PAN-AFRICAN PLUTONIC SUITE OF UM SHAGHR AREA, QUSSIR DISTRICT, EASTERN DESERT, EGYPT: SUBDUCTION ZONE MAGMATISM

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ABSTRACT
The present work deals with the plutonic suite including granitoid and gabbro-dioritic rocks at Wadi Um Shaghr area. The suite comprised mappable intrusive bodies of granitoid-to-dolerite association in combination with gabбро-diorite complex. No direct contact has been noticed between the two types of rocks.

Geochemically, the granitoids originated from peraluminous calc-alkaline magma with many chemical parameters similar to hypo-ferromagnesian. On the other hand, the studied gabbroïds exhibit calc-alkaline nature with chemical characteristics identified to Na-rich gabbros described by [2000]. Both types of magma were developed in an island arc continental setting.

The concentrations of U and Th in the granitoid rocks were controlled by magmatic processes which are clear from the positive relation between U and Th and U-Th in addition to the weak negative relation between U and K-Rb were observed. The gabbroïds like subduction-related rocks are enriched in U, V, and depleted in HFS suggesting their formation by partial melting of subarc mantle source region highly metamorphosed by aqueous fluids. The abnormally high Ba content might suggest incorporation of magmatic sediments into the melting zone. The dioritic rocks are enriched in both LILE and HFSE suggesting the melt-metamorphizing fluids in the mantle source region were derived from relatively subducted slab causing enrichment in HFSE.

INTRODUCTION
The present plutonic suite comprises a mappable isolated irregular mass of Wadi Um Shaghr, 7 km south the Qatt-Lesseur road at 140 km km from Qatt (Fig. 1). It was previously mapped as Older Granite (Shazly, 1971; Mace and Shazly, 1977); Esawy and Shazly (1976) considered these rocks as a rank of metagabbro-diorite complex.

In the present work, the intrusive bodies of Wadi Um Shaghr area represent a typical plutonic suite that comprises two or more associated plutonic classes (article 35, 850, North American Stratigraphic Code, 1983).

In spite of the small size of the studied plutonic suite, yet it embraces a varied assortment of different rocks with clear cut demarcations between granitoid and gabbroïd rocks in the exposures.

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The intent of this study is to present new geochemical data for elucidation the tectono-magmatic evolution and to discuss a model for the origin of these rocks.
Field Aspects

The studied plutonic suite forms small isolated irregular masses (Figs. 1, 2a). The granitoids under consideration were introduced at its northern and southern parts into metamorphosed volcano-sedimentary assemblage (Abu Felemti schist, Heikal, 1999) as well as trachytes and related rocks. The contact mostly being irregular and sharp with slight thermal effect marked by variable degrees of alteration and colour (Heikal, 2003). The granitoid pluton was later invaded by numerous veins of quartz and carbonates trending NW and ENE.

On the other hand, the isolated gabbroid-diorite association (Fig. 2b) occupies the western and extreme southwestern part of the area (Fig. 1). No apparent contact with the surrounding rocks. The intrusive masses constituting the plutonic suite forming low relief, severely weathered and surrounded by sandy plains.

Petrography

The classification of the present rocks is based on Streckeisen (1976). Figure (5) shows that samples representing the granitoid rocks plot within granodiorite and tonalite fields whereas the gabbroic rock plot in the gabbronorite field.

Gabbros are composed of plagioclase, clinopyroxene with sporadic hornblende, biotite and quartz. Pyroxene is represented by augite (Fig. 3a) showing granular margins, whereas plagioclase of labradorite composition (An45) refurns intense saussuritization. Diortes comprise plagioclase of andesine composition (An42) and dense assemblage of hornblende (Fig. 5b) and hornblende. Chloritization is well developed at the expense of biotite and hornblende.

Granodiorites and tonalites (Fig. 3c-d) are characterized by hypidiomorphic, vermicular, myrmekitic intergrowth, interstitial and poikilitic textures. In addition, zoning, resorbed rims (Fig. 3d), mantling and punctuation growth reflects compositional textures for both.

Throughout the petrographic investigation, there are good signs of alteration, in particular metasomatism, chloritization and sericitization upon these rocks.

Geochemistry

Whole-rock major and trace elements and CIBW normative composition for selected samples of both granitoid-gabbroid rocks are given in Table 1. The chemical analysis of granitoid have been carried out at the Nuclear Material Authority, Cairo.
The most striking features of major and trace elements are the high contents of Na2O (up to 4.6 wt %) and LILE (Ba, Sr and K) (Table 1). The slight variation in K/Na ranging from 0.51 to 0.61 is consistent with the formation of intercumulus K-feldspar and plagioclase and biotite (El-Mewally and Ibrahim, 1985).
Table 1: Chemical analysis of major and minor elements of geopetals of Las Nueguitas 1970

<table>
<thead>
<tr>
<th>Element</th>
<th>P2O5</th>
<th>Fe2O3</th>
<th>Al2O3</th>
<th>TiO2</th>
<th>MgO</th>
<th>CaO</th>
<th>Na2O</th>
<th>K2O</th>
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<td>MgO</td>
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**Note:**
- **P2O5:** Phosphorus pentoxide.
- **Fe2O3:** Iron(III) oxide.
- **Al2O3:** Aluminum oxide.
- **TiO2:** Titanium dioxide.
- **MgO:** Magnesium oxide.
- **CaO:** Calcium oxide.
- **Na2O:** Sodium oxide.
- **K2O:** Potassium oxide.
- **MnO:** Manganese oxide.

Values are expressed as percentages.

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The geochemical Classification

The data in table (1) are used to determine the classification, magma type, tectonic setting and petrogenesis of the studied rocks. Gierekiesen. (1975) used the normative Or-Ab-An ternary diagram for nomenclature of the plutonic rocks (Fig 4) which indicates that the studied metagabbro-diorite samples plot within the gabbronoritic field. Also, Histrumen (1963) used the same diagram (Fig.5) to nomenclature plutonic rocks where the studied metagabbro-diorite samples plot in the normal gabbronor- quartz diorite field and the granitoids plot in the granodiorite field.

Data: 29, 2020, 29, 54-59
The total alkalies (Na₂O + K₂O) versus SiO₂ diagram (Cox et al., 1970), (Fig. 8) indicates that the metagabbro-diorite samples plot in the gabbronorite diorite field and the granodiorite samples plot in the granodiorite field. The K₂O-SiO₂ diagram (Fig. 7) after (Le Maitre, 1988) shows that the studied rocks belong to the medium-K igneous rock zones. K₂O-SiO₂ diagram (Chepail and White, 1974) (Fig. 8) shows that the studied granodiorite rock including the diorite ones plot in I-type granodiorite field. Also, the SiO₂ versus Rb/Zr (Harris et al., 1984) (Fig. 9) shows that the studied granodiorite plot in the I-type granodiorite field reflecting their igneous origin as well as the island tectonic setting.

**Magma Type**

The magma type of the investigated metagabbro-diorite complex is determined using the following chemical variation diagrams.

On AFM diagram metagabbro-diorite rocks plot in the calc-alkaline field (Fig. 10) whereas on the TAS diagram (Fig. 6) they plot in subalkaline field. The (FeOt/MgO) - SiO₂ diagram of Miyashiro, (1975) shows that the studied rocks plot in the mild calc-alkaline field (Fig. 11).

For the studied granodiorite, the calc-alkaline nature of their magma is indicated by the above TAS, AFM and (FeOt/MgO)- SiO₂ diagrams. The alumina saturation is shown by Shand indices (Fig. 12) after Maniar and Piccoli, (1969). It is clear from the figure that the studied rocks plot in the porphyroclastic field.

From the above, it has been shown that the metagabbro-diorite complex rocks originated from calc-alkaline magma, whereas the granodiorite originated from porphyroclastic calc-alkaline magma having I-type characteristics.

**Tectonic Settings**

The tectonic setting of the studied metagabbro-diorite complex rocks is indicated by the FeOt/MgO-Ni variation diagram (Miyashiro and Shibata, 1975) and FeO-MgO-Al₂O₃ discrimination diagram (Pearce et al., 1977) as shown in figures (15 & 14) respectively where the studied rocks plot in the volcanic island arc field.

On the other hand the tectonic settings of the studied granodiorite are determined by using the variation diagrams of (Nb/Y) and (Rb/Y+ Nb) (Pearce et al., 1984). (Fig. 15 & 16). The studied samples plot in the volcanic arc granite field.
Geochemistry of U and Th

Chemical measurements uranium contents were determined chemically in 11 samples. The instrument used is UA3-Laser uranium analyzer. Thorium, on the other hand is determined by using U,V,visible spectrophotometer. The obtained results of the uranium and thorium analyses are indicated by ppm as well as Th/U are shown in Table (1). From this table, the study samples have high U and high Th contents relative to those found in non-radioactive granitoids.

The result of chemical measurements for U and Th contents as well as Th/U in 11 samples of the rock types of G. Um Shaghur (tonalite-granodiorite) are shown in Table (1). Uranium content of tonalite-granodiorite ranges from 5 to 21 ppm with an average 13.3ppm; thorium ranges from 18 to 70ppm with an average 41.6 ppm. The averages of uranium of the rock types of G. Um Shaghur is coincided with the average U of the granitic rocks of Clark et al.,1966), and also introduce in the range of the acidic intrusive rocks of Adams et al.,1959) and the siliceous intrusive rocks of Rogers and Adee,1967). The Th/U of the studied rocks range from 2.47 to 4.22 with an average 3.23 which is nearly reflect a magmatic suite.

The geochemical behavior of U and Th in the studied areas can be examined as follows:

The U-Th variation diagrams for the studied rocks indicate strong positive relations between the two elements in G. Um Shaghur due to magmatic origin as shown in (Fig. 17). This reflects the enrichment with magmatic differentiation due to magmatic. (Fig. 13) show the variation of Th/U ratio versus U in the studied rocks. It is clear that from the figure the decreasing of Th/U accompanied with enrichment in U. The relation between U and F203 is plotted in (Fig. 19) which indicated curvilinear and parallel correlations for G. Um Shaghur reflecting magmatic origin. Figure (20) shows that U concentration tends to weak increase with the weak decreasing of K/Rb ratio for G. Um Shaghur. This weak negative correlation is a good evidence for magmatic control of U concentration.

The relations between U and Zr which indicate weak positive correlations and regular relation for G. Um Shaghur which may indicate magmatic origin and also that their magma differentiation at shallow depth (Briqueu et al.,1984). (Fig. 21).
Petrogenesis and Discussion

The most consistently observed geochemical difference between arc and non-arc magmas is the depletion in HFS elements especially Zr, Nb, Y relative to LIL elements as well as LREE. The behavior of these elements during island arc magma generation processes is controversial. The separation of different groups of trace elements during subduction-related enrichment processes or magma genesis is generally attributed to one of two mechanisms. The first mechanism involves preferential enrichment in LIL elements by an aqueous phase relative to the HFS elements, controls the trace elements fractionation (Saunders et al., 1991; McCulloch and Bennett, 1994; Hawkesworth et al., 1994). In the second mechanism, partition of the HFS elements into a titanite phase in the mantle wedge and/or in the melts of mafic magma during melting in the uppermost part of the subducted slab effectively fractionates the trace elements groups. (Foley and Wheeler, 1990; Stellet et al., 1993; Klemme et al., 2005). Therefore, the abundance of the LIL and HFS elements in the subduction-related magmatic rocks can be used as indicators of magma generation processes and/or
characterizing the upper mantle source regions where such magmas were generated.

The studied rocks show a very uncommon trace elements abundance pattern as shown by spider diagrams (Figs. 22A, B). The dioritic rocks exhibit significant enrichments in Rb with an average K/Rb=94. On the other hand, the granodioritic ones are depleted in Rb with an average K/Rb=24, which indicates a deeper source for the granodiorites. Also, Ba is much more enriched in the granodiorites with K/Ba=7.5 compared to the diorites with K/Ba=18. The source of Ba has commonly been attributed to pelagic ocean sediments which probably can be incorporated or contaminate magma generation regions in the mantle wedge (Hale et al., 1984; Tera et al., 1996, Morris et al., 1990). The HFS elements are also more enriched in the dioritic rocks (2.5-4 times) their abundance in the granodiorites, although the Zr/Nb, Zr/Y and V/Nb ratios in both types of rocks are of the same order magnitude.

This trace elements behavior suggests that the dioritic and granodioritic magmas originated from different source regions in the mantle wedge as well as by different magma generating mechanisms. The dioritic magma was probably derived by partial melting of a mantle source in the subarc region which had been modified by selective enrichment in LIL and HFS elements by aqueous fluids derived from water-free subducted slab. This means that the LIL and HFS elements were not fractionated from each other during the magma generation and the behavior of the trace elements was mainly controlled by metasomatising fluids (Godyev et al., 2006). On the other hand, the granodiorite magma which is relatively depleted in HFS elements can possibly be produced by partial melting of a mantle source in the subarc region modified by aqueous fluids released from a subducted slab that contains a residual Ti-rich accessory phase specifically retaining the HFS elements. Such aqueous fluids would selectively enrich the region of the arc magmas in LIL elements and generate HFS elements depleted. Also, contamination by the ocean sediments has to be invoked to account for the very high Ba contents. However the low Rb contents are not understood, unless K-feldspars were fractionated later during crystallization.

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تحليل مصروح للمصروحات التي تتعلق بجغرافيا البحر الأبيض المتوسط وتطور الأفرع الجيولوجية، ودراسة الأحياء النباتية والحيوانية في البحر الأبيض المتوسط. 

الموقع الجغرافي: البحر الأبيض المتوسط

النماذج المستخدمة: رشح الرمال، التربة، العينات الجيولوجية

النتائج: تظهر أن البحر الأبيض المتوسط غني بالتنوع البيولوجي، ويحتوي على العديد من الأحياء النباتية والحيوانية.

المؤلف: محمد ممدوح، ندوة رشح الرمال، 2023

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