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Unidirectional Solidification Textures In Pegmatitic-Aplite Dykes In South Wadi Rimarim, South Eastern Desert, Egypt

Osman. R.A.
Nuclear Material Authority, Cairo, Egypt

Abstract

Rimarim area is asmall occurrence in the basement rocks of the Precambrian Nubian shield covering the Eastern Desert of Egypt. This occurrence is characterized by the presence of pegmatitic-aplite dykes intruded in in a host rock of metasediments, both are located at the immediate north of wadi El Gemal. The aplite dykes are of the Rimarim subvolcanic suite, 2 to 50 m thick and up to 300 m long striking NE – SW and dipping 80–85° towards NW. Pegmatitic-aplite dykes are characterized by alternations of two main textural units: (i) fine-grained aplite unit with garnet stripes and (ii) pegmatitic-grained in fine granitic matrix unit with oriented Qtz, Plg and Kfs comb-like crystals known as Unidirectional Solidifcation Textures (UST) that describes a magmatic layering case. Both units developed in graditional zones with the thickness varying from several cm to 1–2 m for aplite unit, and 3-8 cm for the UST unit. To date, this strange petrographic phenomenon is recorded for the first time in the entire Nubian Shield.

Average contents of unidirectional solidification and aplite units of subvolcanic suite have a respective felsic character documented by; 67.37 and 67.71% SiO_2, high concentrations of 5.12 and 5.12% Na_2O, 7.4 and 7.8% Fe_2O_3, moderate concentrations of 2.1 and 1.4% CaO, 1 and 1% MgO and 0.72 and 0.72% TiO_2, slightly low concentrations of 1.83 and 1.7% K_2O. Two distinctive units have respective high average concentrations of 106.5 and 92 ppm Cr and 14.5 and 29 ppm Pb. Meanwhile, the low respective values for the ratios 99.31 and 48.42 K/Rb and 37.8 and 34.31 K/Ba reflect the degree of fractionation of pegmatites -aplite rocks.

The UST unit is considered as within plate granite, meanwhile the aplite unit is considered as volcanic arc granite. Geochemical and mineralogical features of the aplite–pegmatites are characterized by (1)peraluminous, subalkaline chemistry and A-type affinity, (2)occurrence of specific accessory minerals including garnet and (3)a remarkable absence of micas and other minerals with volatiles (F, B, P and H_2O). Therefore the studied suite differs from all other granitic rocks with UST described to date, which are typically characterized by volatile-bearing minerals

Based on all available petrographic and geochemical data, the following evolutionary model was developed that crystallisation of these dykes proceeded in closed-system conditions from the bottom upward. Volatiles and exsolved bubbles of water-rich fluid migrated to the upper- most part of the dykes. When the pressure of exsolved water overcame the lithostatic pressure and cohesion of surrounding rocks, the system opened. Propagation of existing cracks or opening of new cracks started. Vapour escaped and the adiabatic decrease in pressure resulted in sudden decrease in temperature. The UST crystallised from the undercooled melt. This process was repeated several times.

Nonequilibrium crystallisation in layered rock produced small domains with contrasting chemistry and finally very small amounts of liquids of unusual composition.

Keywords: Unidirectional Soldification Texture, magmatic layering**,** pegmatites-aplite, south wadi Rimarim area,Egypt.

1-Introduction:

Wadi Rimarim occurs in the southern part of the Eastern Desert of Egypt Fig (1). The study area is a part of the basement complex that covers the central part of the Egyptian Eastern Desert.

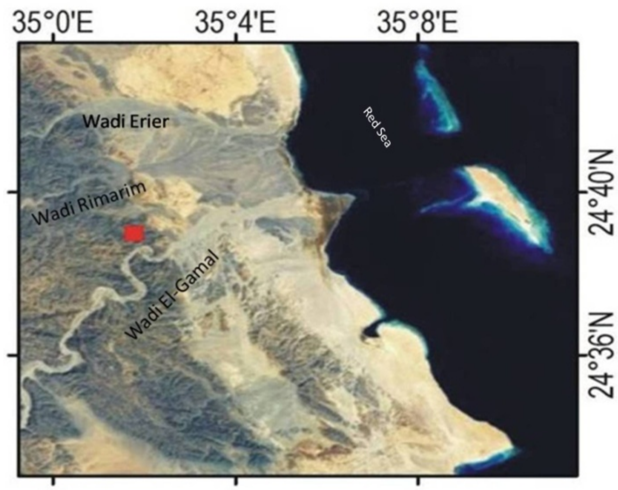

Fig. 1: Location map of the studied area, South Rimarim area.

Fax: (202)33457295
Phone: (202)33457296
Corresponding author:
(e-mail:ramag_osman@yahoo.com).

The most conspicuous feature in this area is the presence of a swarm of pegmatitic-aplite dykes intruding the southern part of the relatively wider Rimarim metasediments. These dykes are subvolcanic suite which are characterized by high variability in their internal structure, mineralogy in general and, textures in particular.

Pegmatitic-aplite dykes are characterized by alternations of two main textural units; (i) fine-grained aplite unit with garnet stripes and (ii) coarse-grained (Pegmatite)unit with oriented Qtz, Plg and Kfs comb-like crystals known as Unidirectional Solidification Textures (UST) in fine granitic matrix with, the occurrence of garnet as a specific accessory mineral. Other minerals closely associated with garnet are extremely rare: magnetite, sulphides, zircon, chloritized biotite and muscovite. This area has been geologically investigated on a semi-detailed scale (Soliman et al, 2007). During the petrographical examinations of samples collected from the pegmatite-aplite dykes a strange phenomenon has drew my interest since it describes the internationally known Unidirectional Solidification Textures (UST) which were recognized as a specific type of the magmatic layering. It was used for the first time by Shannon et al. (1982) for textures observed in subvolcanic granitic bodies at the Henderson Mine, Empire, Colorado; however, older Russian texts published by Kormilitsyn and Manuilova (1957) also described identical textural features in the transbaykal region. Similar textures were recently found in many pegmatites -aplite as well (e.g., London 1992; Breiter et al. 2005).

The objective of present work is to focus on these pegmatitic - aplite dykes, including their internal structure, mineral composition, and nature/genesis of UST in particular. Typical W–E oriented pegmatitic – aplite bodies cut metasediments association, VAG granites of Wadi el Gamal. In other words, this paper is trying to explain strange petrographical phenomenon in Rimarim dykes which is supported by limited geochemical investigations. Previous field observations has also recorded this phenomenon in limited geological (granitic) occurrences in the Eastern Desert of Egypt

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(e.g. Um Eldebaa and Hmr Akarem) but did not provide any petrographical and/or geochemicale explanations (Hasan, 2015).

2-Geologic Setting:

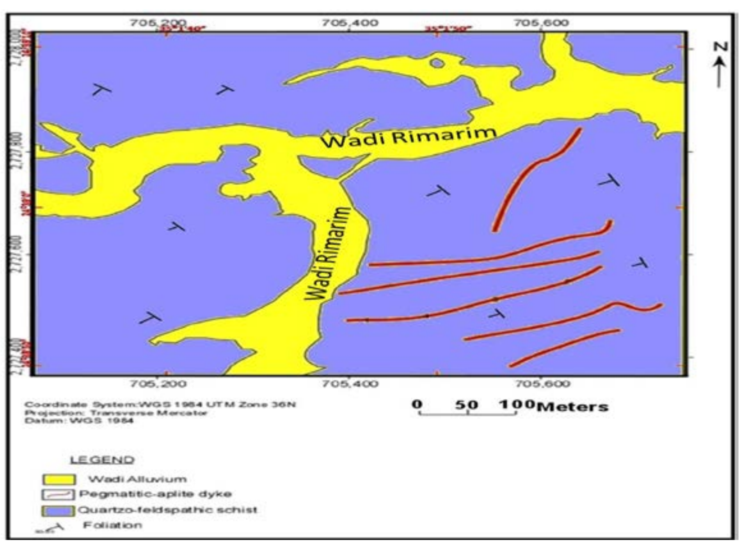
Wadi Rimarim lies inbetween wadi Ghadir in the north, wadi El Gemal in the south Hafafit range in the west and the Red sea in the east (Fig 1). The wider area, including Rimarim, will be referred to as wadi Ghadir-wadi El Gemal district (GGD). Several petrological features in the exposed pegmatite-aplite dykes reveal effects of deep seated igneous activity as well as effects of late magmatic processes. The present study focuses on the south part of wadi Rimarim where the dykes are exposed.

Wadi Rimarim forms a subcircular shape with two distinguishable concentric zones. The outer zone is characterized by high to moderate relief and occupied by older granite, while the inner zone is represented by younger granites showing low to moderate relief. According to Soliman et al, 2007, the regional stratigraphic rock units (from youngest to oldest) in wadi Erier-Rimarim area compose of by as follows:

-Sediments
-Dikes
-Younger granites
    -Equigranular granite and episyenite
    -Porphyritic granite
    - Pegmatitic granite
-Older granite (diorite-tonalite-granodiorite associations)
-Ophiolitic ultramafics

The semi-detailed geological map of the Rimarim area (Figs 2 and 3) demonstrates the pegmatitic-aplite dyke swarm of subvolcanic suite which cut through the Rimarim metasediments (quartzo-feldspathic schist). These dykes have a width 2 to 50 m and length up to 300 m with general E–W orientation and dip 80–85°towards NW are along striking NE – SW. Pegmatitic-aplite dykes can be divided into two graditional alternative unites:

Fig. 2: Geologic map of the studied area, South Rimarim area.



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- Fine-grained aplite unit with garnet stripes and
- Coarse-grained (pegmatite) in fine granitic matrix unit with oriented crystals known as Unidirectional Soldification Textures (UST).

Both units were developed in graditional zones with the thickness varying from several cm to 1–2 m for aplite unit, and 3-8 cm for the UST unit.

Fig. 3: Field photograph showing felsic pegmatites-aplite dykes cut metasediments.

3-Sampling and Techniques:

Petrographical and mineralogical characteristic of different rock were examined using five representative thin sections (4 from dyke and 1 host rock). Meanwhile, five samples were prepared for chemical analyses, two from each units of aplite dyke and one from host rock (schist). These samples are analyzed for major and trace elements in NMA laboratories.

4-Petrographical and Chemical Data presentation:
4-1 Petrography:

The macrotextural-paragenetic textures in dyke (Fig 4) describe two main units; fine grained aplite and coarse graied (pegmatites) in fine granitic matrix. Therefore, they signifcantly differ in texture and grain size. They include the prevalent, fine pale grey (creamy) aplite unit with garnet stripes (Fig 4a), the subordinate (transitional Fig 4b) and coarse dark grey UST unit (Fig 4c) which was subjected to detailed studies.

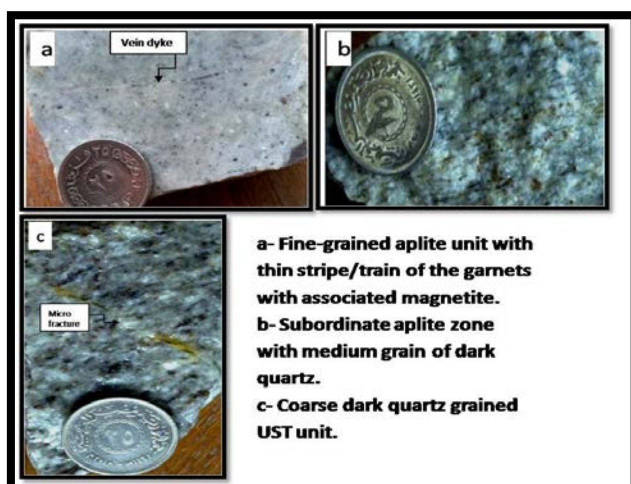

Fig. 4: Macrotextures of aplite-UST from pegmatitic-aplite dyke at South Rimarim area.

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The microscopic investigations focused mainly on two distinctive units of granitic - aplite dyke. These units are UST (pegmatite) and fine aplite. The characteristic features of mineralogical, internal structures and textures within fine aplite and UST units are described in Figs 5 and 6. Even the hosting quartzo-feldspathic schist is also investigated (Fig 7).

Fig. 5: Photomicrographs of characteristic features of aplite unit in pegmatitic-aplite dyke.

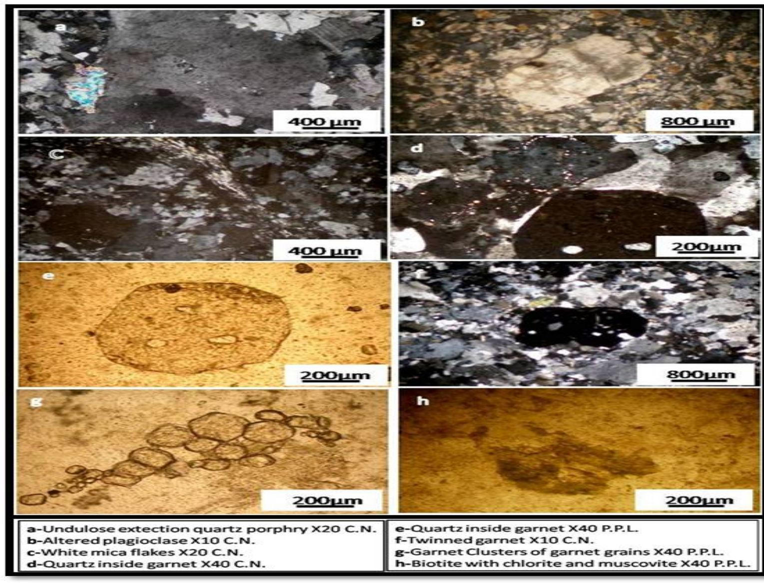


Fig. 6: Photomicrographs of characteristic features of Unidirectional Soldification Textures(UST) unit in pegmatitic-aplite dyke.

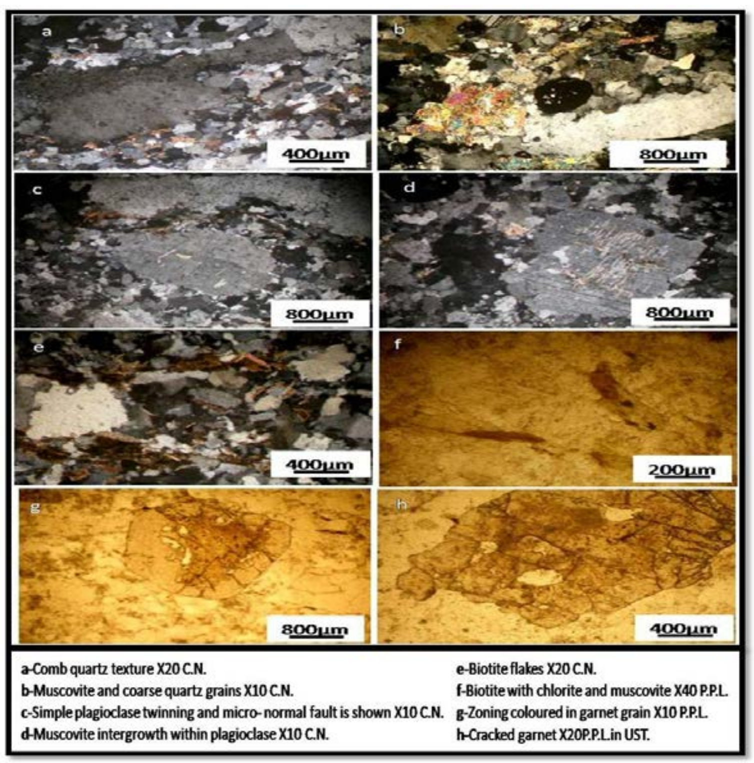
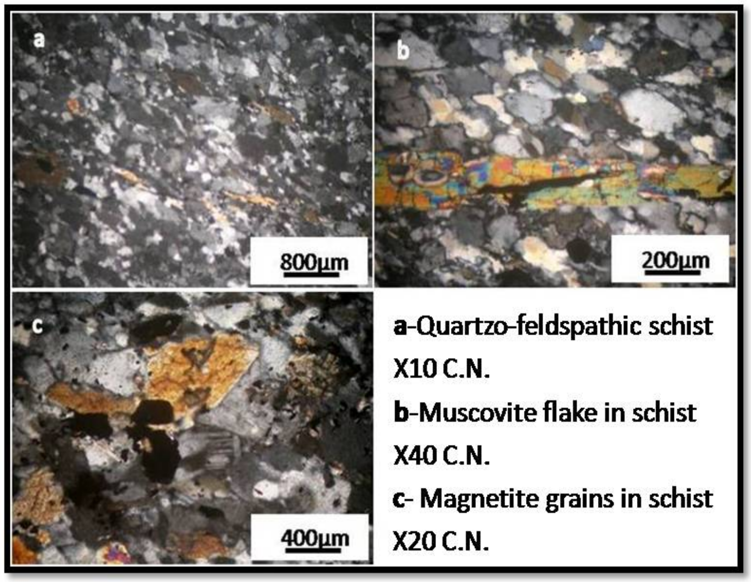


Fig. 7: Photomicrographs of characteristic features of quartzo-feldspathic schist.



4-2 Chemical Analysis:

Five samples (four from pegmatitic-aplite dyke and one from the hosting metaschists) were subjected to detailed chemical analyses (major oxides and trace elements). These investigations were conducted to provide supports to the petrographic examination.The resulting analytical data are presented in Tables 1 and 2.

Table 1: Major elements (oxides wt %) analysis for the studied units of pegmatitic-aplite dyke and metaschist.

Rock Type	Sample Nos.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	110 °C	1000°C	K/Rb	K/Ba
Aplite	1	67.88	12.12	0.70	8.40	1.40	1.00	5.33	1.49	0.02	0.27	1.05	200	35.6
	2	67.53	12.93	0.73	7.20	1.40	1.00	4.91	1.91	0.02	0.60	1.34	124	33.5
UST	3	66.83	12.53	0.67	7.20	2.80	1.00	5.14	1.91	0.02	0.24	0.84	124	44
	4	67.90	12.50	0.77	7.60	1.40	1.00	5.10	1.75	0.28	0.14	0.58	96.9	37.6
Meta schist	5	49.96	11.40	3.29	15.98	4.20	2.00	5.40	1.39	1.74	0.30	3.24	206.1	9.3

Table 2: Trace elements (ppm) for the studied units of pegmatitic-aplite dyke and metaschist.

Rock Type	Sample Nos.	Cr	Ni	Cu	Zn	Zr	Rb	Y	Ba	Pb	Sr	Ga	V	Nb
Aplite	1	80	13	11	42	67	31	33	174	7	3	5	3	12
	2	104	14	14	74	104	64	51	237	22	5	11	5	18
UST	3	113	14	9	69	128	67	56	180	13	6	10	3	21
	4	100	9	7	72	166	75	71	193	16	8	8	3	29
Meta-Schist	5	82	6	32	48	36	28	3	620	13	55	8	30	2

5-Petrographical and Geochemical Data Analysis and Interpretation:

Fine aplite zone: units are mostly fine grained, with typical aplitic (panallotriomorphic) texture composed of plagioclase (38–45 %), K-feldspar (23–30 %) and quartz (20–30 %). The average composition of phenocrysts is 3%. The rock unit matrix of variable grains size (0.87µm-9.03µm). The aplite nature, by its texture, contains phenocrysts (30.01µm-60.02µm). Total amount of accessory minerals (e.g., garnet) is very common 1 vol. %. Anhedral grains of quartz (≥ 0.3 mm) are randomly distributed and exhibit undulose extinction (Fig 5a). Plagioclase An15–8 is altered (Fig 5b) and shows simple zone with distinct calcic core. Myrmekitic texture is commonly developed on the contact between plagioclase crystal and K-feldspar. Subhedral plagioclase is replaced by K-feldspar or quartz; late alterations include formation of secondary muscovite (Fig 5c) and prehnite. Light pink subhedral crystals of K-feldspar show two or more crosscutting perthitic systems. The main accessory mineral is garnet which is dominated by spessartine and almandine. Garnets (0.24 to 1.5 mm) are present as solitary (Fig 5d&e) and cluster describing twinned (Fig 5f) and train texture(Fig 5g). The other accessory minerals are chloritized biotite (Fig 5h), zircon, magnetite and galena. Galena, in these dykes, are reported in Mahmoud et al.(in prep.)

UST pegmatitic zone: units with the grain size of 10–12 mm pegmatitic phenocrysts are developed in fine grained granitic matrix occur as alternations of individual layered sequence each of thicknesses of 3–8 cm. The phenocrysts represent about 5 vol.%. The rock unit matrix is of variable grains size (1.67µm-15.70µm). The aplite nature by its texture contains phenocrysts 37.82µm to 100µm. In some dyke localities, a coarse-grained unit occur instead, where evidently predominates. Major minerals include K-feldspar, Plagioclase (An15–10) and quartz. Accessory minerals are mainly garnet and galena. Large phenocrysts of K-feldspar and plagioclase are up to 10 millimeters long, subhedral to euhedral with typical comb-like textures, whereby the individual crystals have the same orientation as the neighboring ones. Comb-like quartz crystals also show the same feature (fig 6a). They are also arranged perpendicularly to the strike of the UST aplite unit. The tops of elongated crystals are always growing into the fine-grained aplite unit with sharp boundaries, in contrast to the bottom sides where transitional boundaries occur (Fig 6b). Quartz grains are coarse in size (1-1.2 cm long). Albite crystal has a simple twinning and micro- normal fault observed in plagioclase crystal (Fig 6c).

Obvious sieve texture occurs in corroded, partially resorbed plagioclase core with quartz and muscovite crystals intergrowth (Fig 6d). This texture may be formed in two ways; either if a plagioclase crystal is placed into magma in disequilibrium state (by magma mixing), then it will become corroded, and melt will penetrate into the crystal structure or the crystal may also become rounded by partial resorption. New plagioclase of a different composition will precipitate from the magma and form a rim around the corroded core. Alternatively, the same effects could possibly be produced by volatile-loss from decompression as magma rises to shallower regions in the crust. As a result Comb texture is then developed consisting of multiple layers of euhedral, prismatic quartz crystals (Type I) that have grown on subplanar aplite substrates. These layers are separated by porphyritic aplite containing equant phenocrysts of quartz (Type II), which resemble quartz typical of volcanic rocks and porphyry intrusions.

Comb-layered quartz is a type of unidirectional solidification texture (UST) found at the roofs of shallow silicic intrusions consisting of multiple layers of euhedral, prismatic quartz crystals (Type I) that have grown on subplanar aplite substrates. The layers are separated by porphyritic aplite containing phenocrysts of quartz (Type II), which resemble quartz typical of volcanic rocks and porphyry intrusions. However the secondary quartz grain is formed as fine grained which is recrystallized as authigenic quartz (Type III). The two populations appear to have formed under different conditions. The Type II quartz phenocrysts almost certainly grew from a high-silica melt between 600 and 800°C (as β-quartz). In contrast, the morphology of Type I quartz is consistent with precipitation from a hydrothermal solution, possibly as α-quartz grown below 600°C. The bulk compositions of comb-layered rocks, as well as the aplite interlayers, are consistent with the hypothesis that these textures did not precipitate solely from a crystallising silicate melt. Instead, Type I quartz may have grown from pockets of exsolved magmatic fluid located between the magma and its crystallised border. The Type II quartz represents pre-existing phenocrysts in the underlying magma; this magma was quenched to aplite during fracturing/degassing events. Renewed and repeated formation and disruption of the pockets are exsolved aqueous fluid accounts for the rhythmic banding of the rocks.

Small flakes of biotite are present in parallel directions (Fig 6e). Chloritized biotite (Fig 6f) occurs with muscovite and iron oxide as an altered product (Fig 6g,h). However biotite converts into muscovite and iron oxides according to the following equation:

$KMgFe_2(AlSi_3O_{10})(OH)_2+2Al(OH)_3 = KAl_2(Al_3SiO_{10})(OH)_2+2FeO(OH)+Mg^{2+}+2H_2O$

Biotite carried by alkaline Hydrothermal solution muscovite iron oxides

Garnet srystals (0.01 to 1.2 mm) are present as solitary grains but some garnet grains are obviously zoned(Fig 6i) and cracked(Fig 6j).

Quartzo-feldspathic schist: Petrographic examination of the hosting metasediments (quartzo-feldspathic schist) Fig 7a reveals a composition of plagioclase (30%), K feldspar (35%), quartz (25%) and mica (5%). The essential minerals of K-feldspar, quartz and plagioclase occurr as fine crystals with a very subordinate amount of muscovite flakes (Fig 7b) meanwhile the accessory minerals compose of zosite, and magnetite(Fig 7c).

A relatively detailed chemical analyses was applied to 4 samples collected from the two main rock units (aplite unit and UST unit) in one of the dykes that occur in south Rimarim area. In addition chemical analyses were also applied to one sample from the hosting metashist. The results of the studied samples are given in tables 1&2, meanwhile

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the representative averages of chemical analyses are given in Table 3. Average concentrations of the major and trace elements of the investigated aplite-pegmatite samples have been normalized to the average low Ca-granite values Turekian and Wedepohl (1961) (Figs. 8&9).

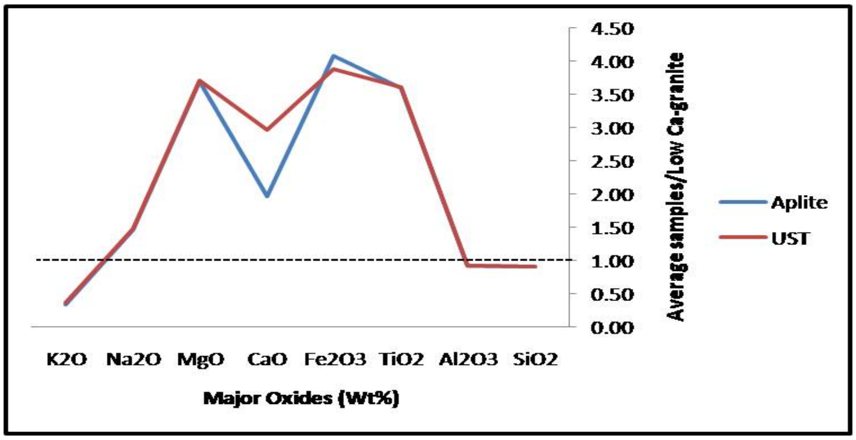
Table 3: Average chemical composition of the studied units of pegmatitic-aplite dyke and metaschist.

Major Elments (Oxides wt%)													
Sample Type	**SiO_2**	**Al_2O_3**	**TiO_2**	**Fe_2O_3**	**CaO**	**MgO**	**Na_2O**	**K_2O**	**P_2O_5**	**$110^{o}C$**	**$1000^{o}C$**	**K/Rb**	**K/Ba**
Aplite	**67.71**	**12.53**	**0.72**	**7.8**	**1.40**	**1**	**5.12**	**1.7**	**0.02**	**0.44**	**1.2**	**148.42**	**34.31**
UST	**67.37**	**12.52**	**0.72**	**7.4**	**2.1**	**1**	**5.12**	**1.83**	**0.15**	**0.19**	**0.71**	**99.3**	**37.8**
Meta schist	**49.96**	**11.40**	**3.29**	**15.98**	**4.20**	**2.00**	**5.40**	**1.39**	**1.74**	**0.30**	**3.24**	**206.1**	**9.3**

Trace Elements (ppm)													
Sample Type	**Cr**	**Ni**	**Cu**	**Zn**	**Zr**	**Rb**	**Y**	**Ba**	**Pb**	**Sr**	**Ga**	**V**	**Nb**
Aplite	**92**	**13.5**	**12.5**	**58**	**85.5**	**47.5**	**42**	**205.5**	**29**	**4**	**8**	**4**	**15**
UST	**106.5**	**11.5**	**8**	**70.5**	**147**	**71**	**63.5**	**186.5**	**14.5**	**7**	**9**	**3**	**25**
Meta-Schist	**82**	**6**	**32**	**48**	**36**	**28**	**3**	**620**	**13**	**55**	**8**	**30**	**2**

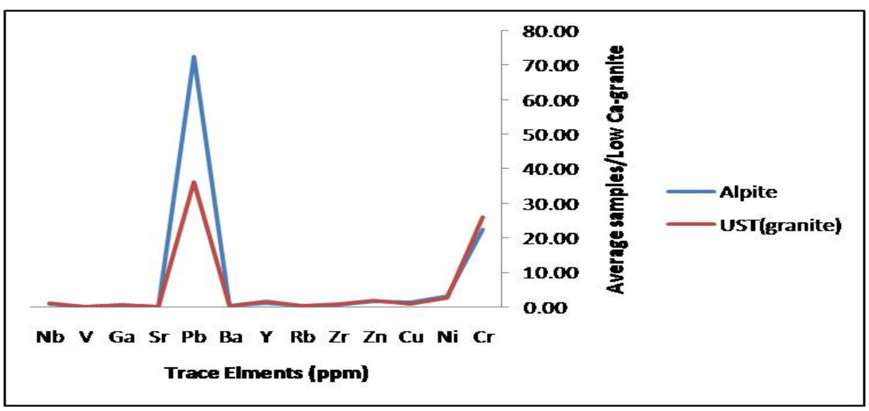
The examination of table 3 demonstrates a summary of the results of the chemical analyses of all the analysed rock types. The two pegmatitic– aplite units (UST and aplite) of the Rimarim suite have a felsic character documented by respective major averages contents of SiO_2 (67.37, 67.71wt. %) and Al_2O_3 (12.52, 12.53), high average contents of Na_2O (5.12, 5.12) and Fe_2O_3 (7.4, 7.8), moderate concentrations of CaO(2.1, 1.4), MgO(1, 1) and TiO_2(0.72, 0.72), slightly low concentrations of K_2O(1.83, 1.7).

Fig. 8: Primordial CI Chondrite-normalized by K.K.Turekian, K.H.Wedepohl(1961) diagram of average major oxides (wt%) for two zone types at pegmatitic-alpite dyke.



Meanwhile the two units have respective high averages concentrations of the trace elements described as Cr (106.5, 92) and Pb (14.5, 29). The respective ratios reveal low K/Rb (99.31, 48.42) and K/Ba (37.8, 34.31) ratios reflect the degree of fractionation of pegmatites -aplite rocks. The volatile investigations were only restricted to calcalution of P from analyzed P_2O_5 giving respective averages of (330, 40 ppm). In spite of content of calculated P from P_2O_5 at metaschist is 3798.6 ppm.

Fig. 9: Primordial CI Chondrite-normalized by K.K.Turekian, K.H.Wedepohl(1961)diagram of average trace elements for two zone types at pegmatitic-alpite dyke.



In order to investigate the tectonic setting of the two units forming the pegmatites-aplite dyke, two tests were applied to their chemical analyses. The first test was applied by introducing the relevant values of Rb–(Y+ Nb), Nb–Y diagrams for discriminating the tectonic setting of granites (Pearce et al. 1984). This process is illustrated in (Fig. 10a) and indicates that the UST values lie in WPG (Within-Plate Granites) region meanwhile aplite values lie in VAG (Volcanic Arc Granites) region.The second test was applied by introducing the values of Y, Nb and Ga×3 in the triangle (Eby 1992; Fig. 10b) which indicates that the

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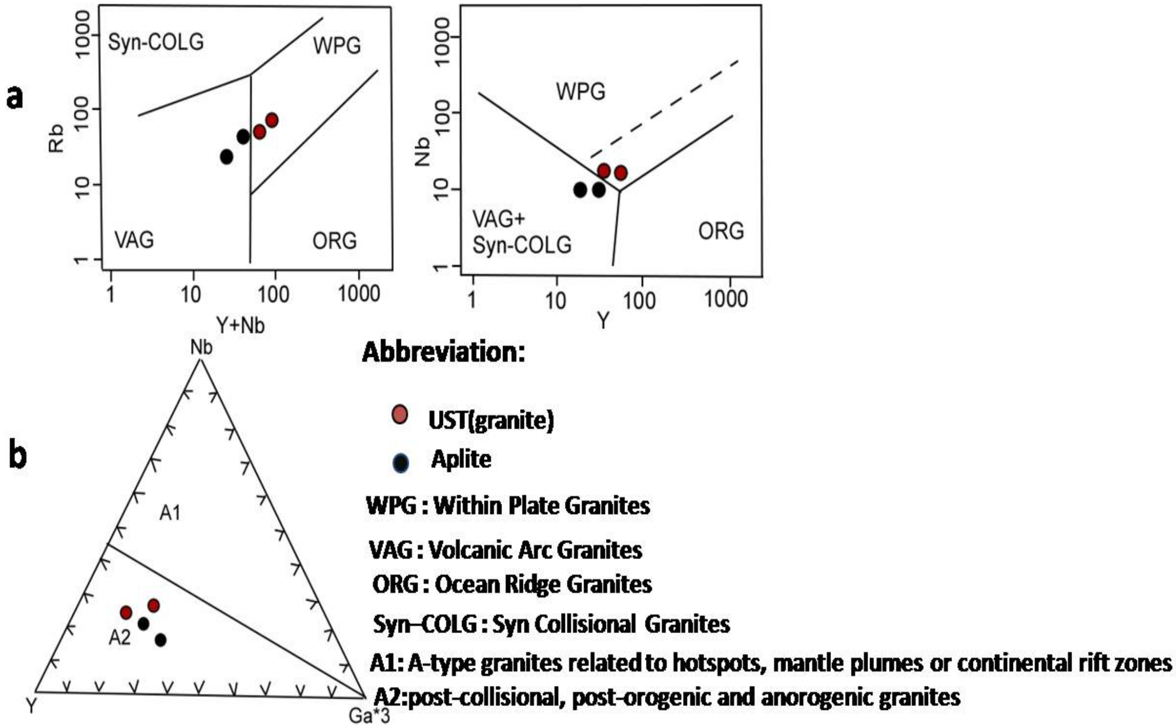
two units of aplite-pegmatite dyke lie into the region of post-collisional, post-orogenic and anorogenic A-type granites.

Fig. 10: Diagrams showing the investigations of the two units of the pegmatitic –aplite dyke; (a) using the Rb–(Y+ Nb), Nb–Y diagrams for discriminating the tectonic setting of granites (Pearce et al. 1984), (b) Triangular Nb–Y–Ga×3 plot for classifcation of A-type granitoids



(Eby 1992),).

6- Discussion:

In comparison with several global models which explained magmatic layering and problems with the genetic interpretations of the layered textures persist. The most reliable scenario for the development of this phenomenon as collected from the international literature is discussed hereafter considering their chronological sequence.

This phenomenon was first discussed as hypothesis invoking segregation and crystallization at supersaturated boundary and published by Jahns and Tuttle (1963). However, Parsons 1987 indicated that gravitational crystal-settling model used for explanation of the layering in the mafic magmatic rock seems problematic in granitic systems because of the higher magma viscosity and the smaller density difference between crystals and the acid melt. In addition, Hort et al. (1993) considered the role of oscillatory nucleation in the origin of layered and cumulate like textures, associated with convection within the melt. In their model, continued growth eventually leads to gravitational settling of layered textures on the floor of the intrusion body. The scenarios based on undercooling and rapid, multistage, non-equilibrium crystallization from H_2O saturated melt currently dominate (London 1992; Webber et al. 1999; Balashov 2000; Breiter et al. 2005). London (1992) suggested that repetitive layers in aplite– pegmatite originated in the system far from crystal–melt equilibrium. This is well documented by different textures and chemical composition of the individual layers. The emplacement environment of these layered bodies is also relevant as is their common volatile over/supersaturation during crystal nucleation and growth (Morgan and London 1999).

According to London (1992), nucleation rate of quartz and plagioclase at the same degree of undercooling (and in the same crystallizing zones) was much higher than that of K-feldspar, which enabled growth of large K-feldspar crystals associated with small plagioclase and quartz grains. Cox et al. (1996) proposed that formation of large K-feldspar crystals can be explained by lower nucleation rate in a water-rich melt. Not only melt saturation by volatiles is important for UST formation.

Webber et al. (1999) constructed conductive cooling models of four aplite–pegmatite dykes with layered textures in the Southern California. Rapid cooling may have resulted in relatively rapid nucleation and growth of albite, K-feldspar, quartz and facilitated development of UST zones. Repetition of garnet-rich zones can be explained by oscillatory crystallization at the chemical boundary front where the saturation of essential elements repeatedly occurred.Bogoch et al. (1997) suggested that stripes of garnet could result from hydrofracturing of the partially crystallized magma by volatiles (especially by H_2O vapor) followed by garnet crystallization. However, it is probable that H_2O-enriched minerals such as micas would have to crystallize along the ruptures.

The last hypothesis “swinging eutectic” (Balashov et al. 2000) may satisfactorily explain the presence of repetitive UST zones in layered aplite–pegmatite dykes. This suggests that abrupt adiabatic drop in pressure caused by opening of the system (e.g. by sudden escape of fluids) during crystallization may also lead to undercooling and formation of the UST zones. Subsequent pressure increase restored normal (fine-grained) crystallization of aplite. Fluid pressure oscillation due to episodic degassing is also important in this model.

The origin of all mentioned subvolcanic intrusion is unknown and their emplacement and formation could be related to so far undisclosed magma bodies and/or heat source that might have caused melting of the crustal rocks and generate the intrusions.

The previous discussion reveals that the most similar global example to Rimarim dykes is that investigated by Balashov et al. 2000 when dealt with pegmatitic-aplite dykes. Up to my knowledge, the studied dykes are the first case that aquire this phenomenon in the Nubian shield. Previous field observations have also recorded this phenomenon in limited geological (granitic) occurrences in the Eastern Desert of Egypt (e.g. Um Eldebaa and Hmr Akarem) but did not provide any petrographical and/or geochemical explanations (Hasan, 2015).

7. Summary and Conclusions:

The pegmatitic -aplite dykes of Rimarim area with locally developed UST (unidirectional solidification textures) are obviously considered within plate granite, meanwhile the aplite unit is considered volcanic arc granite. Geochemical and mineralogical features of the aplite–pegmatites are characterized by (1)peraluminous, subalkaline chemistry and A-type affinity, (2)occurrence of specific accessory minerals including garnet and (3)a remarkable absence of micas and other minerals with volatiles (B, F, P and also H_2O). The studied suite differs from all other granitic rocks with UST described to date, which are typically characterized by volatile-bearing minerals.

The Rimarim aplite–pegmatites dykes exhibit several characteristic geochemical features. (i) A-type affnity is indicated by Fe >> Mg, moderate contents of Y and Zr, low P_2O_5 and subalkaline signature. (ii) Low contents of volatiles such as P (40-330 ppm) and probably also H_2O are manifested by scarcity of volatiles-bearing minerals, in particular micas, although alterations present locally in host metasediments indicate that some fluids (chiefy H_2O and P) were released from aplite–pegmatite bodies. (iii) Degree of fractionation of UST and aplite units are reflected by respective low K/Rb (99.31, 48.42) and K/Ba (37.8–34.31), very low content of MgO (1-1 %).

Based on all available data, the following evolutionary model was developed that crystallisation of pegmatitic-aplite dykes at Rimarim area proceded in closed-system conditions from the bottom upward. Volatiles and exsolved bubbles of water-rich fluid migrated to the upper- most part of the dykes. When the pressure of exsolved water overcame the lithostatic pressure and cohesion of surrounding rocks, the system opened. Propagation of existing cracks or opening of new cracks started. Vapour escaped and the adiabatic decrease in pressure resulted in sudden decrease in temperature. The UST crystallised (comb texture) from the undercooled melt. This process was repeated several times. Nonequilibrium crystallisation in layered rock produced small domains with contrasting chemistry and finally very small amounts of liquids of unusual composition.

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