

## Geology and geochemistry of the upper proterozoic granites of As – said intrusive complex in Lawder – Mudia districts Abyan Governorate

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### Abstract

The study area encompasses about 135km<sup>2</sup> located between latitudes 13° 51' 35" and 13° 56' 20" north and longitudes 45° 56' 40" and 46° 04' 52" east, within the south eastern region of Abyan Governorate , situated to the north east of Aden at a distance of 176km. The area is occupied by the geological map sheet D38 80 and D38 81.

The main rock types of the intrusion includes in the series:biotite granite, monzogranite, syenogranite , rarely gneissosegranites.

The petrographic, mineralogical and geochemical studies revealed that there is no considerable differences between the main massifs;suggesting that these granite massifs represent outcrops of the same magmatic origin.

The massifs of As – Suwaiyda ,Am-Salaa, Al – Hamrah and Al – Hafa (um Zareb),and Am Maisam, geochemically originated from peraluminouscalc alkaline magma and considered as post-tectonic granites intruded at pressure between 1-3kb within crustal depth, greater than 30km of the lithosphere.

**Keywords:** Geology, Geochemistry, Upper Proterozoic granites, As-Said intrusive complex, Lawder – Mudia, Abyan.

### Introduction

The aim of this work is to evaluate the studied post tectonic granite massifs of J. As – Suwaiyda,J.Am-salaa J. Al – Hamra , J. Al – Hafa , J. um Zareb and J.Am-Maisam and their associated pegmatites from the petrographical , geochemical and mineralogical point of view. All these granitic massifsc comprise rock units of As – Said intrusive complex of the main area.

As – Said intrusion covers about 30km<sup>2</sup> of the total area cross cutting the metamorphic formations of Barak Group.

Granites are Classified according to their locality (Jabal) , or classified by different workers (As – Said intrusive complex, Labounets 1988) , or by their relative age as (syntectonic , inter tectonic , post tectonic (2).

The post tectonic granites of Lawder – Mudia area form successive series of younger discordant , commonly massifs, Jointed , grey to pink colour; contains pegmatite dikes and veins with low content of CaO, MgO and related elements. These Granites represent the last major tectonic and magmatic event at the time of craton stabilization (Pan – African tectogenesis,Windly)(2), in the evolution of the Arabian – Nubian shield at Upper Proterozoic – lowerpalaeozoic era.

### Methodology:

Chemical analysis was made for 13 samples from different locations within the granitic massifs with determinations of majoroxides(wt %). Oxides include SiO<sub>2</sub>,Al<sub>2</sub>O<sub>3</sub> , Fe<sub>2</sub>O<sub>3</sub> ,TO<sub>2</sub> ,CaO, MgO , MnO , P<sub>2</sub>O<sub>5</sub> , SO<sub>3</sub> ,Na<sub>2</sub>O , K<sub>2</sub>O and lose of ignition.Petrographic studies of thin sections were carried out on rock specimens taken from each type,including pegmatitic veins, to investigate the mineral composition of different granites. All analysis were done in the laboratories of the Geological Survey and Mineral Resources Board-Aden.

### **General Geology**

The area is composed of Upper Proterozoic-Lower Paleozoic metamorphic rock units, a great number of granitic intrusions besides Jurassic limestones, Neogene-Quaternary volcanics and Quaternary deposits.

The lower metamorphic unit (Barak Group) consists of migmatites, granite gneisses and plagiogneisses. Amphibolites and schists with subordinate interbeds of two mica schists and quartzites. The rocks are regionally metamorphosed into amphibolite and epidote amphibolite facies. The upper metamorphic unit (Fahman Group) is composed of metasandstone, quartz sandstones, quartzites, quartz feldspathic rocks with horizons of biotitic and two mica schists, marbles and dolomite interbeds. The rocks are regionally metamorphosed in green schist facies and almandine amphibolite facies (3).

Jurassic deposits of Amran Group are exposed to the south of the area, gently dipping beds of (10-15°) unconformably overlying the eroded basement surface forming the lower conglomerates, gritstones and limestones with sandstone interbeds. Neogene-Quaternary volcanics of Yemen volcanic series predominates in the south eastern parts in the form of slaggy lava cones and domes, mainly of basic to intermediate composition, basalts, tuffs and volcanic ashes (4).

### **Geologic outlines**

As – Said intrusive complex is composed of rocks of three phases of intrusion. The first and the second phases comprise monzogranites and syenogranites. The first phase is having varieties of granites while the second is represented by syenogranites. The rocks of both phases have massive or gneissose structure and represented by granite gneiss of biotitic composition. Pegmatoid granites and pegmatites, aplites are the latest rocks of the complex. Granite domes, swells, dykes are abundant in the studied area. Geological map of the studied granites is shown in Fig (1).

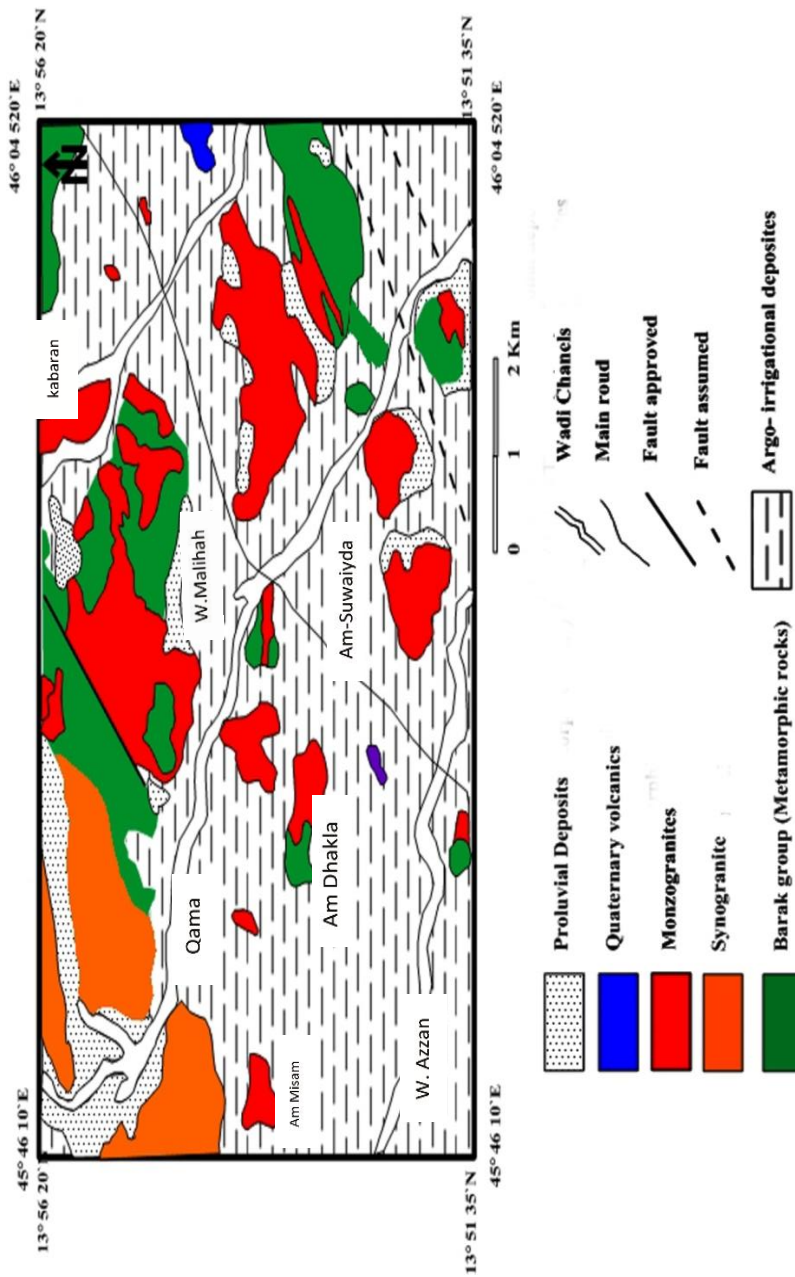


Fig. 1- Geological Map of the studied granites of As-Said intrusive complex - Lawdar – Mudia area.

A brief description of the main studied and visited massifs in the area of Lawdar – Mudia within the metamorphosed complex enclosing rocks of Barak Group is given below.

As – suwayda granite massif.

The massif granite occupies an area of about 1.0 Sq km, situated on the Meilan mountain with coordinates units 13° 53' 00" – 13° – 53' 26" north latitude and 45° 59' 18" to 45° 59' 55" east

longitude. The absolute elevation of this massif ranges from 844 to 1055 meters above sea level ,stretching for 1100 meter in latitudinal direction , the width being 740m .

Strong weathered ,biotitized varieties of Jointed granite are observed amidst the massif to different extents. The contacts are distinct. Granites are medium grained, jointed, weathered rocks containing fine flakes of biotite gives the schistose gneissose texture of the granite around the boundaries. Granites are intersected by different oriented pegmatite veinlets and veins having steep (70 – 90)° dip angles, with thickness of 1 to 5cm , veinlets and veins are traced for tens of meters. Joints are found and are caused probably by magma cooling, solidification and weathering(1).

#### Am – Sala'a granite massif

The massif is situated 1.5 km to the north east of the same named village with coordinates center 13° 54' 40" north latitude and 46° 40' 40" east longitude , being represented by the massif of Um Zareb mountain with absolute elevation from 920 to 1357 meters above sea level. The massif occupies an area of about 1.5 sq km.

The body mainly is composed of jointed biotitized , medium grained granites of light grey colour having biotite schlieren, impersistent veins and veinlets of pegmatites occasionally quartz bearing from (1 – 3) up to (50 – 80) cm in thickness. Joints are confined to systems of northwest 340° with dip angle 80°.

The granite massif is irregularly biotitized schistose , sheet jointed and being crowned by cone-like peak with steep relief.

#### Al-Hamra granite massif

The granite massif is located to the east of Um Shehabiah village at a distance of 1. Km, having an elevation ranging from (840 to 1319) meters above sea level with coordinate center 13° 53' 52" and 46° 04' 52". Granites are biotitic, fine to medium grained, massive, light grey in colour, jointed and weathered from the lower levels of the massif with marks of gneissose structure. Joints found of different sizes and lengths, empty or filled by earthy materials. The top of the massif is steep cone-like peak rising 160 meters above the crest of the same mountain. Veins and veinlets of pegmatites and quartz are reported and being traced in various directions at a distance from a few meters to tens of meters.

#### Al-Hafa granite massif

The massif is located 0.1 km to the south of Al-Hafa village, covering an area of about 0.3 sq km with coordinates center 13° 54' 40" and 45° 56' 50". Steep sided granite cone-like peak of up to 100 meters high; Its elevation is in the range of (900-1400) meters above sea level. The granitic massif is light grey ,locally pinkish, medium grained contains biotite schlieren and pegmatite veins and veinlets. The granite is weathered, jointed, massive, gneissose. Pegmatites are differently oriented in thickness attaining 20 cm in average. Almandine crystals clearly encountered in some veins.

#### Am-Maisam granite massif.

The massif is located nearby the village of Am Maisam with coordinates center 13° 53' 50" north latitude and 45° 57' 00" east longitude, with absolute elevation ranging from (800 to 1040) M, stretches from west to east for 1km with its width being 0.3km.

It is completely composed of monzogranites, jointed, weathers and biotitized to different extents. Granites are massive medium grained, strong, slightly jointed, light grey colour. Granites are characterized by sheet jointing with gentle slopes. Veins and veinlets of pegmatites (2-3 to 15-40 cm thick) and occasionally quartz-bearing (up to 10-20 cm thick) are reported and traced for tens of meters, rarely biotite schlieren recognized.

### **Petrographical study**

A petrographical description of the rocks collected from different outcrops in the studied granites is given below.

**Monzogranites-** These rocks are composed of tabular sometimes twinned grains up to 3mm of latticed microcline(45%), with less and rare perthitic intergrowth of albite , tabular poorly pelitized

of quartz. Xenomorphic grains of quartz have different size(0.2-25mm) forming about 30%, flakes of biotite up to 0.5mm in size. Secondary minerals in monzogranites are represented by muscovite, chlorite, epidote, zoisite, carbonate, sericite, pelite. The accessory minerals are apatite, zircon, and ore minerals (magnetite, hematite, rarely pyrite). The texture of the rock is hypidiomorphic, rarely cataclastic or gneissose.

**Syenogranites-** The rock is formed of tabular xenomorphic grains of latticed microcline up to 0.5mm in size, with microperthetic intergrowths of albite (20-25%) and tabular grains of poorly zonal sericitized oligoclase (15-20%) of 0.5-2.5mm in size. Xenomorphic quartz grains is (25-30%), biotite flakes 3-4% of 0.2-1mm in size. The secondary minerals are chlorite, muscovite, iron hydroxides and carbonates. The accessory minerals are leucoxene, anatase, pyrite. The texture is hypidiomorphic.

**Granite gneiss-** The rock contains biotite flakes and feldspar crystals arranged in plane parallel form grains. The rock is banded or gneissose structure, they have leucocratic to melanocratic varieties. The primary minerals of the rock is microcline plagioclase (30-35%) quartz(20-25%), biotite(7-12%), plagioclase and microcline found in equal amounts. Microcline is not latticed form tabular wide grains and twinned; oligoclase as elongated tabular small size grains, intergrowths of rounded quartz are reported within the microcline grains, myrmekitic intergrowths of quartz also reported in the oligoclase, rarely albite rims. Biotite flakes are altered by chlorite, muscovite is rare. The secondary minerals of the granite gneiss are sericite, muscovite, pelite, chlorite, limonite. The accessory mineral is apatite. The texture is hypidiomorphic granular.

Microcline pegmatites- are composed of microcline (50-60%), oligoclase (30%), quartz (30%), biotite (5%) and magnetite(5%).

### **Geochemistry**

A group of samples were collected from different granitic outcrops for chemical analysis in order to identify their geochemical behavior and petrochemical characteristics including magma type and tectonic setting.

The chemical analysis for major oxides (wt%), for 13 samples is given in Table (1). No evidence of any valuable differences in mineralogical and chemical composition of the granites are shown. Generally, the granites are characterized by their relatively normal contents of major oxides.

The granitoids of As-Said intrusive complex in the studied area characterized by SiO<sub>2</sub> content varying from 71.32 to 76.24%(mean 74.34%) of monzogranites, syenogranites SiO<sub>2</sub> content varying from 71.94 to 74.12%(mean 72.83%),

The total alkali index (Na<sub>2</sub>O+K<sub>2</sub>O) for monzogranites(8.09), syenogranites(8.89), with their ratios of Na<sub>2</sub>O/K<sub>2</sub>O is (0.843) for monzogranites, (0.804) for syenogranites, that is on the whole potassium predominates over sodium.

On the variation diagram of SiO<sub>2</sub> versus major constituents are shown in (Fig 2 and on Fig 3 a). In the monzogranites, the SiO<sub>2</sub> is negatively correlated with FeO, Al<sub>2</sub>O<sub>3</sub>, CaO, TiO<sub>2</sub> and positively correlated with MgO, Fe<sub>2</sub>O<sub>3</sub> and Na<sub>2</sub>O and compatible with K<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub> and MnO. In Syenogranites, the SiO<sub>2</sub> is positively correlated with CaO, MgO, and K<sub>2</sub>O, negatively correlated with Na<sub>2</sub>O, FeO, Fe<sub>2</sub>O<sub>3</sub>, MnO and compatible with K<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>.

On the total alkalis- silica diagram of Cox et al (1979) (6), monzogranites and syenogranites are plotted within the granite field and are classified them as acidic subalkaline igneous rocks (Fig 3). The molar (Al/(Na+k)) versus (Al/(Ca+Na+k)) diagram of White and Chapel, (7) shows that the granites are disturbed between peraluminous and peralkaline fields, the studied monzogranites are plotted within the field of peraluminous affinity, while the syenogranites are discriminated to the peralkaline field affinity (Fig 4a).

On the AFM ternary diagram (FeO, total alkalis, MgO), of Beard (7), all the two types of granites are plotted in the calc-alkaline field (Fig 4b). Hence, these rocks are characterized by Calc-alkali trends and have calc-alkali indices. The agpaitic index (Na<sub>2</sub>O + K<sub>2</sub>O / Al<sub>2</sub>O<sub>3</sub>) of the rocks varies from (0.47) to (0.74).

The ternary diagram ( Or – Ab – An )of ( Barker , 1979)(7) shows that the studied granites are plotted in the field of granites (Fig4c), on the same diagram according to (5) and(7)

Table NO1: Major oxides of monzogranites and Syenogranites

	Sample	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	FeO	TiO <sub>2</sub>	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	H <sub>2</sub> O	L.o.i	TOT
1	M-1	75.34	14.64	0.2	0.85	0.15	0.02	0.02	1.22	3.88	4	0.07	-	0.22	0.28	100.47
2	M-2	73.46	15.37	0.3	0.94	0.2	0.02	0.02	1.68	3.5	3.65	0.08	0.56	-	-	100.28
3	M-3	76.24	12.95	0.92	0.34	0.18	0.02	0.59	0.84	3.29	4.9	0.08	0.14	-	0.14	100.47
4	M-4	76.2	12.18	0.56	0.13	0.03	0.02	0.69	1.25	4.44	4.04	0.03	0.02	-	0.27	99.86
5	M-5	74.98	12.85	0.74	1.35	0.22	0.05	0.3	1.02	3.24	4.44	0.03	0.01	-	0.34	99.75
6	M-6	71.32	15.24	0.12	1.14	0.25	0.01	0.02	3.67	3.67	4.96	0.07	0.03	0.27	0.24	100.01
7	M-7	72.86	13.66	0.17	0.98	0.25	0.02	0.01	2.67	3.67	4.96	0.07	0.02	0.021	0.25	99.62
8	S-1	74.04	13.34	0.21	0.53	0.05	0.01	-	2.26	3.98	4.8	0.03	0.03	0.45	0.39	99.66
9	S-2	72.26	14.12	0.84	0.14	0.07	0.03	-	3.76	4.46	4.52	-	-	-	-	100.88
10	S-3	74.12	13.58	1.12	0.07	0.09	0.01	-	1.76	4.2	4.06	0.01	-	-	-	99.74
11	S-4	72.4	13.37	1.76	0.22	0.05	-	0.6	1.4	3.44	6	0.01	-	-	-	99.5
12	S-5	72.26	11.99	0.25	3.55	0.08	0.004	0.4	1.4	3.76	5.16	0.11	-	-	1.1	100.1
13	S-6	71.94	13.94	0.15	1.27	0.27	0.02	0.02	2.87	3.62	5.37	0.12	0.01	0.32	0.21	99.62

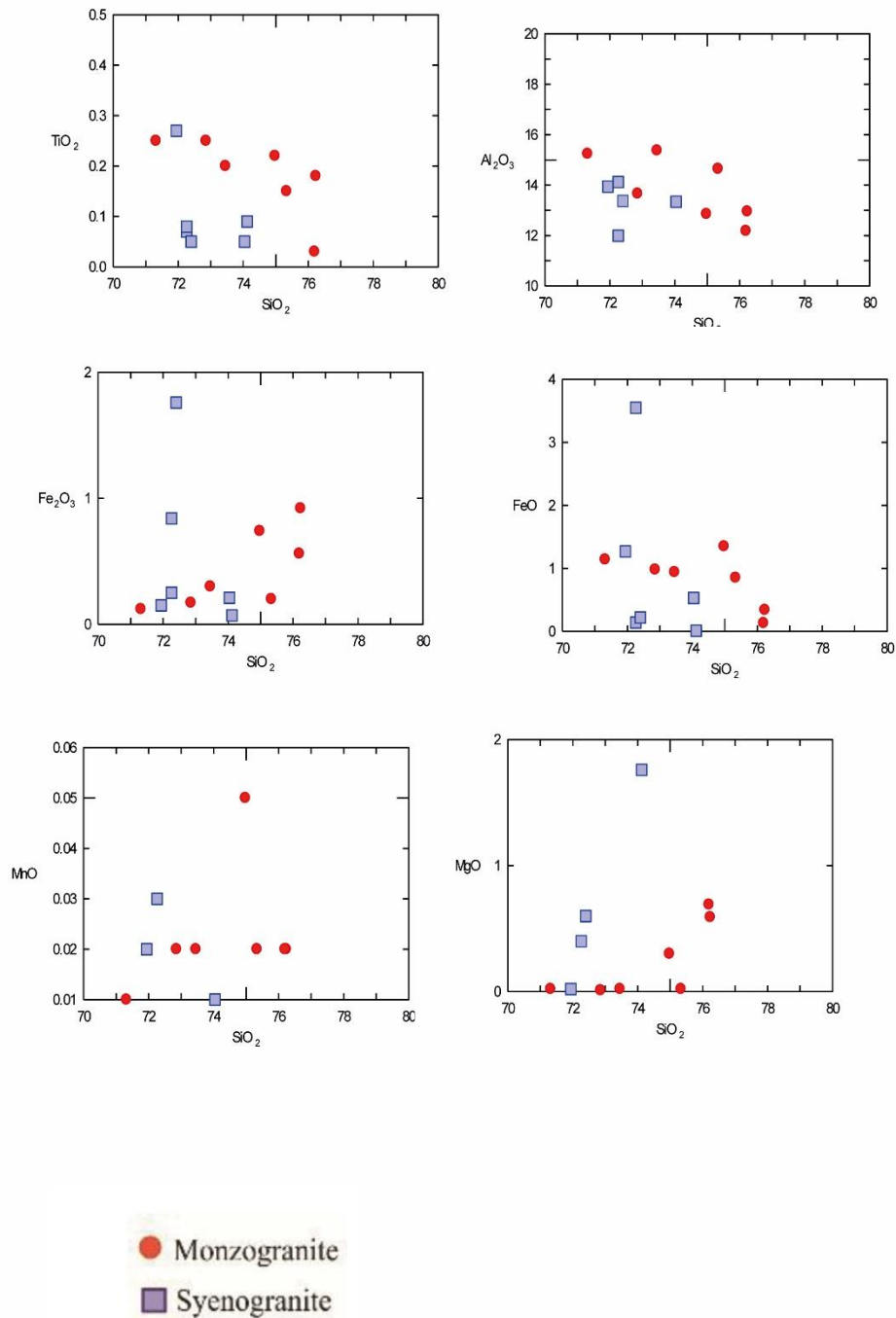


Fig.2-Binary variation diagrams of major oxides (TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, FeO , MnO and MgO) of the granites

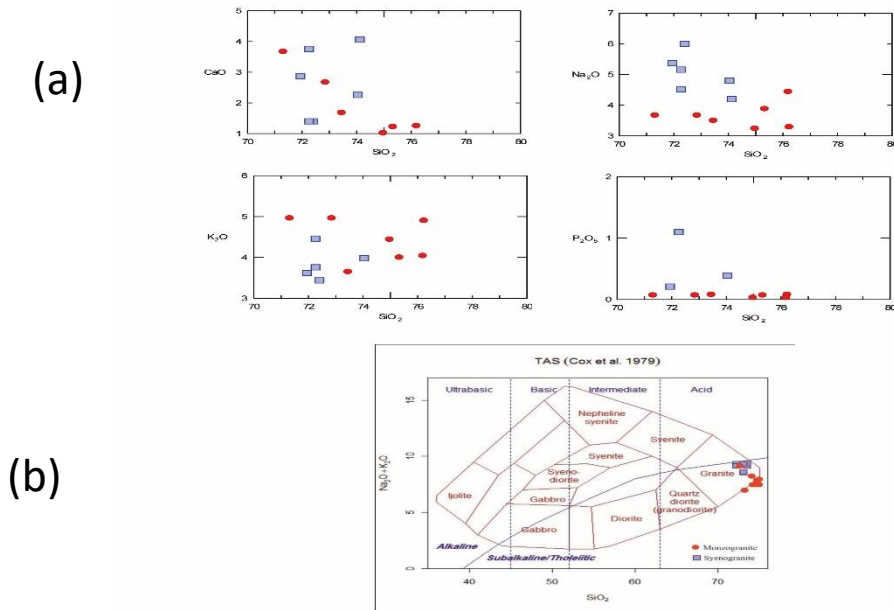


Fig.3 –(a)Binary variation diagrams of the some major oxides

(CaO, Na<sub>2</sub>O, K<sub>2</sub>O , P<sub>2</sub>O<sub>5</sub>) of the granites (b) Binary diagrams of total alkalies versus silica.

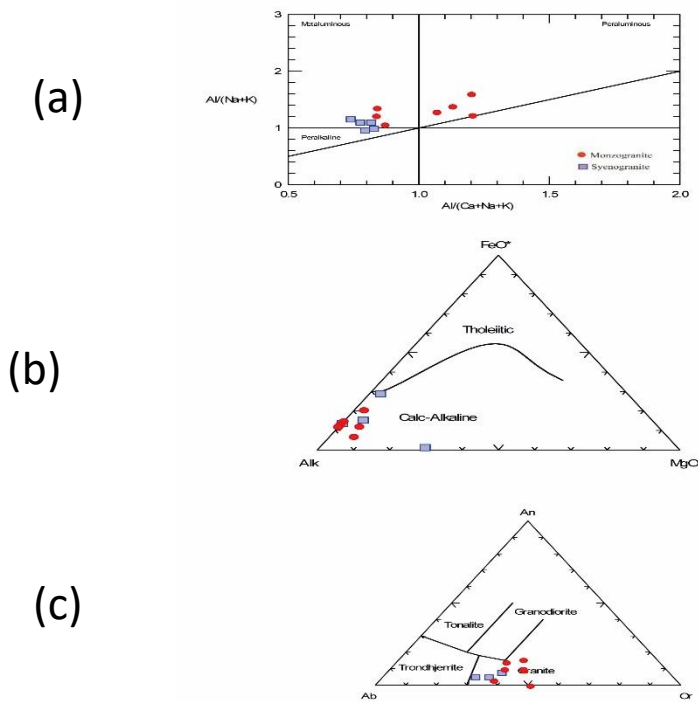


Fig. 4- (a)Variation diagram of Al/(Na+k) atomic ratio versus Al/(ca+Na+K) atomic ratio and (b) AFM ternary diagram and (c) Triangle diagram of igneous acidic rock classification



**Tectonic setting :**

The granites of Lawdar –Mudiaarerepresentative part of the main granite of As-Said intrusive complex originated in the last major tectonic event in the evolution of the crystalline shield of Yemen and Saudia Arabia which were formed at the time of the stabilization (Pan African period of the continental crust (Rogers and Greenberg 1983,Greenwood 1968,Stosser and Camp 1985)(2). This resulted in the initiation ofperaluminousand peralkaline within plate granitic intrusions, they occur as ring structures or as great batholiths which are almost circular. A wide range of theories about the gneisses of peralkaline granites exist (Stosser and Elliott,1980)(2). A tendency toward a peralkaline geochemistry of the post tectonic igneous rocks is mentioned by several workers in connection with the comparable situation in Saudi Arabia, but it is accepted that they are predominantly emplaced with peraluminous granites with which they are genetically related inside within the plate association as products of partial fusion.

Chapman and Hall, 1979(7) suggested that post tectonic granites are charactrized by the following:

Peraluminousleucogranite.

Collision granites.

Crustal type granites.

Crystallized at low pressure (less than 2.5 kb)

The data on the radiometric age of the granites (K-Ar method), collected from massif rocks, has offered figure of 670m.y, late proterozoic by ( Labounetes et al 1988)(5), The age of the similar granites from Saudia Arabia has been established by Pb-Sr method fluctuated from 660 to 550m.y (5).

A tentative correlation of the post-tectonic calc-alkaline granites are correlated with post tectonic granites of Saudia Arabia (Karpoff,1960)(2), Las Bar,Araar andDaimolah younger granites of Somalia,also with younger Gattarian granites (7), of Egypt.

**Conclusions and Recommendations**

- 1-The granites of As-Said intrusive complex in the Lawder-Mudia area are classified intomonzogranites and syenogranites The petrographic mineralogical and geochemical studies revealed that there is no considerable difference between these massifs which represent outcrops of the same originated magma.
- 2-Age determination by K-Ar method revealed that these granites are related to post –tectonic type of granites originatedat the latest stages of the pan-African tectogenesis in the Late Proterozoic –Lower Palaeozoic period.
- 3-The granites is characterized by low potentiality of rare elements and rare earths.
- 4-The granites are of great importance in the association of pegmatites of different widths and extensions that must be included for further studies for rare elements and radioactive minerals.
- 5-High decorative properties of the granites for the production of facing and floor tiles is recommended for future studies.
- 6-Further field studies for pegmatites as ceramic raw material is required in future.

**References**

1. Abramov.S.Z,(1983). Report on prospecting and estimation carried out in 1982-1983 at Am-Suwayda deposit in AbyanGovernorate.Geological Survey-Aden- Volume-1(P39-45).
2. Kruck.W,Schuffer.J(1991). Geological Map on scale 1: 250000 of the Republic of Yemen- Western part ,(1991),part-1,Explanatory Note, Technical cooperation-Hanover (P26-33)
3. Labounetes.G.E.(1988).Geological map on scale 1:100000, map sheet D38-80-lawdar-Moscow-Zarubej geologia, USSR part 2 (1).
4. 4-Labounetes .G.E. (1988) . Geological map on scale 1:100000, map sheet D38-81-Mudia-Mosco-Zarubej geologia, USSR (1).
5. Labounetes.G.E.(1988). Report on the integrated 1-100000 geological map survey in the Western part of PDRY ,volume-1, part-1,Zarubejgeologia- Moscow MSSR (P378-394).
6. Mackenzie.W.S,DonaldsonC.H,Guilford C.(1982). Atlas of igneous rocks and their textures,Longman Group limited ,U.S.A. (P77-78)
7. Moharem A.F.(2001). Geochemistry and Uranium-Thorium distribution in the Suwayqat El-Arsha-AbuAshayir granite plutons and their associated pegmatites. Annals of the geological survey of Egypt-Cairo (P1-18).

## جيولوجيا وجيوكيمياء صخور الجرانيت لحقبة البروتيروزوي الأعلى في متداخلات

### "معقد الصعيد" في مديرتي لودر ومودية - محافظة أبين

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#### الملخص

تنتشر صخور الجرانيت على هيئة كتل جبلية متداخلة ضمن التكوينات الصخرية في منطقة الدراسة والمقدر مساحتها بحوالي 135 كم<sup>2</sup> بين خط عرض 35° 51' 13" إلى 20° 56' 13" شمالاً وخط طول 40° 56' 45" إلى 52° 04' 46" شرقاً ممثلة بالمتداخلات الجرانيتية المتموضعة في محافظه أبين على مسافة 176 كم إلى الشرق من مدينه عدن. والمكونة في الأساس من صخور المونز وجرانيت والسيانوجرانيت والجرانيت البيوتيتي المؤجنس وعروق البيجماتيت والابليت.

أوضحت الدراسات البتروجرافية للعينات الصخرية عدم وجود أي فروق واضحة في الكتل المذكورة أنفاً من حيث منظومة المعادن السيليكاتية الأساسية المكونة لها، مع احتمالية نشوء هذه المكاشف الجرانيتية لمعقد الصعيد من ذات المنشأ الواحد أثناء مرحلة التبلور التفاضلي للصهير السيليكاتي الغني بالألمنيوم والكالسيوم. تعد المتداخلات الجرانيتية لجبل أمسويداء - جبل الحافة- جبل أمصلحة جبل الحمراء مرتبطة بالمرحل النهائية من الحركة البان - أفريقية البانية للجبال في نطاق الدرع العربي النوبي مع نهاية حقبة اللا حياة (نهاية عصر البروتير وزويكو بداية عصر الباليوزويك) مخترفة للقشرة الأرضية من اعماق تتراوح بين 30-35 كم بما يعادل 1 - 3 كيلو بار ضغط جوي.

**الكلمات المفتاحية:** جيولوجيا، جيوكيمياء، جرانيت حقبة البروتيروزوي الأعلى، متداخلات معقد الصعيد، لودر- مودية، أبين.