Geological and petrographical studies around Um Taghir area, Central Eastern Desert, Egypt

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Annotation
Um Taghir area is located in the northern extreme boundary of Central Eastern Desert of Egypt at the west of Safaga City. Um Taghir is represented by island arc related rocks and late to post tectonic magmatism. The island arc related rocks are represented by metavolcanoclastic sequences and metagabbrroic rocks. Metavolcanoclastic rocks are considered as the older rock units of the study are and intruded by the metagabbro. The late to post tectonic magmatism is represented by (dokhan volcanic, gabbro, tonalite-granodiorite, monzogranite, alkali feldspar granites and different types of dikes). Usually, the gabbroic rock is bearing ilmenite lenses or bands in the bottom of the layered; this is related to magma rich of iron oxides.

Petrographically, island arc assemblage is classified in to actinolite hornblende schist and metagabbro that show quite different of their content in plagioclase, hornblende, augite, quartz and biotite. Occasionally, the late to post tectonic magmatism represented by andesite, gabbro, tonalite, granodiorite monzogranite, alkali feldspar granites and different types of dikes. Andesite consists of plagioclase, quartz, alkali feldspar and hornblende. Gabbroic rocks are represented by pyroxene hornblende gabbro and leucogabbro. They show quite different of their content in plagioclase, pyroxene and clear difference in the content of both olivine and hornblende in both of them. While tonalite and granodiorite show quite different of their content in plagioclase, quartz, hornblende, alkali felspar and biotite. On the other hand, monzogranite and alkali feldspar granite, they show plagioclase is varying from oligoclase to albite; K-feldspars, quartz and muscovite are relatively more abundant in the alkali feldspar granite. Finally, the different types of dikes classified into granite, andesite, rhyolite and basalt dikes consist of the different mineral compositions.

Keywords: Um Taghir area, petrography, Eastern Desert, Egypt.

Introduction
Um Taghir area is located in the northern extreme boundary of Central Eastern Desert of Egypt at the west of Safaga City (Fig. 1). It covers about 900 km², between longitudes 33°35ʹ00˝ and 33°50ʹ00˝ and latitudes 26°35ʹ00˝ and 26°49ʹ00˝. The area is characterized by low to relatively high topography reliefs varying from 599 to 1032 m above sea level. It forms a part of Neoproterozoic evolution of the North Arabian-Nubian Shield in the NE Africa which is belonging to the East African Orogen (EAO) as results of accretion plateaus in the course of consolidation of the Gondwana (Gass, 1982; Stern, 1994; Kröner et al., 1994; Abd Elsalam; Abd El-Wahed, I. A. Thabet, 2017; Gahlan H. A., Azer M. K., Asimow P., Al-Kahtany K., 2016; Hamimi Z., Zoheir B. A., Younis M. H., 2015 and Stern, 1996). A generalized picture shows three major organs that shaped the final configuration of greater Gondwana, whereas the East African Orogen (EAO) as results of accretion plateaus in the course of consolidation of the Gondwana (Gass, 1982; Stern, 1994; Kröner et al., 1994; Abd Elsalam; Abd El-Wahed, I. A. Thabet, 2017; Gahlan H. A., Azer M. K., Asimow P., Al-Kahtany K., 2016; Hamimi Z., Zoheir B. A., Younis M. H., 2015 and Stern, 1996). A generalized picture shows three major organs that shaped the final configuration of greater Gondwana, whereas the East African Orogen (EAO) resulted from the collision and amalgamated arc terrains of the Arabian-Nubian Shield (ANS) with the Sahara and Congo–Tanzania crotons to the west and Azania and Afif terrains to the east constituting one of more continent blocks between the Indian Shield and Congo–Tanzania–Bangwenia Croton (Collines and Pisarrisky, 2005). Generally, the ANS represent one largest expanses of mantle-derived, juvenile Neoproterozoic crust in the world, which is extended over 3500 km as length and more than 1500 km as width, on the other hand the part of African Orogen (EAO) of Arabian Nubian Shield is covered about 2.7 · 10⁶ km² (Johnson, 2014). Protolith rocks in the north part of ANS are middle-late Cryogenian age (~780–680 Ma), on the other hand the investigated area is belonging to the rock units crop out in the far of the northwestern part of ANS and it is related to the late Cryogenian–Ediacaran age (~690–600 Ma) (Johnson, 2014). The exposed different rock units of the study area belong to the Northern part of the Arabian-Nubian Shield (ANS) that began at ~870 Ma and established at ~620 Ma ago, when convergence between east and west Gondwana fragments closed the Mozambique ocean along the East African-Antarctic Orogen (EAAO) (Stern, 1994;
Figure 1. Sentinel-2B 421 in RGB image showing the location of the study area.
Рисунок 1. Индикатор-2B 421 в RGB-изображении, показывающий местоположение области исследования.

Figure 2. Simplified geological map of Um Taghir area created from integrated remotely sensed data processing and field observation.
Рисунок 2. Упрощенная геологическая карта области Ум Тагир, созданная на основе интегрированной дистанционной обработки данных и наблюдения на местах.
 Jacobs and Thomas, 2004). According to the Field observations the study area is along to largest shear zone (Qena–Saфaga shear zone is recognized by El Gaby et al., 1988), so the area affected by this shear zone to show metamorphic and non-metamorphic magmatic rocks are covering the study area. The metamorphic rocks are represented by the metavolcaniclastic sequences and metagabbro, while the non-metamorphic rocks are represented by Dokhan volcanic, gabbroic rocks, tonalite, granodiorite, monzogranite and alkali feldspar granite, in addition to various dikes of different composition. The resulting geologic equipment is commonly referred to as the western arc of ANS – oceanic arc terrains of ANS (Stoesser and Forst, 2006; Ali et al., 2009; Johnson et al., 2011). The studied exposed rock units are represent a part of northwestern Arabian Nubian Shield, which it is divided into two main terrains, oceanic arc terrains magmatism ( metavolcaniclastic sequences and metagabbro), and followed by the continental arc terrains magmatism (late and post magmatism) as shown in Fig. 2. Several researchers have been studied Wadi Um Taghir along Qena–Saфaga road (Hume, 1934; Akaad et al., 1973; 1979; Habib, 1987; El Gaby, Habib, 1982; El Gaby et al., 1988; Fowler et al., 2006, Hassan S. M., Ramadan T. M., 2014; El-Bialy M. Z., Omar M. M., 2015).

**Geologic setting.** The exposed rock units in this area have been differentiated into 8 distinct units (metavolcaniclastic sequences, metagabbro, dokhan volcanic, gabbro, tonalite, granodiorite, monzogranite, alkali feldspar granite and dikes) as showing in Table 1, Fig. 2.

The examined rock units are belonging to Late Cryogenian–Ediacaran age magmatism of the Eastern African Orogeny (EAO), they are represented by Island arc assemblage (oceanic crust terrain), late to post amalgamation (continental crust terrain) (Johnson et al., 2011; Johnson, 2014).

I. Island arc assemblage. The investigated rock units of the study area are related to island arc assemblage comprise into metavolcaniclastic sequences and metagabbro and covers about 12% of the all rock volume constitution as shown in Fig. 2. Occasionally, these rocks are related to the western arc or oceanic terrains of ANS that collided and amalgamated between 680 and 640 Ma creating a new continental crustal block referred to as the proto-Arabian-Nubian Shield (pANS), (Johnson et al., 2011).

I.1. Metavolcanoclastic rocks. These rocks are considered as the older rock units of the mapped area (Fig. 2), represent about 5% of exposed rock units, and they are situated at the southern part of the study area in Gable Abu Furad (Fig. 2), they have the banded to show like schistosity bands trends to SW direction in the most cases. Metavolcanoclastic sequences are low land, highly weathered and joints, they are intruded by the metagabbro and show sharp contact with monzogranite. They are mainly varied in color, in composition and in grain size from fine to very fine grained. The metavolcaniclastic sequences are characterized by folding structure according to elastic minerals constituents bearing in the rock and schistosity texture (Fig. 3, a).

I.2. Metagabbro. It is located at the south part of Um Taghir area and represents about 7% of exposed rock units of the study area (Fig. 2). It characterized by low hills to moderate relief out crops relative to the surrounded other rock units. Generally, this metagabbro is dominated by a singular in composition and in color. The metagabbro comprise massive rocks, highly weathered and jointed in most cases. Field observation indicates that they are intruded in metavolcaniclastic sequences and it is directly intruded by the tonalite-granodiorite rocks (Fig. 3, b).

II. Continental crust terrain. It is represented by (dokhan volcanic, gabbro, tonalite-granodiorite, monzogranite, alkali feldspar granite and dikes) as shown in Table 1.

II.1. Dokhan volcanic. It represents about 6% of exposed rock units in the mapped area Fig. 2; it is situated along the asphaltic road of Qena–Saфaga near of Saфaga city. Dokhan volcanic is characterized by imperial porphyry, medium to coarse – grained massive rock, reddish in color and highly jointed in NNE–SSW directions. It has high peaks one sets of joints one predominant trending NNE, casing the columnar like huge plugins. It is intruded directly by both of monzogranite and granitic porphyry with sharp contact between them, at the Qena–Saфaga road, on the other hand, dokhan volcanic cut by basaltic dikes with vertical shape (Fig. 3, c).

II.2. Gabbro. The gabbroic rock in the study area comprises as two types, layered and unlayered gabbro like purpose idea (Augland et al., 2011). The all two types of layered and unlayered gabbro are represented by small masses of moderately relief at the western side of Gable Um Taghir (Fig. 2). The unlayered gabbro has NW and NS trends and it is represented by low-moderate relief. It is characterized by medium to coarse – grained massive rocks, dark grayish to dark greenish color, not layered, highly fractured and deformed, sometimes smooth, generally one set of joints with predominant striking to 235° with vertical dipping to show well developed blocky structure, occasionally, shows spheroid shape (union shape) due to the weathering and exfoliation (Fig. 3, d), generally, unlayered gabbro intruded directly by granodiorite and monzo-

**Table 1. Geochronology of the basement rocks in the study area.**

| Orogenic setting | Rock units | Age, Ma | Reference, Age |
|------------------|------------|---------|----------------|
| Late-Post | Dikes | 650–542 | Youngest |
| amalgamation | Alkali feldspar granite | | |
| | Monzogranite | | |
| | Tonalite-granodiorite | | |
| | Gabбро | | |
| | Dokhan volcanic | | |
| Early | Metagabbro | > 650 | Oldest |
| oceanic | metavolcanoclastic | | |
| crust | | | |
| assemblage | | | |

| locality | H.A.M. Awad, A.V. Nastavkin. Geological and petrographical studies around Um Taghir area, central Eastern Desert, Egypt// Известия УГГУ. 2020. Вып. 1(57). С. 7-25. DOI 10.21440/2307-2091-2020-1-7-25 |
granite with sharp contact between granodiorite and gabbro, sometimes showing as big xenoliths. On the other hand, the layered gabbro is presented by small to medium masses at the middle of the study area (Fig. 2), which it is highly weathered, low land and highly altered. Occasionally, it is bearing ilmenite lenses in the bottom of the layered, this is related to magma rich of iron oxides. The layering type is trending strike 120/30 dipping SW, the ilmenite bands have the same direction of the layering. The bands are varying in thicknesses from few cm to about 3 m and more or less cross cut by quartz veins with SW trend.

II.3.1. Tonalite. It is restricted in south west of study area and represent reached about 13% of the early orogenic granitic rocks (Fig. 2), which it is characterized by grey in color and low hills, it is intruded directly by monzogabbro and cross cut in metagabbro (Fig. 3, b), as well as, there is unconformity surface between the quaternary rocks (conglomerate) with tonalite, occasionally, conglomerate is characterized by boulders and rounded shape (Fig. 3, e).

II.3.2. Granodiorite. According to the field observations show that the granodiorite rocks are characterized by medium to coarse-grained with greyish in color, moderately relief and restricted in most of the study area (Fig. 2), it reached up to 87% of the granitoid constitution. There is sharp contact between the granodiorite and monzogabbro (Abu Hawies granite), Fig. 3, f, on the other hand, monzogabbro intruded in granodiorite (Gable Al Baroud), Fig. 3, g.

II.4.1. Monzogabbro. It represents about 30% of study area, directly intruded in granodiorite (Fig. 3, g), as well as it’s intruded by alkali feldspar granites granite by sharp contact, sometimes it represents as big xenoliths in alkali feldspar granite in Al Baroud and Abu Murat areas. It is white to pinkish in color, coarse to medium grained, massive rock and high relief in gable Abu Murat. It is characterized by highly jointed in two trends E–W and N–S, highly fractured due to the effect of a numerous faults trends, on the other hand the cavernous cavity and exfoliation are very common.

II.4.2. Alkali Feldspar Granites. It represents the latter type of the granitic magma in the study area. Generally, the alkali feldspar granite constitutes an elongated NS belt extending from Abu Hawies in the north to Wadi Um Taghir at the south (Fig. 2). It is represented by relatively high topographic relief up to ~890 m in Abu Hawies and represents about 5% of study area. It is characterized by massive, medium to coarse grained, pink to red color, and less jointed. Moreover, it is intruded through the granodiorite with sharp contact between them (Fig. 3, h).

II.5. Dikes and veins. In the area under investigated have many dikes and veins that differ in the composition and also in extruded time. They have different shapes and composition cutting all the older rocks are easily interpreted on the Landsat image, by their color, tone, contrast, linear shape and field relationships. Firstly, dikes range in thickness from 30 cm to about 15 m and extend to more than 15 km in length. They often comprise acidic dikes, intermediate (andesitic dike) and basic dikes (basaltic dike), Fig. 2. Acidic dikes are represented by granitic and rhyolite dikes as shown in Figs. 3, i, j. According to the field observations, andesitic dike cut alkali feldspar granite as shown in Fig. 3, k Finally, basaltic dikes cut many different rock units in the study area with deferent directions NE–SW, E–W and NW–SE as shown in Fig. 3, l. Secondary, veins range in thickness from a few cm up to 7 m and extend to more than 5 km in length. They often comprise pegmatite, quartz veins and veinlets, as well as pegmatite vein cut in the granodiorite, it has up to 7 m thick as shown in Fig. 3, m, on the other hand, quartz veins and veinlets cut in the monzogabbro as shown in Figs. 3, n, o.

Petrography

I. Island arc assemblage. The investigated of island arc assemblage consists of mostly the metavolcaniclastic and metagabbroic rocks. In the following sentences are the petrographical descriptions of them.

I.1. The metavolcaniclastic rocks. The metavolcaniclastic rocks are usually represented by actinolite-hornblende schist. Actinolite-hornblende Schist. It consist of plagioclase and quartz minerals. Iron oxides and apatite are the main accessory minerals; on the other hand actinolite, chlorite and epidote are the main secondary minerals. Actinolite. It is represented by euhedral-subhedral crystals up to 0.8 mm in length and 0.42 mm in width and ranging from 16.63% to 22.12% of the rock mineral constituents as show in Table 2. Actinolite has often pale to deep green color (Fig. 4, a). Mostly, actinolite crystals formed after alteration of the hornblende crystals as secondary minerals. Hornblende. It covers amount of rock composition ranging from 28.37% to 29.15 of the rock mineral constituents (Table 2). It is represented by subhedral to euhedral crystals up to 0.6 mm in length and 0.38 mm in width with green color strongly pleochroic to deep brown (Fig. 4, a). Sometimes they are deformed, altered to actinolite, epidote and chlorite minerals. Plagioclase. It is represented by subhedral crystals up to 0.32 mm in length and 0.2 mm in width, Carlsbad twining (Fig. 4, a) and forms about 14.09% to 17.08% of rock composition (Table 2). It is andesine in composition with anorthite content up to An49. Sometimes, plagioclase is slightly altered to sericite. Quartz. It covers amount of rock composition ranging from 14.06% to 13.64% (Table 2). It occurs as anhedral crystals and fine grains forming together with plagioclase the white bands of the schist (Fig. 4, a). Chlorite. It presents due to the alteration of actinolite and hornblende. Chlorite covers amount of rock composition ranging from 13.66 % to 15.4% (Fig. 4A) while epidote occurs as euhedral prismatic crystals accounting within the hornblende ones. Iron oxide: It is represented by dark black irregular grains, associating with hornblende up to 3.38% of rock composition (Table 2). Apatite. It is present as fine subhedral colorless crystals associating with the hornblende forming an amount up to 1.2% of rock composition (Table 2).

I.2. Metagabbro. They are characterized by less deformed of greenish black massive rocks, in general showing porphyritic texture as a common texture of the investigated metagabbro. According to QAP diagram of Streckeisen (1976). The studied samples are fall in intermediate metagabbro in composition. The modal composition of the investigated metagabbroic rocks are given in Fig. 5, a and Table 3. The metagabbro is mainly consists of plagioclase, augite, hornblende, quartz and biotite in addition to iron oxide and apatite as accessory minerals, while chlorite and epidote are present as mineral assemblage secondary minerals. Plagioclase. This mineral is the most representative of all mineral constituents of the investigated metagabbro that is varying from 52.6 % to 55.6% of the all rock
Figure 3. Photographs showing. a – well-developed schistosity of the metavolcanoclastic rocks; b – metagabbro (M.g) intruded by the tonalite-granodiorite (Gr) at Gable Abu Furad; c – basaltic dike (B.d) cutting in dokhan volcanic (D.v) at Qena-Safaga road; d – spheroidal shape of gabbro (Gb) as xenoliths in granodiorite (Gr) at Wadi Al-Baroud; e – unconformity surface between sedimentary rocks (Cg) and tonalitic rocks (G) at Wadi Um Taghi; f – sharp contact between granodiorite (Gr) and monzogranite (Mz) at Gable Abu Hawies; g – granodiorite (Gr) intruded directly by monzogranite (Mz) at Gable Al Baroud; h – sharp contact between granodiorite (Gr) and alkali feldspar granite (AG) at Wadi Um Taghir; i – granitic dike (Gr.d) cutting in granodiorite (Gr) at Wadi Al Baroud; j – rhyolite dike (R.d) cutting in granodiorite (Mz) at Wadi Um Taghir; k – andesitic dike (An.d) cutting in alkali feldspar granite (Ak.g) with NE–SW directions at at Wadi Al Baroud; l – basaltic dike (B.d) cutting in gabbro (Gb) EW trending at Wadi Al-Baroud; m – pegmatite vein cutting in the granodiorite (Gr) at Wadi Um Taghir; n – Quartz vein (Q.v) cutting in the monzogranite (Mz) with direction E–W at Abu Hawies; o – quartz vein lets (Q.v) cutting in the monzogranite (Mz) with directions E–W and N–S at Abu Hawies.
composition as shown in Table 3, it is occurred as medium to coarse grains, which it is up to 1.8 mm in length and 1 mm in width (Fig. 4, b). Generally the composition of plagioclase is ranging from labradorite (An$_{30}$) to bytownite (An$_{50}$). It is partly to totally deformed or altered to scerisite mineral. 

Augite. It is represented by subhedral and anhedral crystals of pale yellow color pleochroing to dark yellow color (Fig. 4, b) and forms an amount up to 13% of rock composition as shown in (Table 3). It is often colorless under ordinary light with two set of cleavage. On other hand, augite is altered to chlorite and epidote. 

Hornblende. It is represented by subhedral to anhedral crystals of medium grained, it is characterized by brownish in color, sometimes showing destroyed, which it is up to 0.78 mm in length and 0.44 mm in width and varying in volume from 14.94% to 16.6% of rock composition. It has two sites of cleavage (Fig. 4, b), sometimes hornblende altered to chlorite. 

Quartz. It is represented by anhedral crystals up to 0.38 mm in length and 0.18 mm in width. As well as, the crystals are filing the interstitial spaces of most mineral constituents as shown in Fig. 4, b. It is manly ranging from 3.049% to 4.59% of the rock composition (Table 3). Biotite. It is represented by subhedral crystals up to 3.4% of rock composition (Table 3), it is characterized by pale yellowish crystals and pleochroing to brown color. Sometimes biotite is altered to chlorite and epidote. 

Chlorite and epidote. They are represented by green to pale green crystals. It occurs as secondary mineral mainly, occur due to alteration of the mafic minerals, chlorite covers about 5.25–6.25 % of rock composition, while epidote covers about 1.7–1.88% of rock composition (Table 3). 

Iron oxides. They are represented by deep black grains scattering over the rock mineral constitutes and disseminated within the different minerals. II.2. Gabbroic rocks. According to their modal composition as shown in Table 5 the studied rock samples are plotted on plagioclase, pyroxene and hornblende IUGS diagram, which it is given by Le Maitre (2002), the gabbroic rocks are classified into pyroxene hornblende gabbro and leucogabbro (Fig. 5, c). 

II.2.A. Pyroxene Hornblende Gabbro. It is characterized by medium to very coarse-grained rock, showing often subordinate ophitic and sub ophitic textures (Fig. 4, d). It consists mainly of plagioclase, pyroxenes and hornblende. Chlorite and actinolite present as secondary minerals. The accessory minerals is iron oxides. Plagioclase. It is represented by tabular-euhedral to subhedral crystals, up to 3.2 mm in length and 1.6 mm in width, it has labradorite composition with anorthite content ranging from (An$_{30}$ to An$_{50}$), covers about 60% of the rock composition (Table 5). The plagioclase often shows albite-Carlsbad twinnings, as well as it shows weak zonation and intergrowth with pyroxene to show well developed ophitic and

Table 2. Modal composition of metavolcaniclastic sequences. 

| Serial number | Sample number | Actinolite | Hornblende | Plagioclase | Quartz | Iron oxide | Epidote | Apatite | Chlorite | Total |
|---------------|---------------|------------|------------|-------------|--------|------------|---------|---------|----------|-------|
| 1             | 73            | 13.63      | 18.37      | 19.08       | 27.2   | 2.29       | 1.73    | 1.04    | 16.66    | 100   |
| 2             | 72            | 22.12      | 29.15      | 14.09       | 13.64  | 3.38       | 1.02    | 1.2     | 15.4     | 100   |
| 3             | 72b           | 14.63      | 17.37      | 20.08       | 25.22  | 2.27       | 1.73    | 1.04    | 17.66    | 100   |
| 4             | 71            | 22.12      | 29.15      | 14.09       | 13.64  | 3.38       | 1.02    | 1.2     | 15.4     | 100   |
| Av            | 19.4          | 28.8       | 15.57      | 16.4        | 2.8    | 1.37       | 1.12    | 14.5    | 100      |       |

Table 3. Modal composition of metagabbro. 

| Serial number | Sample number | Plagioclase | Augite | Hornblende | Quartz | Chlorite | Epidote | Iron oxide | Biotite | Apatite | Total |
|---------------|---------------|-------------|--------|------------|--------|----------|---------|------------|---------|---------|-------|
| 1             | 74a           | 55.6        | 11     | 14.94      | 4.59   | 6.25     | 1.76    | 4.02       | 2       | 0.4     | 100   |
| 2             | 70            | 53.4        | 12     | 16.6       | 3.04   | 5.25     | 1.88    | 5.57       | 1.6     | 0.66    | 100   |
| 3             | 70b           | 52.6        | 13     | 15.8       | 4.19   | 5.65     | 1.7     | 4.12       | 3.4     | 1       | 100   |
| Av            | 53.86         | 12          | 15.78  | 3.94       | 5.71   | 1.78     | 4.54    | 2.3        | 0.66    |         | 100   |
Plagioclase, quartz, olivine, hypersthene, and actinolite occur as accessory minerals, on the other hand chlorite occurs as secondary minerals after pyroxene. Iron oxides and apatite are also present. While actinolite and chlorite are characterized by brown in color with strong pleochroism and parallel extinction, occasionally, it fills the interstitial spaces between the mineral constituents, disseminated within the different minerals.

II.2.B. Leucogabbro. This type consists mainly of plagioclase, pyroxene, and olivine. Sometimes, it exhibits subordinate ophitic to sub-ophitic textures (Fig. 4, d). Pyroxenes. It is represented by augite and little amount of hypersthenes, covers about 22% of the rock composition. Augite. It is represented by euhedral to subhedral crystals, up to 1.76 mm in length and 1.2 mm in width. Sometimes, it is partly altered to chlorite. Hypersthene. It is represented by anhedral crystals, covers about 4% of the rock composition. It is characterized by pale green pleochroism and parallel extinction. Occasionally, it fills the interstitial spaces between the mineral constituents sometimes as a rim (Fig. 4, e). Hornblende. It is represented by euhedral to subhedral crystals, up to 1.6 mm in length and 0.7 mm in width. It covers about 13% of the rock composition. Often, it is characterized by brown in color with strong pleochroism from green to brown generally; it shows two sets of cleavage (60–120) and high relief, sometimes it is altered to chlorite and actinolite. Chlorite. It is generally represented by subhedral crystals, with green to pale green colored as secondary mineral, associated with pyroxene. Iron oxides. They are represented by cubic black crystals, often occur as fine grains scattering over the rock mineral constituents. Occasionally, it is occurred as anhedral crystals over the rock mineral constituents, disseminated within the different minerals.

II.3. Early orogenic granites. They comprise essentially the tonalite and granodiorite, according to their modal composition (Table 6), plotted on QAP diagram of Streckeisen (1976), Fig. 5, d.

II.3.1. Tonalite. It is represented by plagioclase, quartz, biotite and hornblende, while sphe re, zircon and iron oxide occur as accessory minerals, on the other hand chlorite occurs as secondary minerals. Plagioclase. It is represented by anhedral crystals up to 0.2 mm in length and 0.8 mm in width, characterized by Carlsbad twinnings (Fig. 4, g). Quartz. It covers area ranging from 28% to 32.5% of the rock mineral constituents. Occasionally, it is occurred as anhedral crystals with different sizes, displaying often wavy extinction (Fig. 4, h). Biotite. It covers an area up to 7% of the rock mineral constituents. It occurs as euhedral to subhedral crystals up to 0.4 mm.

| Sample number | Plagioclase | Pyroxene | Olivine | Hornblende | Chlorite | Actinolite | Iron oxide | Total |
|---------------|-------------|----------|---------|------------|----------|------------|------------|-------|
|               | Augite      | Hypersthene |         |            |          |            |            |       |
| Leucogabbro   | 6           | 65       | 25      | 3.8        | 3        | 1          | 1          | 1.2   |
| 38A           | 67          | 23.6     | 4.4     | 2.2        | –        | 1          | 0.8        | 1     |
| 39            | 69          | 25       | 2.6     | 2.3        | –        | 0.2        | 0.4        | 0.5   |
| 40            | 68          | 24       | 2.3     | 2          | –        | 0.4        | 1          | 1.7   |
| Average value | 67.25       | 24.4     | 3.3     | 2.4        | –        | 0.7        | 0.8        | 1.1   |
| Pyroxene-Hornblende Gabbro | 55 | 60 | 18 | 4 | – | 13 | 2.6 | 1 | 1.4 |

Table 4. Modal composition of the andesitic rocks.

| Rock name | Sample number | Quartz | Plagioclase | Alkali felspar | Pyroxene | Hornblende | Biotite | Muscovite | Iron oxide | Chlorite | Total |
|-----------|---------------|--------|-------------|---------------|----------|------------|---------|-----------|------------|----------|-------|
| Andesite  | 57            | 11     | 58          | 3             | –        | 13         | 10      | –         | 3          | 2        | 100   |
|           | 61A           | 9      | 56          | 4             | –        | 11         | 14      | –         | 3.6        | 2.4      | 100   |
|           | 63            | 8      | 59          | 5             | –        | 12         | 13      | –         | 2          | 1        | 100   |
| Av.       | 9.3           | 57.7   | 4           | –             | 12       | 12.3       | –       | 2.85      | 1.8        | 100      |

Table 5. Modal composition of the gabbroic rocks.
### Table 6. Modal composition of early orogenic granites.

| Sample number | Quartz | Plagioclase | Alkali felspar | Biotite | Hornblende | Sphene | Chlorite | Iron oxide | Total |
|---------------|--------|-------------|----------------|---------|------------|--------|----------|------------|-------|
| Tonalite       |        |             |                |         |            |        |          |            |       |
| 42            | 31.9   | 51          | 3              | 6       | 4          | –      | 2        | 2.1        | 100   |
| 65            | 30.5   | 50.6        | 4              | 5,5     | 6          | –      | 1.5      | 1.9        | 100   |
| 69A           | 25     | 50          | 1.6            | 7       | 10         | 1      | 2        | 3.4        | 100   |
| 79            | 32.5   | 49.6        | 4              | 5       | 6          | –      | 1        | 1.9        | 100   |
| Av.           | 30     | 50.3        | 3.15           | 6       | 6.5        | 0.25   | 1.6      | 2.3        | 100   |
| Granodiorite  |        |             |                |         |            |        |          |            |       |
| 21            | 31     | 47          | 14             | 5       | 1          | –      | 2        | 1          | 100   |
| 23            | 35     | 45          | 15             | 1       | 1.6        | 0.4    | 0.5      | 1.5        | 100   |
| 26A           | 28     | 48          | 17             | 4       | 1          | –      | 1        | 1          | 100   |
| 28A           | 27     | 49          | 16             | 4       | 0.9        | –      | 2        | 1.1        | 100   |
| 31A           | 30     | 44          | 18             | 5       | 1          | –      | 1        | 1          | 100   |
| 46            | 31     | 42          | 19             | 4       | 1.6        | 0.3    | 0.6      | 1.5        | 100   |
| 66            | 26     | 50          | 16             | 5       | –          | –      | 2        | 1          | 100   |
| 75            | 32     | 42          | 17             | 6       | 08         | –      | 2        | 1.2        | 100   |
| 76            | 34     | 46          | 15             | 1       | 1.6        | 0.4    | 0.5      | 1.5        | 100   |
| Av.           | 30.4   | 45.9        | 16.3           | 4       | 1          | 0.12   | 1.3      | 1.16       | 100   |

### Table 7. Modal composition of the late to post orogenic granites.

| Sample number | Quartz | Plagioclase | K-feldspars | Biotite | Muscovite | Chlorite | Actinolite | Total |
|---------------|--------|-------------|-------------|---------|-----------|----------|------------|-------|
|               |        |             | Monzo-granite | Ortho-clase | Perthite |          |            |       |
| Monzogranite  |        |             |              |         |           |          |            |       |
| 1             | 28     | 33          | 20           | 6       | 9         | 1        | 2          | –      | 1     | 100   |
| 4             | 30     | 25          | 25           | 5       | 10        | 1        | 1          | 1.5    | 1.5   | 100   |
| 11            | 27     | 30          | 22           | 6       | 11        | 2        | –          | 1      | 1     | 100   |
| 13            | 28     | 32          | 23           | 4       | 9         | 3        | –          | 0.5    | 1.5   | 100   |
| 16            | 25     | 26          | 30           | 3       | 9         | 4        | 1          | 1      | 1     | 100   |
| 28B           | 23     | 30          | 32           | 3       | 9         | 1        | 1          | –      | 1     | 100   |
| 33A           | 25     | 32          | 29           | 6       | 7         | 1.5      | –          | –      | 0.5   | 100   |
| 35            | 27     | 33          | 27           | 3       | 8         | 1        | –          | –      | 1     | 100   |
| 52A           | 32     | 29          | 26           | 3       | 6         | 1        | 0.5        | 0.5    | 1.5   | 100   |
| 54            | 30     | 26          | 24           | 5       | 10        | 1        | 1          | 1.5    | 1.5   | 100   |
| 61B           | 30     | 31          | 23           | 2       | 9         | 3        | –          | 0.5    | 1.5   | 100   |
| 74B           | 28     | 32          | 26           | 4       | 8         | 1        | –          | –      | 1     | 100   |
| 78            | 29     | 27          | 27           | 5       | 8         | 1        | –          | 1      | 2     | 100   |
| Av.           | 27.8   | 29.7        | 25.7         | 4.2     | 8.7       | 1.7      | 0.5        | 0.6    | 1.12  | 100   |
| Alkali feldspar granite |        |             |              |         |           |          |            |       |
| 14A           | 31     | 6           | 7            | 1       | 53        | –        | 1          | –      | 1     | 100   |
| 19A           | 26     | 2           | 5            | –       | 60        | –        | 5          | –      | 2     | 100   |
| 33B           | 39     | 1           | 8            | –       | 49        | –        | 2          | –      | 1     | 100   |
| 36            | 30     | 5           | 10           | 1       | 50        | –        | 2.5        | –      | 1.5   | 100   |
| 52B           | 40     | 3           | 7            | –       | 48        | –        | 1.5        | –      | 0.5   | 100   |
| Av.           | 33.2   | 3.4         | 7.4          | 0.4     | 52        | –        | 2.4        | –      | 1.2   | 100   |
mm in length and 0.2 mm in width of pale brown color, strong pleochroic to deep brown color (Fig. 4, g). **Hornblende.** It occurs as subhedral and anhedral crystals associated with quartz and plagioclase crystals, in filtered often by quartz crystals and covers up to 6% of the rock mineral constituents. It is characterized by two sets of cleavage and yellowish green color (Fig. 4, h). **Sphene.** It is represented by variable contents, covers an area up to 1% of the main rock mineral constituents as prismatic crystals up to 0.1 mm in length and 0.08 mm in width. **Iron oxides.** They are represented by deep black grains scattered over the rock mineral constituents and disseminated within the different minerals. **Chlorite.** It occurs as secondary mineral after biotite in most cases or hornblende as green bands often parallel with the cleavage of biotite crystals.

### II.3.2. Granodiorite.** It is composed mainly of plagioclase, quartz and orthoclase as essential minerals, while apatite, biotite and iron oxide represent the accessory minerals; on the other hand chlorite occurs as secondary mineral. **Plagioclase.** It is mainly ranging in composition from oligoclase (An_{6-28}) and andesine (An_{32-36}) in composition. It covers an area up to 50% of the main mineral of the rock constituents, represented by euhedral and subhedral crystals up to 1.2 mm in length and 0.7 mm in width, showing Carlsbad twinng's of plagioclase (Fig. 4, i). **Quartz.** It covers an area up to 36% of the main rock constituents, represented by anhedral crystals, sometimes, filling the interstitial spaces of the mineral constituents, characterized by showing wavy extension, as well as fine grained crystals associated with other minerals such as plagioclase and biotite (Fig. 4, i). **Orthoclase.** It covers area ranging from 14% to 19% of the rock composition, represented by medium to coarse subhedral crystals up to 1 mm in length and 0.6 mm in width (Fig. 4, j). **Biotite.** It occurs as flaky crystals, covers an area up to 6% of the main rock constituents. It is characterized by one set of cleavage, enclosing some iron oxide. It is observed also, as fine biotite crystals enclosed by the plagioclase (Fig. 4, i), sometimes, some crystal of biotite partly altered to chlorite. **Hornblende.** It is represented by euhedral crystals up to 1 mm in length with 0.6 in width, covering an area up to 1.6% of rock composition and characterized by strongly pleochroic green (=X) to deep green (=Y) and brown (=Z) colors. **Sphene.** It is represented by subhedral crystals up to 0.09 mm in length and 0.04 mm in width. It covers an area ranging from 0.1% to 0.4% of the main rock constituents, enclosed by plagioclase crystals. **Iron oxide.** It is represented by deep black grain scattering over the rock mineral constituents and disseminated within the different minerals. **Chlorite.** It occurs as secondary minerals after alteration process of biotite and hornblende crystals.

### II.4. Late to post orogenic granites. According to modal composition of the late to post orogenic granites given in Table 7 and plotting on QAP diagram of Streckeisen (1976), they have composition of monzogranite and alkali feldspar granite (Fig. 5, e).

### II.4.1. Monzogranite.** It is composed mainly of alkali feldspar, plagioclase, quartz, muscovite and biotite as essential minerals, chlorite as secondary minerals, iron oxides, apatite and sphene as accessory minerals. **Alkali feldspars.** They cover about 43% of the rock composition as shown in Table 7. They are represented often by microcline and orthoclase as well as microcline perthite determined as vein and flaky types (Fig. 4, k). The microcline crystal has often cross-hatching twinng, covering an average about 30% of rock composition (Table 7). It occurs as subhedral and platy crystals up to 1.6 mm in length and 0.9 mm in width. On the other hand, orthoclase crystal occurs as euhedral to subhedral crystals up to 1.2 mm in length and 0.65 mm in width, enclosing some sphene fine-grain crystals. It covers about 4.25% of rock composition. The flaky microcline perthite is represented by many of flaky albite crystals distributed over the microcline crystal, covering about 8.6% of mineral constituents of rock. **Plagioclase.** It
Figure 4. Photomicrographs showing actinolite mineral (Ac) within some fine grains of plagioclase (P), quartz (Qz) and hornblende (Hb) in actinolite-hornblende schist (a); plagioclase (P) within large corroded grain of augite (Px), chlorite (Ch) and biotite (Bt) in the metagabbro (b); phenocrystal of plagioclase (P) surrounded by fine grains groundmass to show porphyritic texture in andesite (c); subhedral hornblende (Hb) enclosing with albite and Carlsbad twins of plagioclase (P) in pyroxene hornblende gabbro (d); augite grain (Px) inclosing grains of plagioclase (P) to show ophitic texture (e); olivine (Ov) growing with plagioclase (P) in leucogabbro (f); subhedral crystals of biotite (Bt) associated with Carlsbad crystal of plagioclase (P) in tonalite (g); anhedral crystal of quartz (Qz) associated with hornblende (Hb) in tonalite (h); albite twin plagioclase (P) associated with quartz grains (Qz) and flakey of biotite (Bt) in granodiorite (i); subhedral crystal of orthoclase (Or) in granodiorite (j); flaky of strain microcline perthite (M) associated with subhedral crystal of orthoclase (Or) in monzogranite (k); flaky of biotite (Bt) associated with Carlsbad twin of plagioclase (P) in monzogranite (l); albite of plagioclase (Ab) enclosed in microcline of vein perthite to show rapakivi texture in alkali feldspar granite (m); big crystal of muscovite (Ms) with minor crystals of iron oxides (In) scattered in alkali feldspar granite (n); subhedral crystal of plagioclase (P) associated with alkali feldspar, quartz crystal (Qz) and muscovite (Ms) in the granitic dike (o); euhedral crystal of plagioclase (P) partly altered to sericite associated with biotite partly altered to chlorite (Bt), hornblende crystal and fine grains of iron oxides (In) in the andesite dikes (p); microcline vein perthite (M) surrounded by fine grains of quartz (Qz) to show porphyritic texture in the rhyolite dike (q); fine-grained plagioclase crystals (P) associated with pyroxene crystals (Px) and fine grained of iron oxides (In) in the basalt dikes (r). (C.N.).
occurs as oligoclase crystals in composition, which it is varying from (An$_{0.2}$) to (An$_{0.1}$), covering about 29.5% of the rock mineral constituents. It is represented by euhedral to subhedral crystals up to 1.6 mm in length and 0.8 mm in width exhibiting often Carlsbad twinning (Fig. 4, l), while primary zonation is less common, some crystals enclose some opaque minerals such as iron oxides and also infiltrated by quartz and biotite to form subordinate poikilitic texture. **Quartz.** It occurs as anhedral crystals up to 0.85 mm in length and 0.44 mm in width, covering about 27.8% of the rock composition as interstitial components, as well as minor minute’s crystals distributed over all the mineral composition as seen in **Muscovite.** It covers an area up to 0.5% of the rock constituents as show in Table 7. It is represented by flaky crystals up to 1 mm in length and 0.6 mm in width, probably developed during alteration of rock by the late magmatic reaction, characterized often by high interference color and reacted rims. Sometimes, it is altered to chlorite crystals (Fig. 4, l). **Biotite.** It is represented by euhedral to subhedral crystals, covering about 1.5% of the main rock constituents, characterized by one set of cleavage, associated with the plagioclase, quartz crystals and partly altered to chlorite (Fig. 4, l). **Chlorite.** It occurs as secondary mineral, after alteration of biotite and muscovite, with pale green color in most cases (Fig. 4, l). **Iron oxides.** They are represented by deep black grains scattered over the rock mineral constituents and disseminated within the different minerals. They occur with considerable value up to 1% of the rock composition. **Sphene.** It is represented by fine grain crystal, covering about 0.2% of the main rock constituents and associated with different mineral compositions of rock. **Apatite.** It occurs as euhedral prismatic crystal enclosed essentially in the alkali feldspar crystals.

II.4.2. Alkali feldspar granite. It consists mainly of alkali-feldspars, quartz, plagioclase and muscovite. Biotite is less common. On the other hand, sphene and iron oxides are the main accessory minerals. While chlorite is the main secondary mineral. Alkali feldspars. They cover an amount of 59.8% of the rock composition as showing in (Table 7). They consist essentially of microcline, microcline perthite and orthoclase (Fig. 4, m). Microcline covers about 7.4% of the rock composition. It is represented by subhedral or rectangular crystals up to 1.8 mm in length and 1.2 mm in width. It shows clear cross-hatching twinning. Sometimes, it is partly altered to kaolinite, as well as it encloses plagioclase and quartz crystals. On the other hand, microcline perthite is covers about 46% of the rock constituents. It occurs as subhedral to anhedral platy crystals, reaching up to 2.4 mm in length and 1.6 mm in width. Occasionally, microcline perthite mantled by small crystal of plagioclase to show rapakivi texture (Fig. 4, m). Orthoclase is the less common constitution, which is covers about 6.4% of rock composition. It is represented by subhedral to anhedral crystals up to 1.2 mm in length and 0.8 mm in width. The perthites are usually occurring as vein and patchy perthites. **Quartz.** It covers about 33.2% of rock constituents (Table 7). It is represented by subhedral to anhedral crystals of various shape and size (Fig. 4, m), it characterized by wavy excentical, sometimes it fills the interstitial spaces of the rock composition. It reaches about 1.4 mm in length and 0.9 mm in width. **Plagioclase.** It occurs as euhedral to subhedral prismatic crystals. It reaches up to 2 mm in length and 1.2 mm in width, with anorthite content (An$_{0.3}$) of albite composition. It covers about 3.4% of the rock composition (Table 7). Most of plagioclase crystals show albite twinning (Fig. 4, m), but Carlsbad less common twinning. Occasionally, the plagioclase albite twinning is tilted due to deformation. As well as, the albite composition sometimes shows as rim-like surrounded crystals of microcline or perthite to show well developed rapakivi texture. (Fig. 4, m). **Muscovite.** It is represented by euhedral and subhedral flaky crystals. It reaches about 2 mm in length and 1.2 mm in width, and covers about 2% of the rock composition (Table 7). Occasionally, it is partly or completely altered to chlorite particular along the plans of cleavage in banding like shape. It is corroded often by groundmass (Fig. 4, n). **Sphene.** It is represented by prismatic crystals of notably high refractive indices, up to 0.6 mm in length and 0.3 mm in width, is the common accessory mineral, up to 0.4% of the rock composition (Table 7). It characterized by pale yellow, commonly with grayish-brown shades, slightly pleochroing to pale green and often associated with muscovite aggregates. **Iron oxides** occur as black dots within the rock and between the mineral constituents as shown (Fig. 4, n).

II.5. Dikes. The different types of dikes occur in the study area of composition varying from basic to acidic composition (Table 8). The plotted modal composition of them on QAP diagram of Streckeisen (1976), According to these diagrams they are classified into granitic, andesite, rhyolite and basalt dikes as show (Figs. 5, f, g).

II.5.a. Granitic dikes. They consist of alkali feldspar, plagioclase and muscovite minerals. Iron oxides are the accessory minerals, but biotite is less common as shown in (Fig. 4, o).

II.5.b. Andesite dikes. They consist essentially of plagioclase (58.5%), hornblende (16%) and biotite (10.5%), with few amount of quartz (8.5%). Iron oxides are the accessory minerals as shown in (Fig. 4, p).

II.5.c. Rhyolite dikes. These dikes consist of alkali feldspar (36%), quartz (31%) and plagioclase (23%) composition with minor amount of muscovite. On the other hand, iron oxides are the main accessory minerals as shown in. (Fig. 4, q).

II.5.d. Basalt dikes. These types occur as fine-grained rocks composed mainly of plagioclase (65.3%) and augite (29.35%). Chlorite is the main secondary mineral. The accessory minerals are iron oxides as shown in. (Fig. 4, r).
Figure 5. Plot of the investigated metagabbro on IUGS nomenclature for gabbroic rocks of Le Maitre classification diagram, 2002 (a); modal composition of the investigated andesitic rocks on QAP of Streckeisen volcanic classification diagram, 1976 (b); the investigated gabbroic rocks on IUGS nomenclature for gabbroic rocks of Le Maitre classification diagram, 2002 (c); the modal composition of the early orogenic granitic rocks on QAP diagram of Streckeisen, 1976 (d); modal composition of the investigated late orogenic granites on QAP of Streckeisen classification diagram, 1976 (e); QAP of Streckeisen diagram, 1976, for the investigated granitic dikes (f); QAP of Streckeisen classification diagram, 1976, for the study volcanic dikes (g).
Conclusion

Um Taghir area is located in the Central Eastern Desert of Egypt on the Qena–Safaga road. The Qena–Safaga shear zone one of the most important structural occurrences in Central Eastern Desert of Egypt. It is dominated by metamorphic complex and they are intruded by granitic rocks. As well as, Um Taghir is represented by island arc related rocks and late to post tectonic magmatism. The island arc related rocks are represented by metavolcanoclastic rocks and metagabbro. Metavolcanoclastic rocks are considered as the older rock units of the study and are intruded by the metagabbro. Whereas the late to post magmatism is represented by (dokhan volcanic, gabbro, tonalite-granodiorite, monzogranite, alkali feldspar granites and different types of dikes). Usually, the gabbroic rock is bearing ilmenite lenses or bands in the bottom of the layered; this is related to magma rich of iron oxides. Petrographically, island arc assemblage is classified in to actinolite hornblende schist and metagabbro that show quite different of their content in plagioclase, hornblende, augite, quartz and biotite. Occasionally, the late to post magmatism represented by (andesite, gabbro, tonalite, granodiorite monzogranite, alkali feldspar granites and different types of dikes). Andesite consists of plagioclase, quartz, alkali feldspar and hornblende. Gabbroic rocks are represented by pyroxene hornblende gabbro and leucogabbro. They show quite different of their content in plagioclase, pyroxene and clear difference in the content of both olivine and hornblende in both of them. While tonalite and granodiorite that show quite different of their content in plagioclase, quartz, hornblende, alkali feldspar and biotite. On the other hand, monzogranite and alkali feldspar granite, they show plagioclase is varying from oligoclase to albite; K-feldspars, quartz and muscovite are relatively more abundant in the alkali feldspar granite. Finally, the different types of dikes classified into granite, andesite, rhyolite and basalt dikes consist of the different mineral compositions.

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Геологические и петрографические исследования в районе Ум Тагир Центральной части Восточной пустыни, Египет

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Аннотация
Район Ум Тагир расположен на северной крайней границе Средне-Восточной пустыни Египта на западе города Сафага. Ум Тагир представлен скалами, связанными с островной дугой и поздним тектоническим магматизмом. Горные породы, связанные с островной дугой, представлены метавулканокластическими пластами и метагабброобразными породами. Метавулканокластические породы считаются более старыми литологическими единицами исследования интрузируемые метагаббро. От позднего до посттектонического магматизма представлены вулканические свиты, габбро, тоналит-гранодиорит, монцогранит, щелочной полевой шпат и различные типы даек. Как правило, габброгерманная порода является носителем магматических пород или полос в нижней части слоистых слоев; это связано с магмой, образующейся в результате контакта.

Петрографически, состав основной дуги подразделяется на архейский блок, включая различные типы даек, вулканиты доханской свиты, габбро, тоналит-гранодиорит, монцогранит, щелочно-половошпатовый гранит и различными типами даек. Эти породы присутствуют в разных значениях в платигоклае, роговой обманке, авгит, кварце и биотите. Известны поздний и тектонический магматизм представлен андезитом, габбро, тоналит-гранодиорит, монцогранит, щелочно-половошпатовый гранит и различными типами даек. Эти породы присутствуют в разных значениях в платигоклае, роговой обманке, авгит, кварце и биотите.

Ключевые слова: район Ум Тагир, петрография, Восточная пустыня, Египет.

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