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Suitability of Granite from the Jabal Arkenu Region (Southeast Libya) for Cement Powder Production

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Index Terms
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Abstract
There are notable granite formations in Libya, especially in the southern areas. Finding out if granite from the Jabal Arkenu region can be utilized to make cement powder is the aim of this investigation. The findings demonstrated that the concentrations of SiO_2, Al_2O_3, and K_2O are all within the granite powder limits. The concentrations of Fe_2O_3, CaO, and MgO are either below or within the limits. The Na_2O concentration is somewhat beyond the limits. Furthermore, the SiO_2+Al_2O_3+Fe_2O_3 total falls between 76.31 and 90.29%. According to the aforementioned remark, the studied granite is perfectly suited for cement powder.

مدى ملاءمة الجرانيت من منطقة جبل أركنو (جنوب شرق ليبيا) لإنتاج مسحوق الأسمنت

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الكلمات المفتاحية
التقييم الجيوكيميائي، مسحوق الجرانيت، إنتاج الأسمنت، جبل أركنو، ليبيا.

الملخص
توجد في ليبيا تكوينات جرانيتية بارزة، لا سيما في المناطق الجنوبية. هدف هذا البحث إلى تحديد إمكانية استخدام جرانيت الموجود في منطقة جبل أركنو في صناعة مسحوق الأسمنت. أظهرت النتائج وقوع تركيزات ثاني أكسيد السيليكون وأكسيد الالومنيوم وأكسيد البوتاسيوم ضمن الحدود المسموح بها لمسحوق الجرانيت. كما ان تركيزات أكسيد الحديد وأكسيد الكالسيوم وأكسيد الماغنسيوم إما دون الحدود أو ضمنها. أما بالنسبة لتركيز أكسيد الصوديوم فهو يتجاوز الحدود قليلاً. علاوة على ذلك، يتراوح مجموع ثاني أكسيد السيليكون + أكسيد الألومنيوم + أكسيد الحديد من 76.31% إلي 90.29%. وبناءً على ما سبق، يعد الجرانيت المدروس مناسبًا تمامًا لصناعة مسحوق الأسمنت.

1. INTRODUCTION

Although its fine dust can cause respiratory health risks like silicosis if inhaled, granite powder—a fine, dusty byproduct of cutting and processing granite—is increasingly being used in construction, material synthesis, soil amendment, and specialty cleaning and polishing products. Granite powder is frequently a significant industrial waste issue. By filling pores and compacting the microstructure, granite powder, which is frequently used in place of some of the cement or sand in cement, increases the density, strength, durability, and water absorption of concrete while providing a sustainable way to use industrial waste. However, the best replacement levels (roughly 10–40%) and fineness are essential to prevent strength decline and guarantee consistent performance (e.g., Williams et al., 2008; Felixkala and Partheeban, 2010; Aliabdo et al., 2014; Damare et al., 2017; Ramadji et al., 2020; Chajec, 2023; Al Ismaeel et al., 2026).

Granite powder can support sustainability through the following: (1) Reusing granite powder in cement-based products is a sustainable way to handle industrial waste, lessening the load on landfills and the need for natural sand and cement (Hou et al., 2024); (2) Relying on Taguchi-based multi-response optimization in developing sustainable concrete made from granite powder (Raman and Nateriya, 2025); and (3) By recycling waste, granite powder serves as an additional cementitious material in fiber-reinforced cementitious composites, increasing sustainability (Demirtürk et al., 2026).

Granite is abundant in Libya's southern desert regions, which is crucial for comprehending the nation's mineral resources and geological past. Granite in different parts of Libya has undergone multiple geochemical evaluations (e.g., Oun, 1987; Said et al., 2000; El-Makhrouf and Fullagar, 2000; Suayah et al., 2006; Kovačević et al., 2013; Naji et al., 2018; Bensera, 2024). A geochemical evaluation of the Precambrian granite in the Jebel Arkenu area (southeast Libya) was carried out by Said et al. (2000). They found that the granitic rocks are adamellite to granite and calc-alkaline nature. The goal of this study is to determine whether granite from the Jabal Arkenu area (Fig. 1) can be used to produce cement powder.

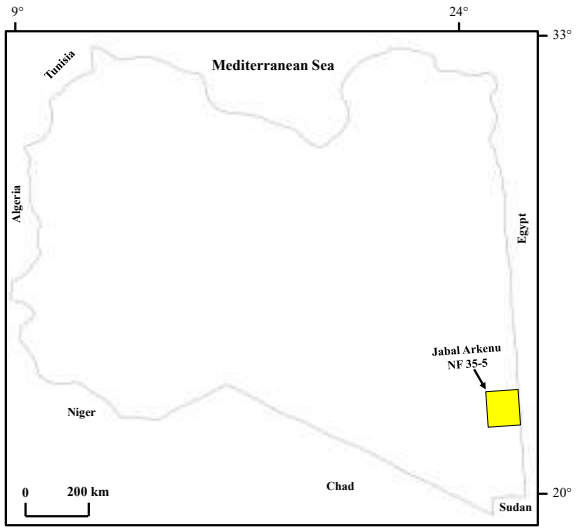


Figure 1. Location map of the Jabal Arkenu region (modified after Said et al., 2000).

2. METHODOLOGY

In this work, the Precambrian granite in the Jebel Arkenu area was evaluated based on the chemical data of Said *et al.* (2000). Thirteen samples were evaluated in total. The data included concentrations of SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, and P_2O_5. The technique used was X-ray fluorescence (XRF).

3. RESULTS AND DISCUSSION

SiO_2, TiO_2, Fe_2O_3, FeO, MnO, MgO, CaO, and P_2O_5 show a clear variation in the concentration (58.3-76.4%, 0.08-0.93%, 0.29-4.02%, 0.13-4.5%, 0.01-3.49%, 0.09-5.3%, and 0.01-0.73%, respectively), while there is a slight difference in the concentration of Al_2O_3, Na_2O, and K_2O (11.76-16.07%, 3.31-6.03%, and 2-5.1%, respectively, Tables 1 and 2).

SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, and SO_3 are the main constituents of granite powder (Table 3). SiO_2+Al_2O_3+Fe_2O_3 should typically be greater than 70% for granite powder to function as a binder in concrete (e.g., Machado *et al.,* 2025). Fig. 2 displays the following:

(1) The concentrations of SiO_2, Al_2O_3, and K_2O are within the limits of granite powder.

(2) The concentrations of Fe_2O_3, CaO, and MgO are below or within the limits.

(3) The Na_2O concentration is slightly above the limits.

Moreover, the sum of SiO_2+Al_2O_3+Fe_2O_3 ranges from 76.31 to 90.29%, indicating that the studied granite is certainly suitable for cement powder.

TABLE I. CHEMICAL ANALYSIS DATA (CONCENTRATION IN WT%) OF GRANITE IN THE JABAL ARKENU REGION (AFTER SAID ET AL., 2000)

Sample No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
1	66.08	0.39	15.03	0.79	0.79	2.77	3.08	4.03	4.28	3.21	0.14
2	73.48	0.33	12.68	4.02	0.14	0.33	0.75	0.95	3.44	3.59	0.16
3	58.30	0.93	16.07	1.94	4.50	0.09	3.49	5.30	3.66	3.55	0.45
4	73.38	0.63	12.72	1.76	0.14	0.03	0.65	1.90	3.71	3.80	0.73
5	71.49	0.31	14.66	4.00	0.32	0.04	0.46	0.09	3.47	4.51	0.09
6	72.28	0.36	13.04	3.36	0.35	0.04	0.49	1.14	3.34	4.69	0.06
8	72.35	0.62	13.74	1.87	0.13	0.04	0.38	1.00	4.00	5.10	0.06
9	76.40	0.08	12.48	1.15	0.41	0.19	0.01	0.34	3.40	4.48	0.01
10	75.70	0.09	12.96	1.63	0.16	0.02	0.10	0.21	6.03	2.00	0.01
11	71.25	0.27	13.80	0.36	0.36	2.16	1.27	1.63	3.82	4.37	0.08
12	72.44	0.18	14.85	0.29	0.29	1.62	0.25	0.98	4.17	5.08	0.06
14	71.10	0.27	14.82	2.10	0.20	0.05	0.45	1.85	3.75	3.98	0.09
15	76.11	0.18	11.76	1.75	-	0.05	0.01	0.49	3.31	4.65	0.01

TABLE II. DESCRIPTIVE STATISTICS OF THE ANALYZED OXIDES

Oxides	N	Minimum	Maximum	Mean	Std. Deviation
SiO_2	13	58.30	76.40	71.57	4.80
TiO_2	13	0.08	0.93	0.36	0.24
Al_2O_3	13	11.76	16.07	13.74	1.26
Fe_2O_3	13	0.29	4.02	1.92	1.22
FeO	12	0.13	4.50	0.65	1.23
MnO	13	0.02	2.77	0.57	0.95
MgO	13	0.01	3.49	0.88	1.12
CaO	13	0.09	5.30	1.53	1.53
Na_2O	13	3.31	6.03	3.88	0.72
K_2O	13	2.00	5.10	4.08	0.86
P_2O_5	13	0.01	0.73	0.15	0.21

TABLE III. CHEMICAL COMPOSITION OF GRANITE POWDER (AFTER CHAJEC, 2020)

Oxides	Concentration (%)
SiO_2	50–80
Al_2O_3	10–20
Fe_2O_3	3–8
CaO	5–15
MgO	2–5
Na_2O	1–3
K_2O	2–5
SO_3	<1

4. CONCLUSIONS

Granite powder in cement serves as a pozzolanic material and sustainable filler, increasing the density of concrete, decreasing porosity, and strengthening its resistance to chemical attacks. However, superplasticizers are needed to preserve workability and excellent performance.

The southern regions of Libya are characterized by large quantities of granitic rocks. The authors aimed to evaluate the viability of producing cement powder from granite in the Jabal Arkenu region located in southeastern Libya. They concluded that the chemical composition of the studied granite indicates its suitability for the aforementioned purpose.

Granite is processed to produce cement powder by turning quarry waste or sludge into a fine additive that can be used as filler or supplemental cementitious material (SCM) to improve the strength and durability of concrete. To increase pozzolanic activity, the method usually entails drying, crushing, grinding (commonly using roller or ball mills), and calcination at 700–900 °C.

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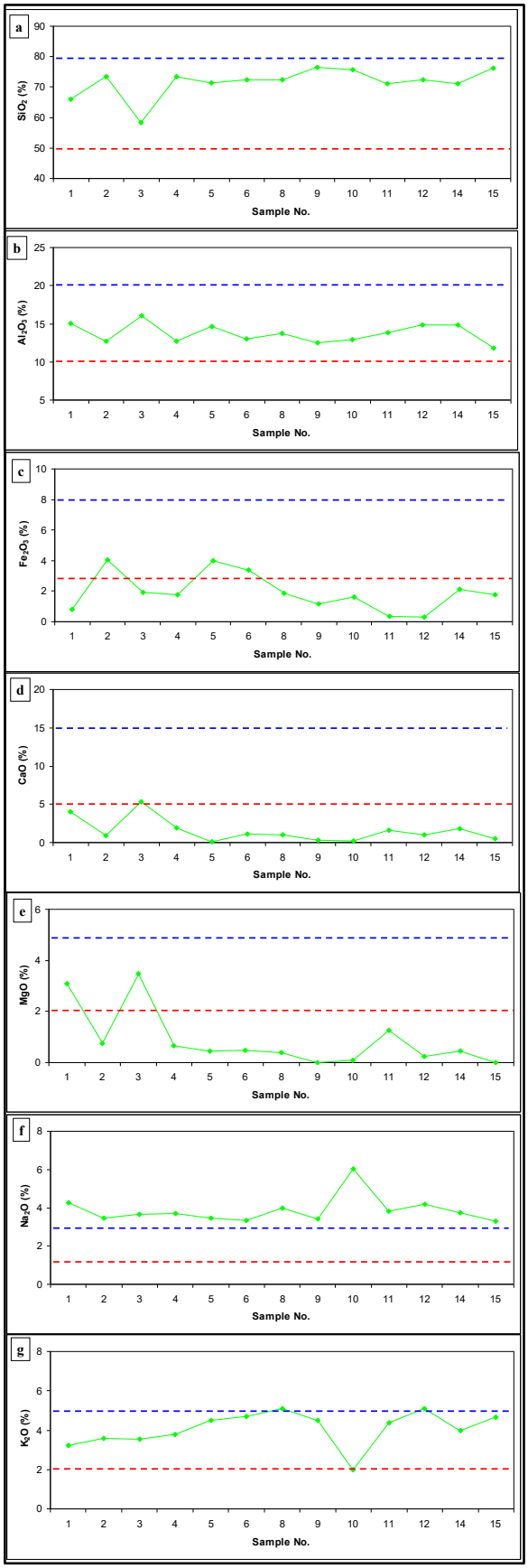


Figure 2. Binary plots showing the suitability of the studied samples for producing granite powder (the red line indicates the lower limits of granite powder, whereas the blue line represents the higher limits).

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BIOGRAPHIES



Osama Rahil Shaltami is a professor in the field of geochemistry and a senior researcher. His most important works are publications related to geochemistry of sedimentary rocks, industrial geology, economic geology, petroleum geochemistry, gas geochemistry, hydrogeochemistry, nuclear geochemistry, environmental geochemistry, and sustainable development.



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