Some Mechanical and Physical Studies of Granitic Rocks in Um Taghir, Eastern Desert, Egypt

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Abstract. Granitic rock is considered one of the most important economic materials used as building materials, ornamental stones, and other purposes. According to previous radiological studies conducted on these granites, it was found that the activity concentrations of $^{238}$U, $^{232}$Th and $^{40}$K of these granitic rocks are natural as well as the radiation effects are not harmful due to the natural radioactivity of the examined granites so that it can be exploited economically in the future. The current study aims to determine some of the physical and mechanical properties of granites in the Um Taghir area to detect these rocks' suitability for ornamental stones. The samples of the granitic rocks were cut according to the American Society for Testing and Materials specifications (cubic shape) for the detection of uniaxial compressive strength in addition to some of the physical properties were determined for each sample. Granite rock samples showed good results according to mechanical and physical tests. So that it can be extracted, transported and later used for various economic purposes.

1. Introduction

Geology is considered one of the most important and best sciences in ancient and modern times, as it helps discover some of the geological secrets hidden in the deep burials and different rocks that contain some economic minerals in addition to ornamental stones. From here, Egyptian geologists began in ancient and modern times to discover and prospect for economic raw materials and metals that contribute to reviving the Egyptian economy. A large variety of stones represent ornamental stones in ancient and modern Egypt. Their beautiful colors, designs and luster make them desirable as decorative elements in art and architecture. Previously, the ancient Egyptians exploited nearly eighty-four types of ornamental stones, of which 45 types were from the well-known and familiar archaeological quarries [1]. Some Roman names for these stones have been preserved and the traditional names Italians call stone cutters [2]. With the help of modern nomenclature, Roman stones are referred to mainly today in archaeological and artistic historical literature. There is much confusion regarding the geological names applied to Egyptian ornamental stones. Many of these now popular names were suggested more than a century ago by archaeologists and other non-geologists who have no experience and weaknesses in conceptualizing and naming the rocks, they were describing. Geologists are still introducing other things by following them such as neglected or inappropriate classifications of rocks. [1]. Identifying and exploiting local resources used in historical and rural buildings are the basis for preserving the comprehensive local heritage [3].

Generally, the granitic rocks of this area are creating part of a huge batholith of the central Eastern desert along Qena-Safaga road. These granitic rock suites of the study area are distinguished into two orogenic stages, early orogenic and late to post orogenic granites, the oldest one occurred by granodiorite-tonalite, while the youngest represented by monzogranite and alkali feldspar granite [4]. The early orogenic
granitic rocks (tonalite-granodiorite) cover most of the mapped area parts as seen in (Fig. 1). They extend from Gable Abu Furad in the south to Wadi Al Baroud in the north and cover a small area nearby Gable Ras Al-Baroud. Otherwise, monzogranite and alkali granite cover Gables of Ras Baroud, Abu Hawis and Abu Murrat (Fig. 1). The features of this batholith are consistent with it being an entirely intrusive igneous body and not as an autochthonous granitoid detected from the remobilized Pre-Pan-African basement as proposed by [5], [6]; [7]; [8] and [9]. Substantially, ornamental stones are represented by specific, igneous, metamorphic, and certain sedimentary rocks characterized by strength, high hardness, and resisting climate changes, preserving their varied beautiful colors and patterns [10], [11]. They are widespread in Egypt, and they represent in Eastern Desert, Sinai and the Nile Valley, as shown in (Fig. 2). The investigated granites have normal radioactivity concentrations [12], so they can be used economically in the field of construction, decoration and other economic purposes.

2. Experimental and materials
More than thirty representative samples of the investigated granitic rocks have been collected from the study area. The petrographic observations were studied by one thin section from each sample that was prepared for this object. The samples of the granitic rocks were cut according to the American Society for Testing and Material specifications (ASTM) for the detection of mechanical property and some of the physical properties. The mechanical and physical properties were carried out in Institute of the Earth Sciences, Southern Federal University and Technical Sciences, Don State Technical University, Russia.

Figure 1. Geological map of study area created from integrated remotely sensed data processing and field observation.
3. Result and Discussion

The mechanical and physical properties that were detected during the present study consist of eight parameters: Strength test, Water absorption, Porosity, Thermal expansion, Abrasion resistance and Weather and Frost resistances, and Acid resistances.

3.1. Strength test

It is considered one of the basic parameters useful to detect the quality of natural stones. Compressive strength is the resistance of materials to tearing under pressure due to the force acting from the above and below on the rock sample or it is the capacity of a material or structure to withstand loads tending to reduce size. Results of uniaxial compressive strength (UCS) of granitic samples as showing in (Table. 1). The relation between compressive strength and porosity, thermal expansion and water absorption showed a negative relationship between them (Fig. 3a, b and c). When the compressive strength decreases, it is accompanied by an increase in these properties and porosity, mainly attributed to the increase in the number of pores, microcracks and voids, and grain boundaries. Otherwise, specific gravity versus compressive strength displayed positive relationship as shown in (Fig. 3d). So that increasing this property is accompanied by increase compressive strength.

3.2. Apparent porosity

It is the ratio of the size of the open pore space in the sample to the external volume and it used to give a complete concept of resistance of weather and frost resistance in addition to compressive strength. The factors affecting rock porosity include grain size, grain shape, and mineral composition, especially clay minerals [14]). The obvious porosity is mostly less than 0.6 %. Generally, the porosity of stone is more than 0.6% need special care if used for external work. Increased porosity has an undesirable effect on the weathering characteristics [15]. The average porosity of these rocks is 0.4% as shown in (Fig. 4) and suitable for outdoor work.

3.3. Specific gravity

It is determined by the actual ratio between the bulk density of the rock material and the bulk density of water at 4°C. Specific gravity of the investigated granite samples was detected, and the results are
found in (Table. 1). The rock samples have specific gravity ≥ 2.5; these are compatible with heavy construction work [16]. Observed specific gravity of granite samples refers to their suitability for use in heavy construction projects.

3.4. Water absorption
It is a main property in assessing rock durability used as building material ([17]. Water absorption is the water weight absorbed by a material due to the number of pores in the rock sample, it is expressed as a percentage of its dry weight. The water absorption results are found in (Table. 1) showing low content less than 1%. The studied rocks have water absorption less than 1% by weight and can be used as a dimensional stone because of its high weather resistance [16].

3.5. Abrasion resistance
It is an indication of how much stone can resist heavy use without damage according to quality and durability of this rock in addition to good results for some physical and mechanical properties such as porosity and strength test. The granite samples have good results as showing in (Table. 1) related to standard values [10], [11].

3.6. Thermal expansion
It is an important characteristic of describing dimensional stones. Samples were placed in convection ovens and exposed to high temperatures, when the material heats up, its linear dimensions increase steadily. The studied granitic samples have values thermal expansion to some extent, compatible with the international standard of ornamental stones [10], [11].

Table 1. The mechanical and physical properties of the studied granitic samples.

| Sample No. | Bulk specific gravity gm/cm³ | Apparent porosity % | Water absorption % | Thermal expansion cm | Compressive strength kg/cm² | Abrasion resistance | Weather resistance | Frost resistance | Acid resistance (HCl & H₂SO₄) |
|------------|-------------------------------|---------------------|--------------------|---------------------|-----------------------------|--------------------|-------------------|-----------------|-----------------------------|
| 26C        | 2.7                           | 0.44                | 0.22               | 0.03                | 1882                        | Good               | Good              | Good            | Good                        |
| 42         | 2.8                           | 0.41                | 0.2                | 0.02                | 1910                        | Good               | Good              | Good            | Good                        |
| 46         | 2.5                           | 0.5                 | 0.31               | 0.02                | 1773                        | Good               | Good              | Good            | Good                        |
| 79         | 2.4                           | 0.43                | 0.24               | 0.03                | 1785                        | Good               | Good              | Good            | Good                        |
| 23         | 2.2                           | 0.42                | 0.23               | 0.01                | 1887                        | Good               | Good              | Good            | Good                        |
| 26A        | 2.6                           | 0.46                | 0.36               | 0.02                | 1784                        | Good               | Good              | Good            | Good                        |
| 31A        | 2.7                           | 0.45                | 0.18               | 0.02                | 1812                        | Good               | Good              | Good            | Good                        |
| 33A        | 2.52                          | 0.4                 | 0.17               | 0.05                | 1825                        | Good               | Good              | Good            | Good                        |
| 34A        | 2.51                          | 0.55                | 0.3                | 0.04                | 1704                        | Good               | Good              | Good            | Good                        |
| 16         | 2.54                          | 0.5                 | 0.31               | 0.03                | 1779                        | Good               | Good              | Good            | Good                        |
| 28B        | 2.5                           | 0.51                | 0.4                | 0.03                | 1785                        | Good               | Good              | Good            | Good                        |
| 28C        | 2.53                          | 0.52                | 0.16               | 0.02                | 1767                        | Good               | Good              | Good            | Good                        |
| 34B        | 2.55                          | 0.4                 | 0.14               | 0.05                | 1782                        | Good               | Good              | Good            | Good                        |
| 54         | 2.57                          | 0.38                | 0.2                | 0.03                | 1790                        | Good               | Good              | Good            | Good                        |
| 61A        | 2.6                           | 0.37                | 0.16               | 0.03                | 1795                        | Good               | Good              | Good            | Good                        |
| 74B        | 2.58                          | 0.42                | 0.32               | 0.02                | 1758                        | Good               | Good              | Good            | Good                        |
| 36A        | 2.53                          | 0.43                | 0.34               | 0.01                | 1746                        | Good               | Good              | Good            | Good                        |
| 36B        | 2.51                          | 0.39                | 0.22               | 0.09                | 1753                        | Good               | Good              | Good            | Good                        |
| 61B        | 2.5                           | 0.46                | 0.17               | 0.04                | 1698                        | Good               | Good              | Good            | Good                        |
3.7. Weather and frost resistances

Weathering degree is generally expressed in terms of changes in the physical and mechanical properties of the rock material.[18] suggested some important and main points that should be considered when determining weatherin gdegree as follows:

1- Changes in color and texture of rock material and rock mass. 2- Changes in strength (uniaxial compressive strength, point load strength etc.). 3- Changes in porosity of rock material. 4- Determination of rock quality designation (RQD). The samples have been placed in water, dried their surface from the water and stored in room that has very low tempreture (less than 0°C) for more than four weeks. Virtually, the granitic samples showed a good resistance to corrosion and fragmentation. They also have a good resistance to weathering and frost resistances according to measured values for compressive strength, porosity, and water absorption (Table. 1).

3.8. Acid resistance

It is detected by the effect of both hydrochloric acid and sulfuric acid on the stone material for one hour. The granite samples display an excellent result for the acid resistance (Table. 1). So that economical appearances of the granite samples of the study area were assembled to give an idea of how much we can save costs due to quarry, ease of loading and transportation.

Figure 3. Binary diagrams between compressive strength (C. S), porosity (A. Ps), (a), water absorption (W.Ab), (b), thermal expansion (Th. Ex), (c) and specific gravity (S.Gr), (d) of the studied granitic samples.
4. Conclusion
The current study area is restricted in the Central Eastern Desert of Egypt on the Qena-Safaga road. Granite rocks of attractive colors and high hardness represent a high economic value due to the possibility of using them as decorative stones used in decoration and construction in addition to various industrial purposes. The samples of the investigated area have a good result due to mechanical and physical tests. So that economic appearances of the granite samples of study area were assembled to give an idea of how much we can save costs due to quarry, ease of loading and transportation and later use for an economic purpose.

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