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Textural, Mineralogical and Physico-Mechanical Properties of Some Granitic Rocks in Sinai, Egypt

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ABSTRACT. Six granitic localities from southern Sinai, Egypt were selected for the present study. Representative samples were collected from each area. These samples were examined microscopically and mineralogically analysed using X-ray diffraction technique. Porphyritic and granular textures occur. These samples are essentially composed of quartz, K-feldspars (microcline-orthoclase), plagioclase feldspars (oligoclase-albite) and biotite. They vary in the relative proportion of these minerals, alteration and degree of interlocking. The mechanical and physical properties of specimens prepared from each granitic locality were determined. The results are promising since they are within the range of specifications required for construction and ornamental stones. In addition, the variation in the compressive strength values of these granites was correlated with the texture and composition.

The crystalline basement of Sinai holds an important position in the Precambrian Arabo-Nubian Shield lying between the two branches of the Red Sea rift system (Gulf of Suez and Gulf of Aqaba trends, Fig. 1). There are two basement belts assumed to be represented in Sinai.

i) Taba-Sharm belt, along the N-E strip of Sinai

This belt includes the calc-alkaline and silica-rich magmatic rocks of granitic type. These types are equivalent to the granites dominating in Egypt; Younger granites (El-Ramly and Akaad, 1960 & Greenberg 1981). These rocks are widespreed in Sinai and characterized by an formation process probably involving several consecutive phases of pluton emplacement from silica-rich to silica-poor types (Bentor 1985). Bentor alos noted that the same rock types are represented over a vast area to the north at Catherina area. They were emplaced during a non-orogenic period in which the new rigid massif was subjected to tensional stresses, block faulting and differential uplifting. The subjected rocks form a large number of small plutons, circular to oval in shape with discordant and sharp boundaries.

ii) Feiran-Solaf belt, along the western portion

These granites are mainly Old or Grey or Shaitian granites (Shurmann 1953). The rock sequence is composed of an assemblage of variable composition. These rocks are preserved as groups of isolated exposures and associated with faults which are the result of later tectonic or other intrusive events. The age of this rock type is assigned as early Paleozoic or possibly late Precambrian time (Ernst 1972).

Natural building materials are classified into three groups, namely dimension stone, roofing and ornamental stones. Each group has certain specifications such as strength, extent of weathering in natural exposures and the uniformity of colour and texture. Therefore, the present study deals with textural and mineralogical composition and physico-mechanical characteristics of some granitic rocks from southern Sinai.

Sampling and Field Characteristics

Representative samples were collected from different localities at southern Sinai, namely; Sidri, El-Shallal, Sahu, Tarfa, Zaghra and Newaiba (Fig. 1). Generally, the garnitic rocks of southern Sinai form in the majority of localities moderate to high elevated features which show rugged profiles and several peaks (plate I_1). Some outcrops of these granites make formidable landmarks which can be seen for several kilometers around and may posses rather steep slopes covered with weathering products. They exhibit several types of weathering. Coulmnar, boulder formation and spheroidal weathering are recognized. They have gentle to steep inclined faults. These rocks include several types based on couler which comprise white, pink, pinkish-white, brownish-pink and buff (plate $I_{2\text{-}7}$).

Petrography

Generally, the examined granitic samples are characterized by a high degree of interlocking. They exhibit two major textural varities; porpheritic and granular (mainly anhedral to subhedral, plate $II_{1\&2}$). They are classified petrographically into: 1-Biotite-hornblende granites with porphyritic texture (El-Shallal, Tarfa and Newaiba). 2-Biotite-hornblende microgranites with equigranular texture (Sedri). 3-Biotite-granites, medium-grained with granular texture (Zaghra and Sahu).

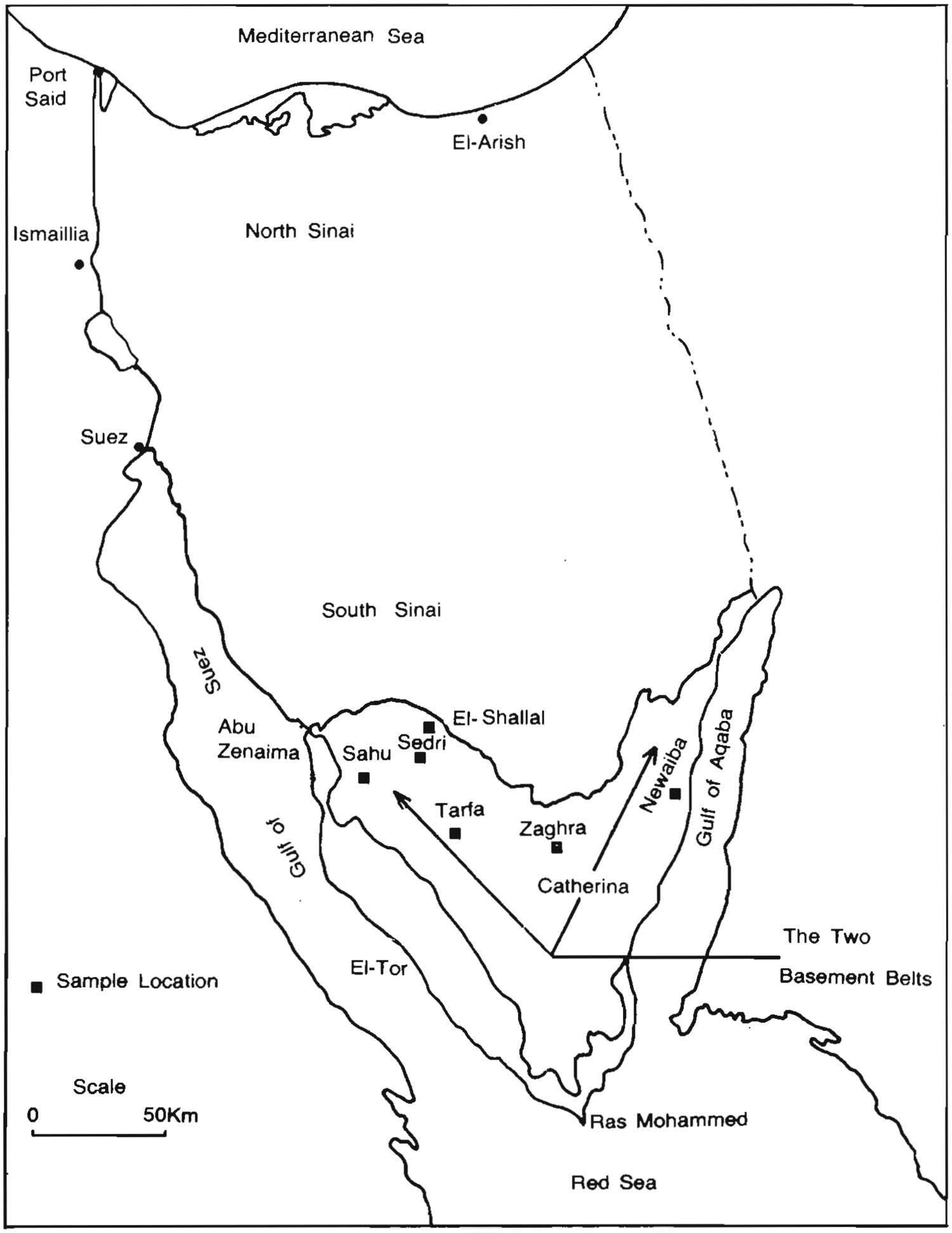


Fig. 1. Map shows the approximate sample locations through the two basement belts in south Sinai, Egypt.

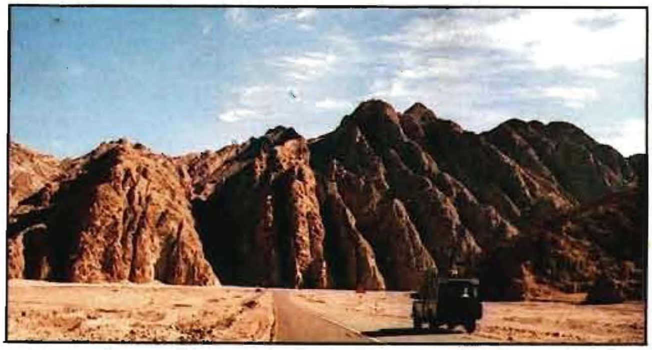
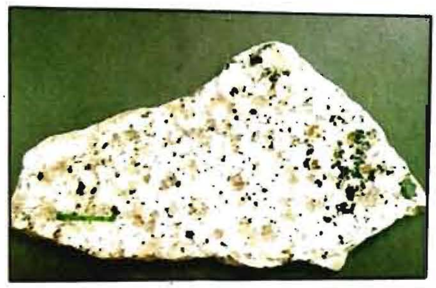


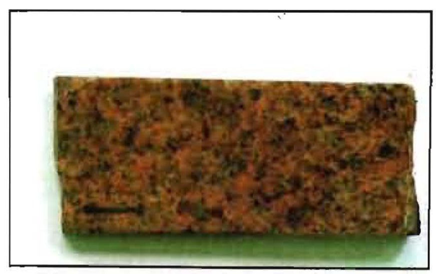
Plate (I_1): The rugged granites with steep slopes.



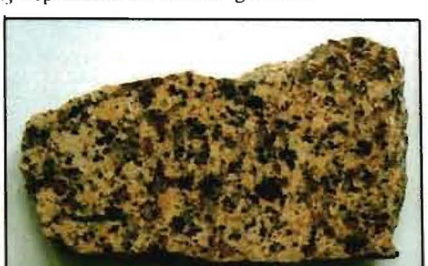
I_2 represents Newaiba granites.

I_5 represents Sahu granites.

I_3 represents El-Shallal granites.



I_6 represents Tarfa granites.



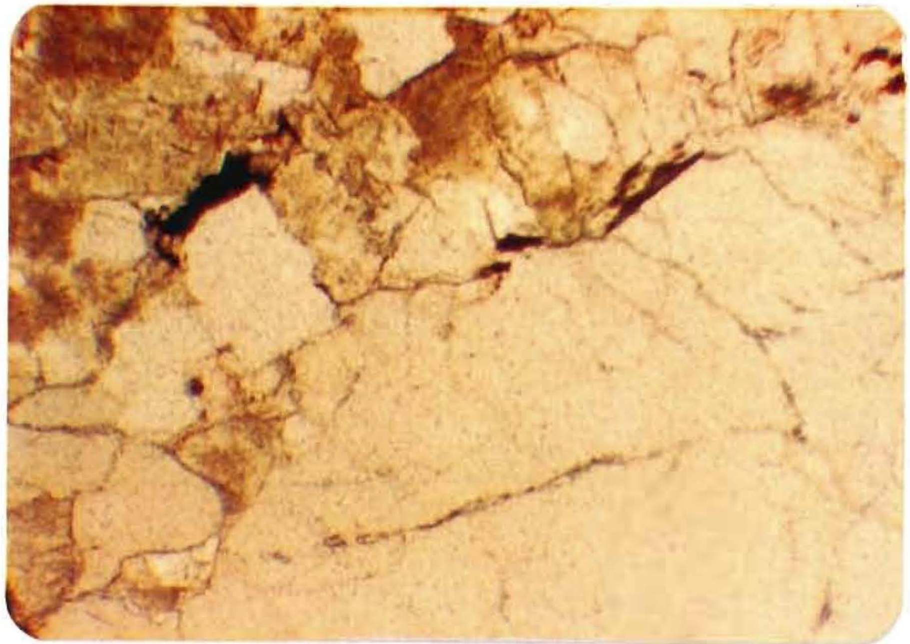
I_4 represents Sedri granites.

I_7 represents Zaghra granites.

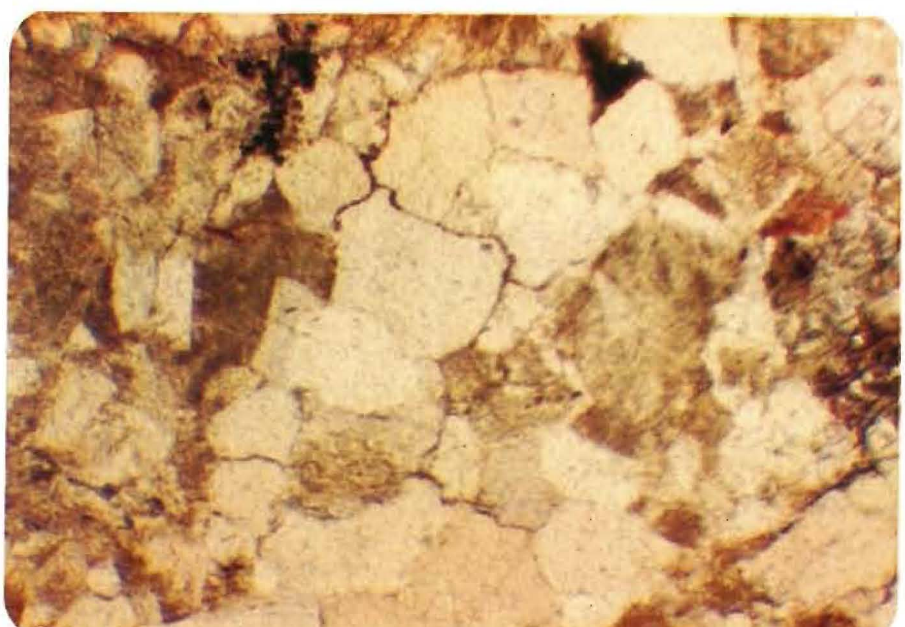
Plate(I_{2-7}): Different types of granites collected from southern Sinai. (scale 1:6)

0 3 6 cm.
Scale

Plate (II):

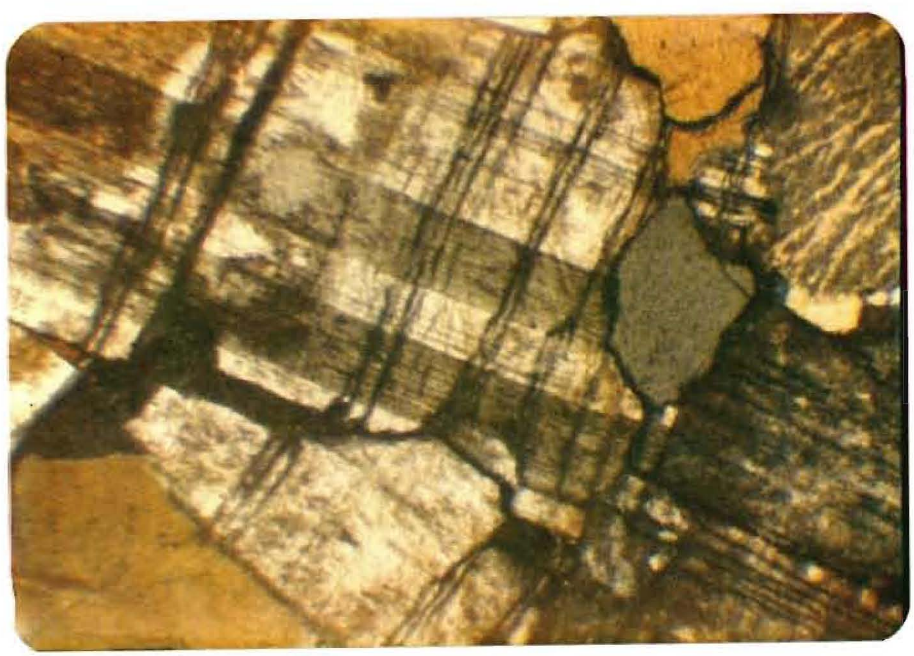


(1) Porphyritic texture (El-Shallal, × 60)

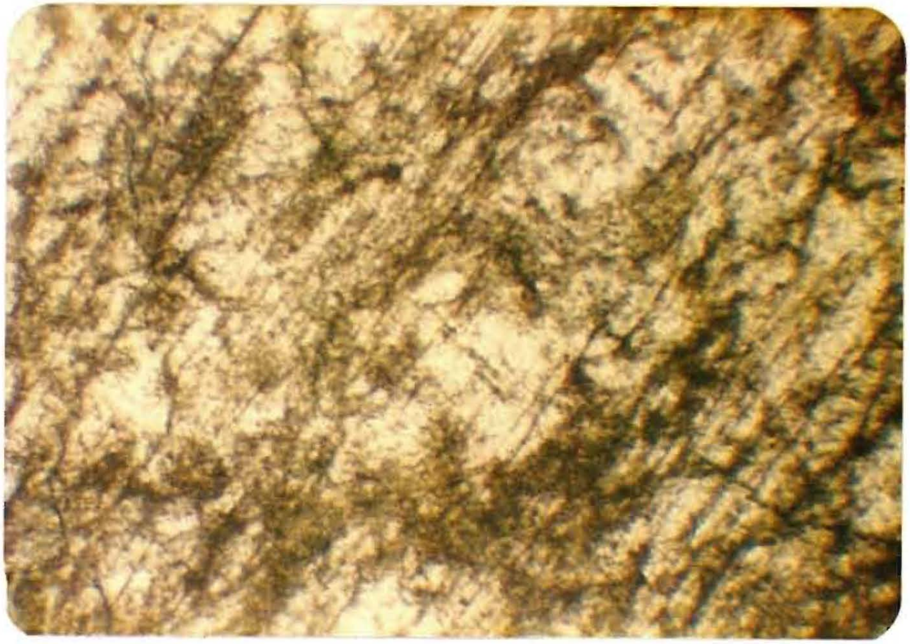


(2) Granular texture (Zaghra, × 60)

The examined samples are essentially composed of quartz, microcline, plagioclase feldspar (mainly oligoclase), orthoclase and biotite. Hornblende, iron oxides and apatite are accessories. The samples from different localities vary mainly in the proportions of these minerals. Quartz occurs in rounded to subrounded clear grains which usually occupying the interstices between the other constituents and making an interlocking texture. Microcline is present as subhedral grains enclosing quartz and other feldspars. The large phenocrysts of microcline are traversed by parallel veinlets of albite and sometimes show alteration along cleavage planes (plate II_3). Orthoclase is usually turbid through kaolinization (plate II_4). Plagioclase feldspar forms euhedral to subhedral crystals which are faintly altered into sericite (plate II_5). They exhibit combined Carlsbad and lamellar twinning and may be zoned. Biotite is present as brownish flakes associated with few brownish-green varieties. It is occasionally chloritized along the cleavage planes. Some inclusions in biotite occur mainly as magnetite or ilmenite (plate II_6). Accessories include iron oxides, apatite and hornblende. The latter forms green subhedral prismatic crystals which sometimes show simple twinning.

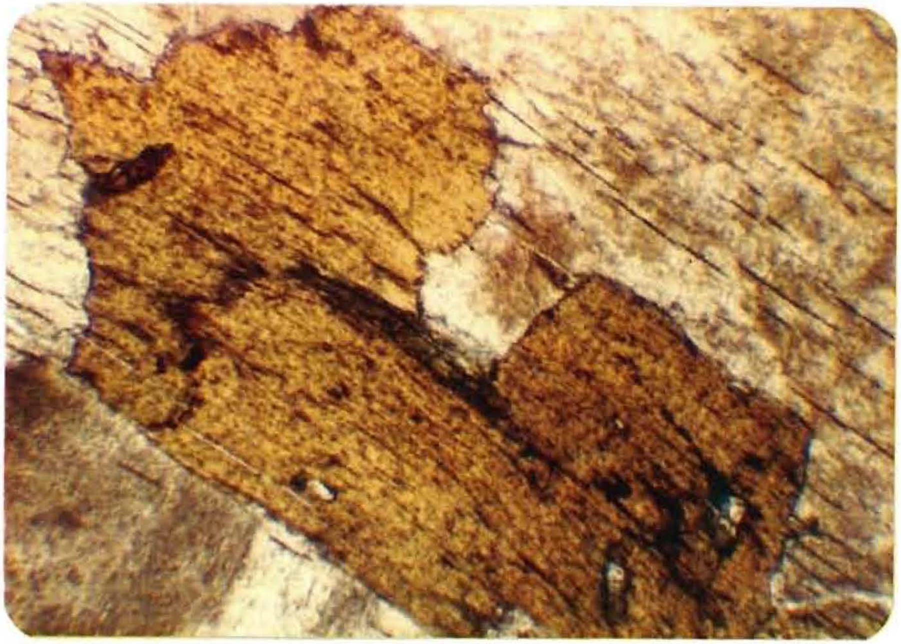


(3) Alteration along the cleavage plains of microcline (Sahu, × 120)



(4) Kaolinization of orthoclase (Tarfa, × 120)

(5) Sericitization of feldspars (Newaiba, × 60)



(6) Corroded biotite crystal with some inclusions (Zaghra, × 120).

X-Ray Diffraction Analysis

In order to detect the alteration products, the samples were analysed using X-ray diffraction technique (Philips Pw 1050/70 X-ray diffractometer, Ni-filter CuK radiation and a scanning speed 1°2θ/min.). The diffractograms are shown in Fig. (2). It can be noticed that:

- The studied samples are mainly composed of quartz, feldspars (oligoclase), K-feldspars (microcline & orthoclase) and biotite. Hornblende, ilmenite and clay minerals are accessories. These results are in an agreement with those of the microscopic examination with respect to the main composition.
- The difference between the various localities lies mainly in the relative proportions of the easily altered minerals, such as biotite, K-feldspars and plagioclase feldspars. Consequently, this is reflected in the peak areas resulting from the relative amounts of the alteration products. These alteration products are mainly consists of kaolinite, sericite and chlorite. Fig. (2) shows that the kaolinite main peaks at 7.14 and 3.58Å are clearly presented in Newaiba till Tarfa granites. They are slightly biforcated with

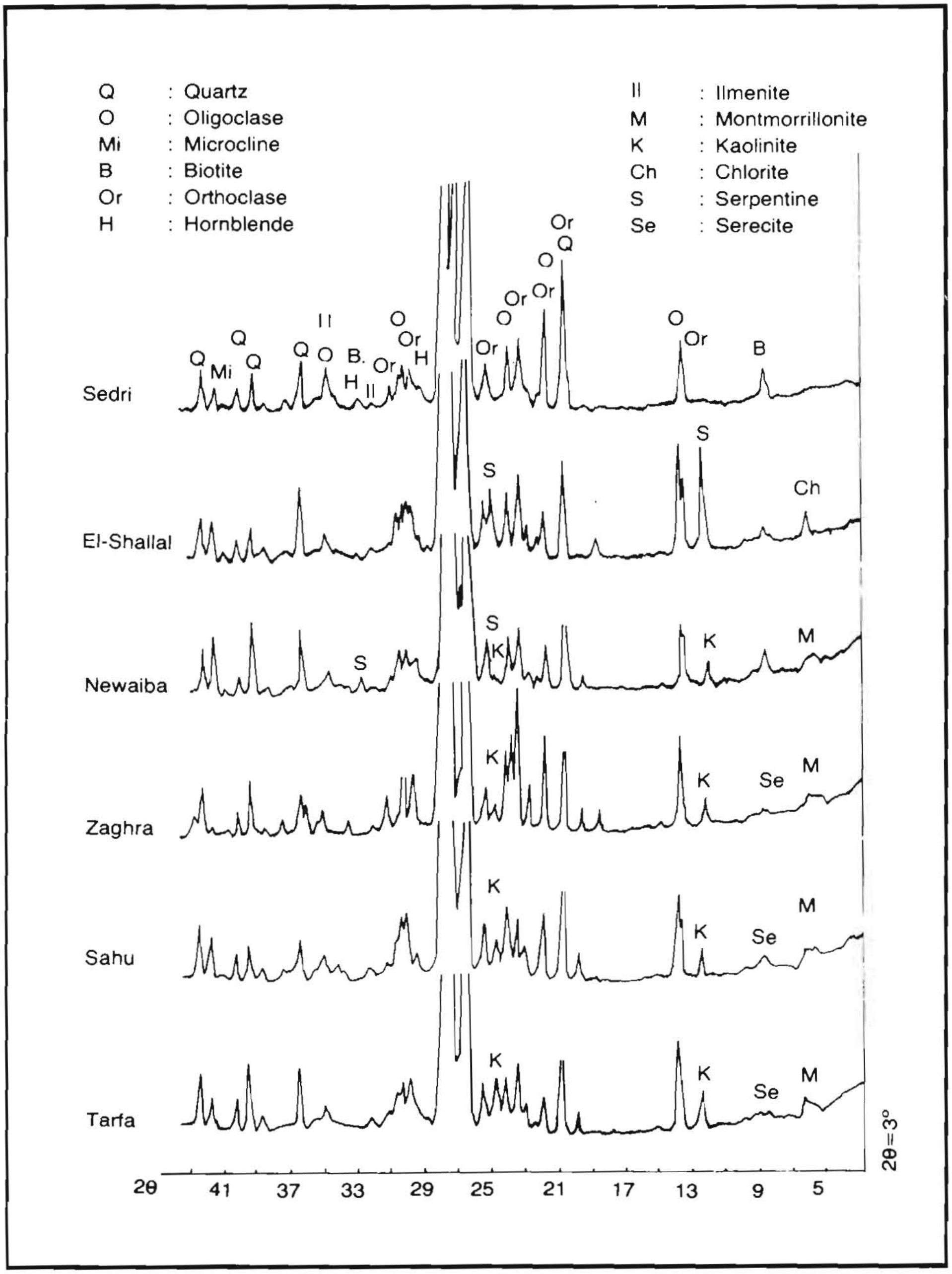


Fig. 2. X-ray diffractograms of the studied granitic samples (south Sinai).

the adjacent serpentine peaks in El-Shallal granite and completely absent in Sedri one. The sericites (Se) peaks can be followed in the same manner of kaolinite peaks. Therefore, the general direction of increasing amount of alteration products is Sedri, El-Shallal, Newaiba, Zaghra, Sahu and Tarfa granites.

Physical and Mechanical Properties

The physical and mechanical characteristics of the studied granitic samples were determined following the standard methods for testing materials (ASTM 1970, and BS. 882). The results are summarized in Table (1) which shows that:

1. The physical properties of all the studied samples are almost in the same range.
2. The samples are characterized by a very low porosity, water absorption and a very good resistence against abrasion.
3. Generally, the values of compressive strength of these samples are relatively high but they show a significant variation from one location to another.

The lattter results concerning the compressive strengths of the different granitic samples may be attributed mainly to the conditions of formation of all granitic rocks. A body of magma which is under pressure may be forced to higher levels in the earth's crust penetrating the upper rocks and cooling at some depth below the surface. Therefore, a coarsely crystalline mass (*i.e.* granitic rocks) is produced and a very good interlocking of different crystalline forms will occur. This interlocking gives the high strength values of the rock (Blyth and Freitas 1977). Consequently, the latter fact may explain the relatively high values of compressive strength of all studied granites, (Tabel 1). On the other hand, it does not explain the significant variation in the compressive strength values from one

Table 1. Physical and mechanical properties of the studied Sinai granitic samples

Locality	Bulk Density (gm/cm^3)	Specific gravity (gm/cm^3)	Water absorp. %	Porosity %	Abrasion loss	Compressive strength (kg/cm^2)
El-Shallal	2.53	2.55	0.27	0.63	0.05	727
Sedri	2.53	2.54	0.27	0.67	0.05	781
Tarfa	2.55	2.55	0.24	0.61	0.11	375
Zaghra	2.53	2.59	0.53	0.78	0.06	562
Sahu	2.54	2.56	0.29	0.75	0.07	440
Newaiba	2.54	2.57	0.28	0.58	0.06	626

location to another. Since, the microscopic observations show no clear variation in the degree of interlocking. Therefore, the variation in compressive strength values may be attributed to other factors affecting the rock after formation.

When these granites have been exposed and their sedimentary roof-rocks removed by denudation, they are altered. Such alteration would be a result of several factors such as jointing, cracking, solutions, mineral resistance and mineral associations. The alteration products increase along the twinning planes of plagioclase, cleavage planes of feldspars and mafics and even alonge the borders of the grains. From the above mentioned, it can be expected that as the amount of minerals succeptable to be altered increase, the compressive strength decreases and *vic versa*. The petrographic and X-ray diffraction examinations of Tarfa and Sahu samples show that they have the relatively highest amount of altered minerals in respect to El-Shallal and Sedri samples but Newaiba and Zaghra granites may have the intermediate amounts (Fig. 2). Thus, such alteration process may affect negatively in the strength values (*i.e.* it may combunsate the positive effect of interlocking on the strength).

Conclusion

1. The studied granitic samples from southern Sinai have porphyritic and equigranular textures and are essentially composed of quartz, K-feldspars (microcline, orthoclase), plagioclase feldspars (oligoclase, albite) and biotite. The samples are varied in the relative proportions of these minerals and alteration products.

2. The variation of compressive strength values of these samples may be correlated to a great extent with the degree of alteration which combunsate the positive effect of the initial interlocking on the strength values.

3. The samples under investigation can be utilized as building elements since the mechanical and physical properties are in the range of specifications required for construction materials and ornamental units.

References

A.S.T.M: Standards (1970) Concrete and mineral aggregates. Part 10, Philadelphia.

Bentor, Y.K. (1985) The crustal evolution of the Arabo-Nubian massif with special reference to the Sinai Peninsula. *Precambrian Res.*, **28**(1): Elsevier Sci. Publ. Netherland.

Blyth, F.G.H. and **Freitas, M.H.** (1977) A geology for engineers. 6th edition. The English Language Book Society and Edward Arnold Pub. London.

B.S. 882 (1965) Aggregates for concrete. B.S. Institution, 2 Park Str. London, W.1.

El-Ramly, M.F. and **Akaad, M.K.** (1960) The basement complex in the central-eastern Desert of Egypt between latitudes 24°30′ & 25°40′ N. *Geol. Surv.* Egypt, **8**: p. 35.

Ernst, W.G. (1972) Occurrence and mineralogic evolution of blueschist belts with time. *Am. J. Sci.*, **272**: 657-668.

Greenberg, J.K. (1981) Characteristics and origin of Egyptian Younger Granites: Summary, *Geol. Soc. Am. Bull.* Part I, **92**: 224-232.

Schurmann, H.M.E. (1953) The Precambrian of the Gulf of Suez area. *19th Int. Geol. Cong. Algeria, Sec.* **1**: 115-135.

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الخواص النسيجية والمعدنية والفيزيو ـ ميكانيكية لبعض الصخور الجرانيتية في سيناء «مصـر»

علي ايمن عبدالمنعم كامل و علي محمد شراره و عادل محمد أمين

الهيئة العامة لبحوث الإسكان والبناء والتخطيط العمراني ـ الدقي ـ ص . ب : ١٧٧٠ ـ مصر

أختيرت ستة مواقع لتواجد الصخور الجرانيتية في جنوب سيناء «مصر» لهذه الدراسة، وهذه المناطق هي : منطقة سدري، منطقة الشلال، منطقة نويبع، منطقة زغرا، منطقة صهو ومنطقة طرفا، وتهدف هذه الدراسة إلى التعرف على الخواص النسيجية والمعدنية وكذا الخواص الفيزيائية والميكانيكية لهذه الصخور وذلك لمعرفة مدى إمكانية استخدامها في أغراض البناء، وقد تم جمع عدد من العينات الممثلة لهذه المناطق الستة المذكورة ثم أختيرت من بينها ست عينات تمثل كل منها منطقة معينة تمثيلاً دقيقاً .

وقد فحصت هذه العينات بعد تجهيزها تحت الميكروسكوب المستقطب وبواسطة جهاز الاشعة السينية المتفرقة لمعرفة التركيب والخواص المعدنية والميكروسكوبية، وقد تميزت هذه العينات بوجود نوعين أساسيين من النسيج هما النسيج البورفيري «لعينات الشلال وطرفا ونويبع» والنسيج الحبيبي «في باقي المناطق» وتتركب هذه العينات أساساً من معادن : الكوارتز، والفلسبار البوتاسي «ميكروكلين ـ أرثوكليز»، فلسبار البلاجيوكليز «البيت» ومعدن البيوتيت. وقد اختلفت هذه العينات من حيث نسب تواجد المعادن السالفة الذكر وكذا في درجة تحولها إلى معادن أخرى «مثل معدن الكاولينيت ـ السيريسيت ـ الكلوريت» وكذلك في درجة تماسك وتعاشق الحبيبات الصخرية .

وقـد تم التعرف عـلى الخواص الـطبيعية «مثـل الكثـافـة الكتليـة ، الكثـافـة النـوعية ، نسبـة امتصاص المـاء ، درجة المسـامية» والخـواص الميكانيكيـة «الفاقـد بـالبرى ـ قـوة التحمل الميكـانيكي» لعينات مجهـزة من هذه الصخـور الجـرانيتيـة المختلفـة ، وقد اشـارت النتائـج إلى أن هذه العينـات في عمـومهـا تقـع في نـطاق المواصفات القياسية للأحجار المستخدمة في الاغراض الإنشائية والزخرفية ، هـذا بالاضافة إلى أن التغير في قيم التحمل الميكانيكي للعينات الجرانيتية المستخدمة قد نـوقشت علاقتهـا بالنسيـج والـتركيب ودرجـة التعـاشق الحبيبي ، ووجـد أن قـوة التحمل الميكانيكي تقل بزيادة نسب المعادن المتحـولة وتـزيد بـزيادة قـوة التعاشق الحبيبي لها ، وكان تـرتيب المناطق حسب اتجـاه الزيـادة في قوة تحملهـا الميكانيكي كالتالي : طرفا ـ صهو ـ زغرا ـ نويبع ـ الشلال ـ سدري .