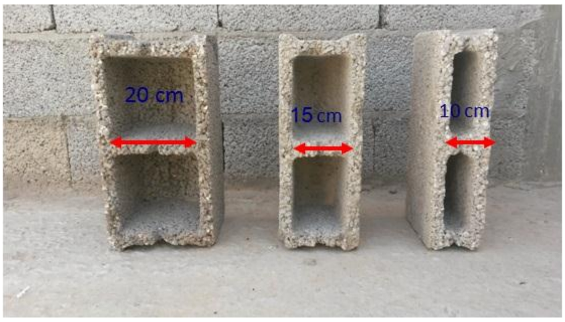

Fig. 10: Photograph showing the three sizes of dimension stones in the Al Abyar quarry.

Fig. 11: Photograph showing fine aggregates filling the spaces between aggregates in a dimension stones the Al Abyar quarry.

The average density is 2.72 g/cm^3 for the Al Huarry quarry samples and 2.75 g/cm^3 for the Al Abyar samples. Generally, there is no significant difference in the chemical composition between the studied samples. Accordingly, we conclude that the Al Huarry quarry samples can be used as aggregates for building.

4. Conclusion

Three points can be drawn from this work:

1) The Benghazi Formation samples in the Al Huarry and Al Abyar quarries are dolomitized.
2) The Benghazi Formation samples are classified as impure limestone.
3) The Benghazi Formation in the Al Huarry quarry is suitable as aggregates for building.

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