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CHARACTERIZATION OF ABU KHRUQ NEPHELINE SYENITE AND ITS COMPENSATION WITH SODA-LIME-GLASS FOR PREPARATION OF GLASS-CERAMIC

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ABSTRACT

The Abu Khruq ring complex (ARC) is located in the Southern Eastern Desert of Egypt. It is composed mainly of nepheline syenite, syenite and quartz syenite. Petrographical and chemical analysis (XRF) were achieved to identify the mineral composition and to define the nature of the various rock types present in the area.

Geochemically, the different types of alkaline syenitic rocks from margin and the center of the ring show decrease of Na_2O and enrichment of SiO_2 toward the margin. The syenitic rocks have a considerable value of Al_2O_3 (12.8 - 17.3 wt. %) and total alkalis are above 8.5 wt.% which might indicate magma developed from deep crustal source of mixed material from the mantle. According to plate tectonic theory, the different types of syenitic rocks placed in within plate anorogenic belts.

Sintered glass-ceramic was prepared from local nepheline syenite with soda-lime-silicate glass. B_2O_3 added to the glass batches to decrease the melting temperature as well as the glass melt viscosity. MgF_2 and CaF_2 were added to the glass batches as nucleation catalysts. Little nepheline, augite, xonotlite and fluorite were developed in the samples after sintering process. Very little or traces of nepheline was formed in boron-free and -containing sample. Although MgF_2 enhance augitic pyroxene, CaF_2 appropriate the formation of xonotlite. In all samples nano- and micro-size rods were developed in the glassy matrix. The Vickers microhardness and densities values were between ~ 396.5 to 676.2 kg/mm^2 and ~ 2.14 to 2.52 g/cm^3, respectively. The produced glass-ceramic can be used in building materials.

Keywords: Raw material, glass ceramics, xonotlite and augite.

INTRODUCTION

Ring complexes in Egypt generally evolved during Phanerozoic age (550– 80 Ma), which can be classified to four groups, the first one emplaced during Paleocene (550 – 313 Ma), the second evolved during Permo-Triassic age (230 – 200 Ma), the third one occurred at late Jurassic-Early Cretaceous age (160 – 120 Ma), and the last one of Late Cretaceous ago (110– 80 Ma) (Serecsists et al. 1979; Hashad and El Reedy 1979; Meneisy and Kreuzer 1974). El Ramly and Hussein (1985) classified the ring complexes, on the basis of variety of rocks, their magmatic differentiation and on the degree of development of the ring nature and complexity of the structure, into five type groups: 1- Abu Khruq ring complex, 2- Gezira ring complex, 3- Mishbeh ring complex, 4- Mansouri ring complex, 5- Tarbtie ring complex.

Abu Khruq ring complex includes volcanic rocks and sub-volcanic intrusions forming number of incomplete ring dykes of various alkaline syenites in addition to cones, sheets and stock-like bodies of nepheline syenites. These types are found in Gebel Abu Khruq, El Naga, El Kahfa and Nigrub.

Abu Khruq ring complex represented the main type of alkaline rocks in Egypt, which belongs to the latest group in Late Cretaceous (89 ± 2 Ma ago) (Lutz et al. 1988). This ring complex consists of a wide variety of rocks including syenitic rocks and their volcanic equivalent. Their rocks range between under-saturated to over- saturated with clear alkaline affinities (El Ramly and Hussein 1982 and 1985; El Afandy et al. 2012 and Mogahed, 2016).

These rocks are considered as natural raw materials to be exploited in glass ceramic production. In contemporary years, syenites and nepheline syenite have been used gainful in manufacture of glass ceramics because of achieving mechanical and chemical properties.

Glass ceramic is a polycrystalline material produced throughout the heat-treatment of pre- prepared glass. There are many types of parameters which control development of crystalline phases and fabric of microstructures. These parameters are chemical composition, nucleating agents, heat-treatment, developed phases, etc. The controlled crystallization may be depended on efficient nucleation (Aitken and Beall, 1994). The properties of glass ceramics are defined by the inherent features and the microstructures resulting from the nucleation and growth processes (Beall, 1989). The purpose of influential nucleating agent has permitted the development of greatly crystalline material of widespread industrial application (McMillan, 1979). Pyroxenes and feldspathoids are most desirable mineral phases, developed in Na_2O-K_2O-CaO-Fe_2O_3-Al_2O_3-SiO_2 glasses due to their interesting properties (Hamzawy and Khater, 2005). The fluorspar or CaF_2 can facilitate the development of aluminum silicate glass ceramics with fine grained microstructure (Salama, et al., 2002). Also, fluorspar improves initial crystallization of aluminum silicate glass system by lowering both of crystallization peak temperature and activation energy (Mukherjee, and Das, 2012). On the other hand, MgF_2 promote initial crystallization of Li-Al_2O_3-SiO_2 system and diffusion in this glass (An-Min, et al., 2004).

GEOLOGICAL SETTING

Abu Khruq Complex is located between latitudes 24°38′10″ and 24°41′15″ N in the Southern Eastern Desert, about 60 Km far from Wadi El-Gemal protected area. This area looks like dissected elliptical two rings with diameter 4 Km. Gabal Abu Khruq represent alkaline rock type in two form, extrusive and intrusive rocks which had been formed from about 89 million years ago (Fig. 1). These two types consist of alkaline trachyte and rhyolitic porphyry as extrusive type at the center of the ring followed by alkaline gabbroic and syenitic rocks comprises oversaturated to under-saturated syenites. The form of these rocks is diverse in shape as dissected ring, cone, sheets and stock like bodies (El Ramly, et al., 1969 and El Afandy, et al., 2012). The lithologies created at the same time and place as another consequently they are represented as indistinguishable ages in this area (El Afandy and Abdalla, 2001).

PETROGRAPHY

The studied syenitic rocks of Abu Khruq ring complex is intervened into Late Proterozoic Pan African country rocks. Generally, Mineral proportions permit the rocks to be classified into under-saturated composition, transitional to be over-saturated for the alkaline rocks of Abu Khruq ring complex area.

Syenites are medium to coarse grained massive bodies that were affected by alteration processes on the surface. They are distinguished in the field by its grayish to pinkish white color. Microscopically, they mainly consist of perthitic orthoclase, albite, ageirine and ageirine-augite with minutes of opaque minerals as iron oxide as well as zircon and apatite. They have some of quartz less than 5%. Alkali feldspar occurred as euhedral to subhedral lathes perthite with diverse size, albitic plagioclase detected as small prismatic subhedral grained and mafic minerals are including aegirine and aegirine-augite which are found as aggregated associated with minutes of iron oxides and closed to perthitic lathes.

Quartz Syenites are generally similar to syenites as massive and sometimes showed altered surfaces except they have a higher proportion of modal quartz by 10%. They are clearly showed affected by shear forces. Petrographically, they are composed of elongated subhedral to anhedral crystals of alkali feldspar perthite, albitic plagioclase, quartz, aegirine-augite and alkali amphibole. In addition to, minor mounts of zircon and opaque minerals. Quartz occurred as anhedral grained and sometimes associated with alkali feldspar to form graphic texture. Aegirine-augite and alkali amphibole are detected subhedral crystals associated iron oxides and heavy minerals as zircon, which enclosed by perthite lathes.

Nepheline Syenites occurred as hard, massive and ellipsoidal in the field with grayish white in color. Petrographically, they consist of medium to coarse grained, composed of lathes of alkali feldspar perthite, albite, nepheline, aegirine-augite and biotite with minutes of analcite, concrinite and accessory minerals. Generally, they show an equigranular hypidiomorphic texture. Nepheline crystals usually occurred interfered with perthitic lathes, and sometimes altered to muscovite pseudomorphous. Aegirine-augite occurred as subhedral crystals. Perthitic orthoclase occurred in small prismatic subhedral grained usually show Carlsbad twins.

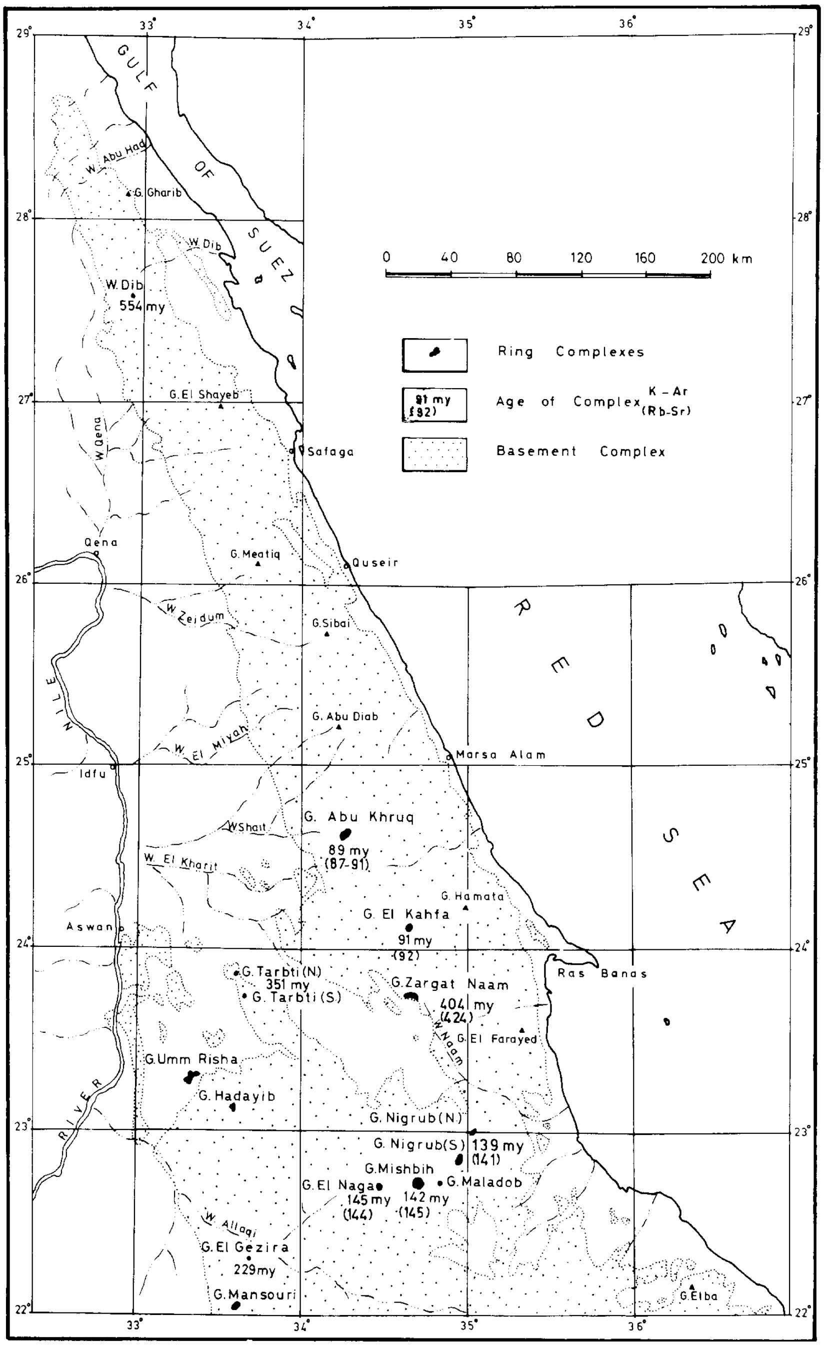


Fig. 1: Ring complexes in the Eastern Desert of Egypt (After El Ramly and Hussein, 1985).

GEOCHEMISTRY

Seven samples were selected from different types of syenites of Abu Khruq Complex for chemical analysis of major oxides and trace elements using XRF technique in the Central laboratories of the Geological Survey of Egypt. The results with CIPW normative are listed in Table 1.

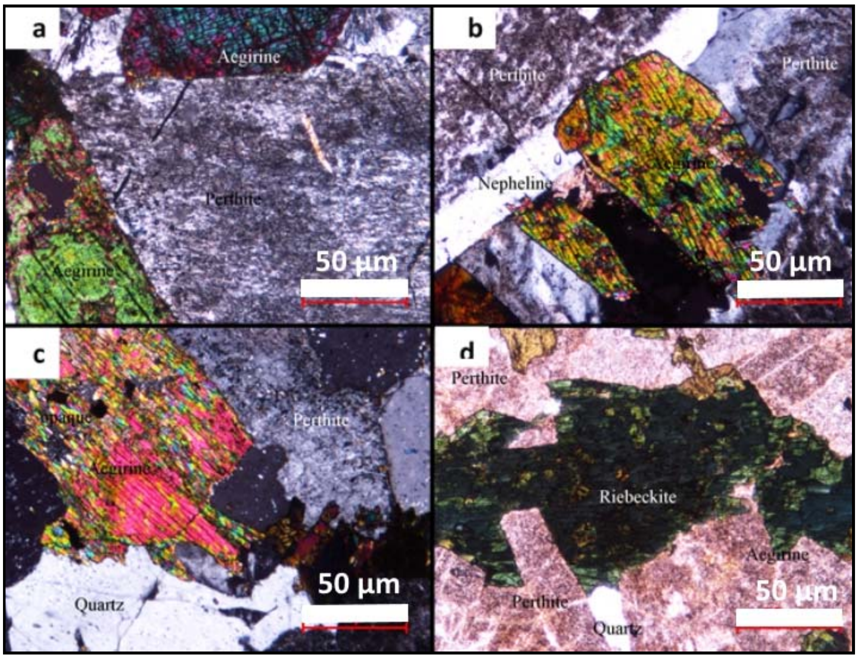


Fig. 2: Photomicrographs of Abu Khruq syenites: a- Phenocrysts of aegirine in Syenite with inclusions of opaque, and laths of perthitic orthoclase, C.N. b- Phenocrysts of aegirine, nepheline and orthoclase perthitic laths, in nepheline syenite C. N. c- Quartz Syenite with quartz phenocrysts, aegirine and perthitic alkali feldspar, C.N. D- Phenocryst of riebeckite, aegirine as well as perthitic alkali feldsparin syenite, PPL.

Table 1: Major and trace elements of alkaline samples.

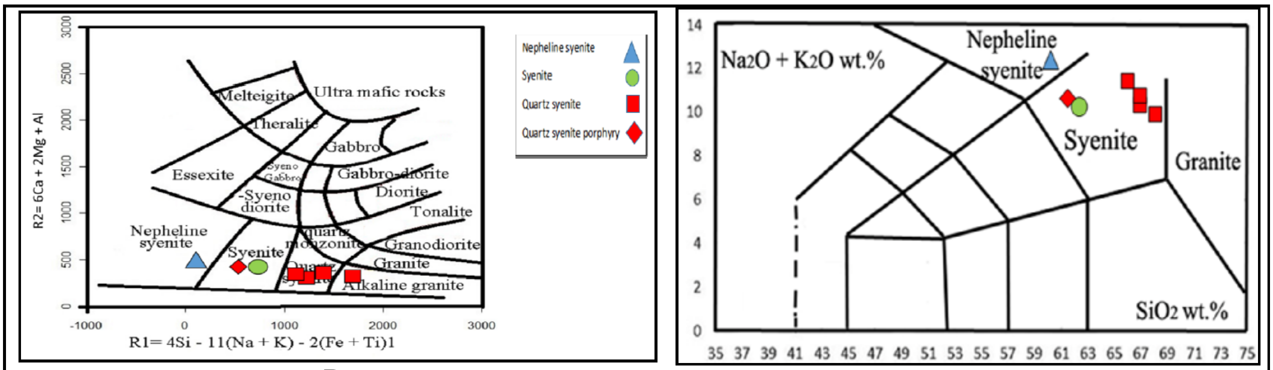
Sample	Nepheline syenite	Syenite	Quartz Syenite porphyry	Quartz syenite			
Major oxides							
SiO_2	59.62	62.52	61.95	66.42	67.49	67.52	68.03
TiO_2	0.27	0.81	0.38	0.34	0.34	0.71	0.4
Al_2O_3	17.3	15.52	15.52	14.7	14.25	12.83	13.3
Fe_2O_3	6.67	7.91	7.48	5.59	6.04	8.11	6.15
MnO	0.24	0.29	0.21	0.17	0.13	0.12	0.22
MgO	<0.01	<0.01	<0.01	0.32	<0.01	<0.01	<0.01
CaO	1.1	0.64	1.05	0.48	0.59	0.3	0.97
Na_2O	5.9	6.32	5.87	5.36	6.63	4.79	4.14
K_2O	6.5	4.50	5.29	5.61	3.57	5.03	4.85
P_2O_5	0.04	0.04	0.19	<0.01	<0.01	0.02	<0.01
LOI	2.07	1.32	1.57	0.5	0.63	0.2	1.35
Total	59.62	62.52	61.95	66.42	67.49	67.52	68.03
Trace elements							
V	17.4	40.6	21.7	24.5	26.7	31.5	24.6
Cr	36.3	35.3	46.9	55.4	36.2	47.2	45.5
Ni	14.8	17.4	19.5	22.8	17.1	18.9	20.7
Cu	3.9	2.4	4.9	3.6	4.3	<2.0	<2.0
Zn	186.7	233.8	174.0	158.9	149.0	147.9	263.8
Co	17.2	24.7	15.4	13.0	14.6	22.2	17.4
Ga	34.5	38.0	34.8	36.6	37.2	38.4	39.6
Rb	140.6	82.9	108.2	120.1	79.8	95.1	133.3
Sr	36.9	50.9	79.9	17.6	120.4	29.2	40.5
Y	96.7	72.9	78.8	107.5	46.6	60.0	159.0
Zr	1392.5	645.1	979.1	1297.4	616.9	563.0	1397.4
Nb	148.5	97.4	112.8	86.7	63.5	63.8	148.8
Ba	13.8	339.8	358.2	148.1	1060.6	337.3	388.6
La	190.9	108.2	139.9	112.5	88.2	90.9	148.1
Yb	4.7	4.3	9.6	11.3	<2.0	5.7	15.2
Ta	2.5	2.5	2.3	2.2	2.1	2.2	2.5
Pb	14.9	10.3	14.4	17.8	11.2	9.6	11.8
Th	34.2	17.1	23.9	26.6	12.5	5.8	32.8

Classification of alkaline rock samples

De La Roche et al. (1980) proposed a chemical classification of intrusive rocks based on R_1 = 4Si-11 (Na+K) - 2(Fe+Ti) versus R_2 = 6Ca +2Mg +Al binary diagram (Fig. 3a). The figure shows that quartz syenite samples plot within quartz syenite field except one sample was shifted to alkali granite field due to increasing amount of normative quartz, whereas syenite samples plot within syenite field and nepheline syenite fall in nepheline syenite field. According to classification of **Le Maitre (1989)** based on SiO_2 versus Na_2O+K_2O wt. %, all samples are plotted in syenite field except on sample located at nepheline syenite field (Fig. 3b).

Magma Type

MacDonald (1968) illustrated type of magma is alkaline or sub-alkaline based on SiO_2 versus total alkali (Na_2O+K_2O) binary diagram (Fig. 4a). All selected samples plot in alkaline field to distinguish type of origin these rocks came from alkaline origin. On the binary diagram (Fig. 4b) of ANK versus ANCK for Maniar and Piccoli (1989). All samples are located within per-alkaline to very slightly metaluminous field. Wright (1969) determined magma type according to alkalinity ratio versus SiO_2. Samples fall within range between strong alkaline to per-alkaline fields (Fig. 4c). On Al_2O_3- Na_2O-K_2O ternary diagram proposed type of origin magma. Selected sample is located at the range between strongly alkaline (per-aluminous) to peralkaline (Fig. 4d). All samples of Abu Khruq fall within the peraluminous field in a ternary diagram Shand (1951) (Fig.4e) however absence of normative corundum besides, the presence of acmite is attributed to the secondary alkali enrichments. Therefore, Lameyre (1974) suggested that the increasing of alkali and decreasing of alumina cause the presence of normative acmite.



B A

Fig. 3: Classification of Abu Khruq syenitic rock samples. A. R1-R2 nomenclature diagram (de la Roche et al. 1980). B- SiO_2- Na_2O+K_2O (wt. %) nomenclature diagram of Le Maitre 1989.

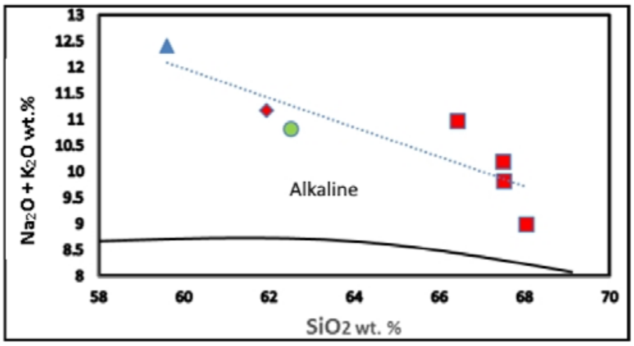


Fig. 4a: Alkali-silica diagram of Irvine and Baragar (1971).

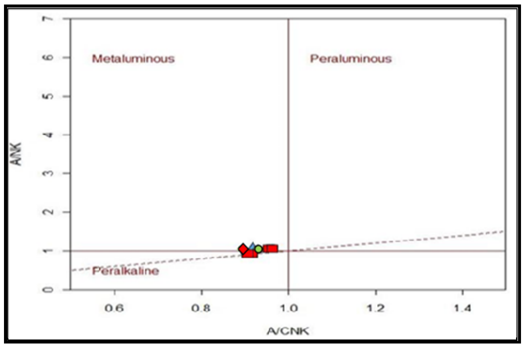


Fig. 4b: A/CNK versus A/NK diagram (After Maniar and Piccoli, 1989).

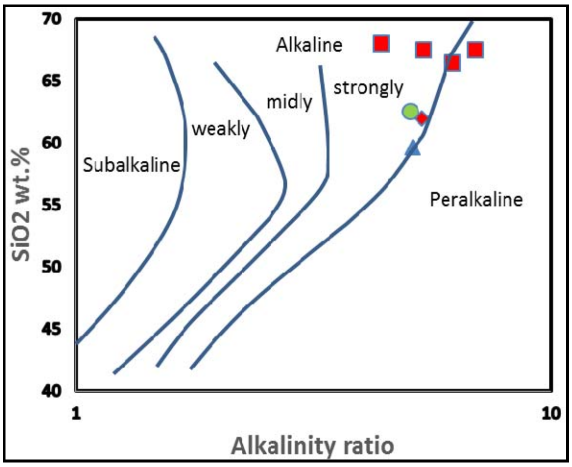


Fig. 4c: Alkalinity ratio diagram of Wright (1969).

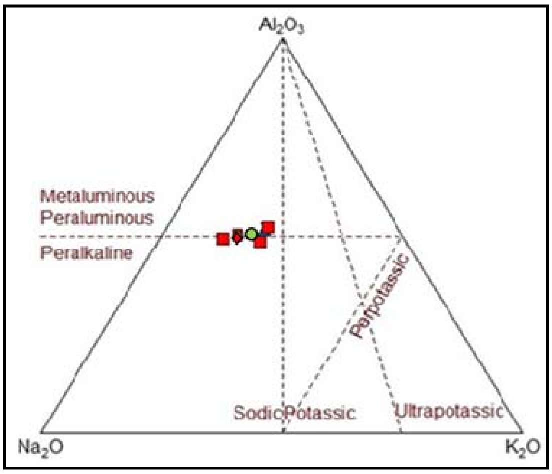


Fig. 4d: Molar Na_2O-Al_2O_3-K_2O diagram for the studied alkaline rocks (after Bonin, 1974).

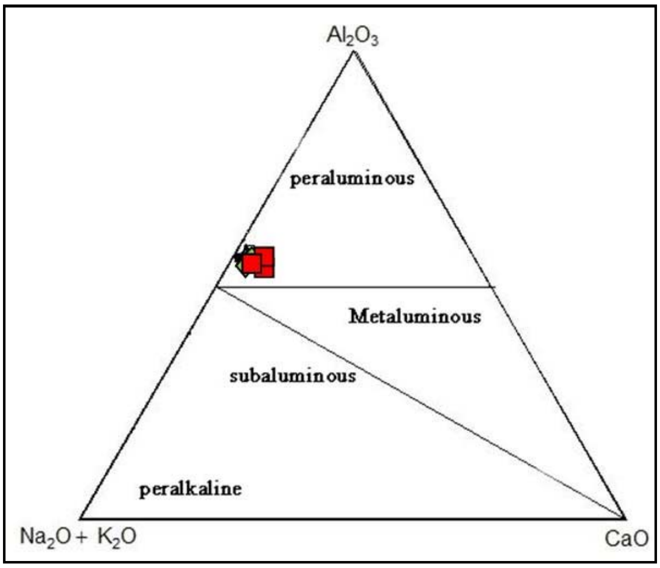


Fig.4e: Al_2O_3-Na_2O+K_2O-CaO ternary diagram of Shand (1951).

On the binary diagram of Y-Nb and (Y+Nb)-Rb of Pearce et al. (1984), all samples are located at within plate field (Fig. 5a and b), which is in accordance with the anorogenic affinities as revealed by R1-R2 diagram (Batchelor and Bowden 1985) (Fig. 5c).

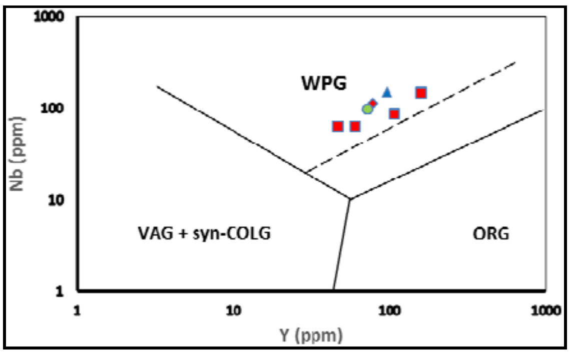


Fig. 5a: Y versus Nb diagram of Pearce et al. (1984).

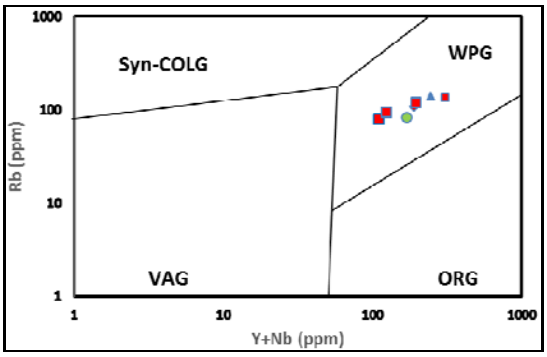


Fig. 5b: Y+Nb versus Rb diagram of Pearce et al. (1984).

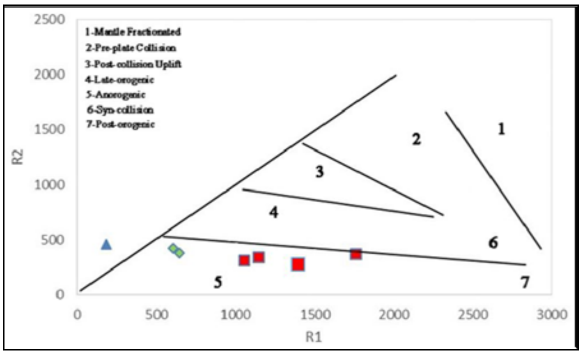


Fig. 4i: R1-R2 diagram of Batchelor and Bowden (1985).

Based on the chondrite-normalized trace elements by Thompson, et al. (1984) diagram, the alkaline rocks of Abu Khruq exhibit enrichment of LIL element Nb, Y and Zr and, depletion in Rb and Sr (Fig. 6).

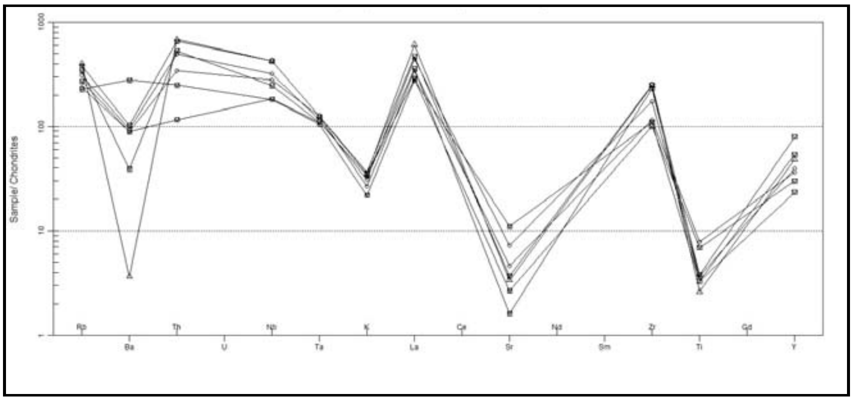


Fig.6: Primordial mantel-Spider diagram of Thompson, et al. (1984).

Material and Experimental methods for glass ceramics

In Abu Khruq area, Syenites raw materials have different grades according to the iron ratio. In the present work the low iron ratio syenites-mix was used. The starting materials of the batches were low iron nepheline syenite and soda-lime-silica glass and the chemical composition of raw material are mentioned in table (2). Boric acid was added as source of B_2O_3 as flux to lower the melting temperature. Also, MgF_2 and CaF_2 were added as nucleating agents in different ratio (Table 3). The weighed batches were mixed in a laboratory size ball mill and put in platinum crucible for melting process in a temperature range 1450-1500 ºC for 2 hours. Glass frits were crushed and ground up to (<0.053 mm), and was uniaxially compressed to pellet in a hydraulic operated pellet press at 20 KN. Pellets were divided and putted in muffle furnace for an sintering process at 750, 800, 850, 900 and 950 ºC for 2 hours separately.

Table 2: Chemical composition of the raw materials (wt. %)

Raw material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	LOI**
Syenitic rock	65.51	15.1	5.98	0.7233	trace	5.093	5.773	0.31	1.07
SLSG*	73.73	1.202	0.068	10.73	0.02	0.014	13.76	0.029	-

* SLSG: Soda-Lime - Silicate Glass ** LOI: Loss On Ignition

For crystalline phases identification, x-ray diffraction analysis were performed with Burkur AXS X-ray Diffractometer using the monochromatic Cu Kα1 line (λ = 1.54056 Å). The microstructure with microanalysis was determined by scanning electron microscope (SEM/EDX SEM Model Quanta 250, Holland). Density is obtained for some selected samples using quantachrome (Upyc 1200e V5.03) by helium gas, and Archimeds method. Vickers microhardness value (model HV-1000 Micro Hardness Tester) was obtained using load 100 g and time with 15 second.

Table 3: Batch constituents with additives H_3BO_3, MgF_2 and CaF_2.

Sample No.	Molar ratio				
	Raw Material		Additives		
	Ne Sy*	SLSG**	Boric acid H_3BO_3	MgF_2	CaF_2
B-free	50	50	-	-	-
B-con	50	50	5	-	-
2-MgF2	50	50	5	3	-
3-MgF2	50	50	5	5	-
4-CaF2	50	50	5	-	3
5-CaF2	50	50	5	-	5
*Ne Sy: Nepheline Syenitic rock **SLSG: Soda-Lime-Silica-Glass					

Result and discussion

X-ray diffraction analysis

The developed crystalline phases after heat treatment at 800, 850, 900 and 950ºC for 2h have been identified for some selected samples (B-free, B-containing, 2-MgF_2, 3-MgF_2, 4-CaF_2 and 5-CaF_2). Crystallization of nepheline ((K, Na) $AlSiO_4$) with a hump were detected in B-free and B-containing specimens at 800ºC (Fig. 7 and 8). The nepheline indexed peaks were at 2.988, 3.834, 3.271, 2.324, 2.885, 3.00, 2.57, 3.266 Å (JCPDS file no. 88-1231). In 2-MgF_2 and 3-MgF_2 specimens, heat-treated within 800 and 950 °C, augite **$(Ca_{0.61}Na_{0.25}Fe_{0.07}Mg_{0.07})(Mg_{0.65}Fe_{0.1})Al_{0.22}\ Si_2O_6)$** were identified with an amorphous hump (Fig. 8). On the other hand, in 4-CaF_2 and 5-CaF_2 specimens, heat treated within the previous temperature, xonotlite **$(Ca, Na)_6\ Si_6O_{17}(F)_2)$** was developed with a low amorphous hump (Fig. 8). In general, the intensity of x-ray lines increases with increasing of the heat-treatments parameter from 800 to 950°C (compare Fig. 8). Due to the high ratio of SiO_2 and Al_2O_3 which cause relatively high viscosity and sluggish mobility of cations at lower temperature that lead to the persistence of amorphous without change and an amorphous hump were detected. However, in literature alumina and silica in the glass batches are effective in rising the viscosity of the glass due to formation of SiO_4 and AlO_4 polymorphs which effect on the network strength of the glass structure (MacDowell, 1990). Both MgF_2 and CaF_2 have a different effect on the sintering process and the crystallization behavior. MgF_2 facilities the crystallization of augite while CaF_2 additive affected on the crystallization of fluor-amphibole (xonotlite).

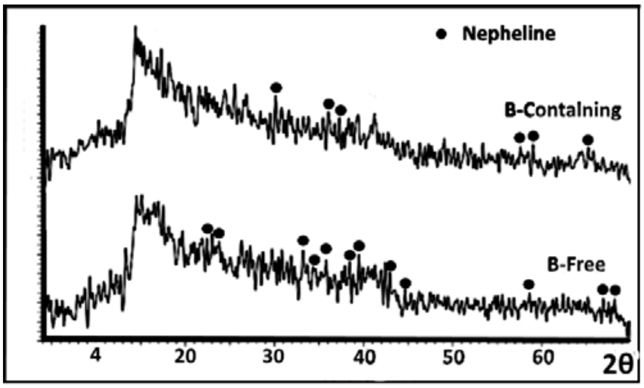


Fig. 7: XRD patterns of B-free and B-containing glasses heat treated at 800^0C/2h.

Looking to the developed crystalline phases, although nepheline has been reported to be composed mainly **$NaAlSiO_4$**, it can accept considerable amount of Ca, K and Fe (Kimura, and Ikeda, 1995). Also, augite can accept many cations in its structure such as Na^+ and, Fe^{+2}, Fe^{+3}, Mn, Ti and Al^{+3} (Klein, and Hurlbut, 1993), Crystallization of xonotlite was enhanced in CaF_2-containing samples. Crystallization of xonotlite was enhanced in CaF_2 - containing samples. Xonotlite can accept respectable amount of Fe, Na (Eberhard, et al, 1981), which is enriched in calcium and fluorine (Hamedani, et al, 2013). In general, boron lowers the melting temperature or the viscosity of glass. Fluorine not only affect in lowering viscosity but also enhancing the formation of F- containing droplet of phase separation which consider as nuclei for the subsequent crystallization process

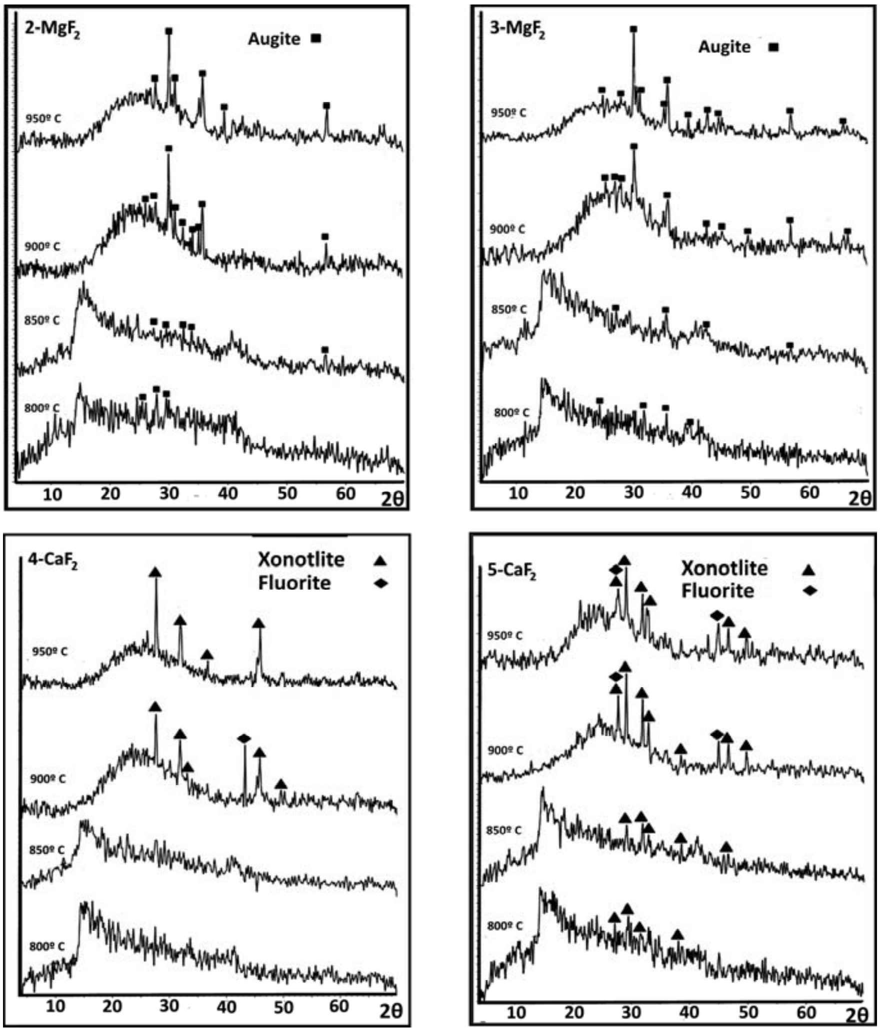


Fig. 8: XRD patterns of 2-MgF_2, 3-MgF_2, 4-CaF_2 and 5-CaF_2 glasses heat treated at 800ºC, 850ºC, 900ºC and 950ºC/2h.

SEM results

SEM photomicrographs of the sintered glass-ceramic samples heat-treated at 800ºC and 850ºC for 2 h are represented in figure 11a and b. Microstructure of the B-free glass ceramic shows prismatic shape crystals immerged in glass matrix, while in B-containing sample, an impression of prismatic shape that tend to be rod-like shape with distinct residual glass with average crystalline size in thickness (938.3 x 246.5 nm). The observation in 2-MgF_2 at 800ºC and 3-MgF_2 at 800ºC and 850ºC photographs show prismatic crystals spread in glassy matrix where they increased in size by rising of heat-treatment. The thicknesses of the later prismatic crystals were within 2.869 x 0.255µ, and 1.432 x 1.561µ, respectively. Also, prismatic-like or needle-like crystals were developed in the 4-CaF_2 at 800ºC and 5-CaF_2 at 800ºC and 850ºC specimens. Fig. 10 (a and b), the later increased prismatic crystals were in size by heat treatment. The thickness of later prismatic crystals were within 0.823 x 0.21µ, and 0.9 x 0.17µ, respectively.

Physical properties

Density and microhardness

The densities of some selected sintered glass ceramic samples are reported in Table 4. It is evident that as the amount of fluorine content increase the density decrease between (2.14-2.3 g/cm^3) while B-containing and B-free glass heat treated at 750^{0}C show higher in density (2.48 and 2.52 g/cm^3), respectively. The decrease in density may be because of the difference between density of crystalline and residual glass phase cause to lack the porosity. Consequently, density increase due to lowering in atomic mobility at 750ºC and by increasing of fluorine content lead to increase mobility, sintered process and decrease viscosity of glass (Jang and Matsubara, 2005).

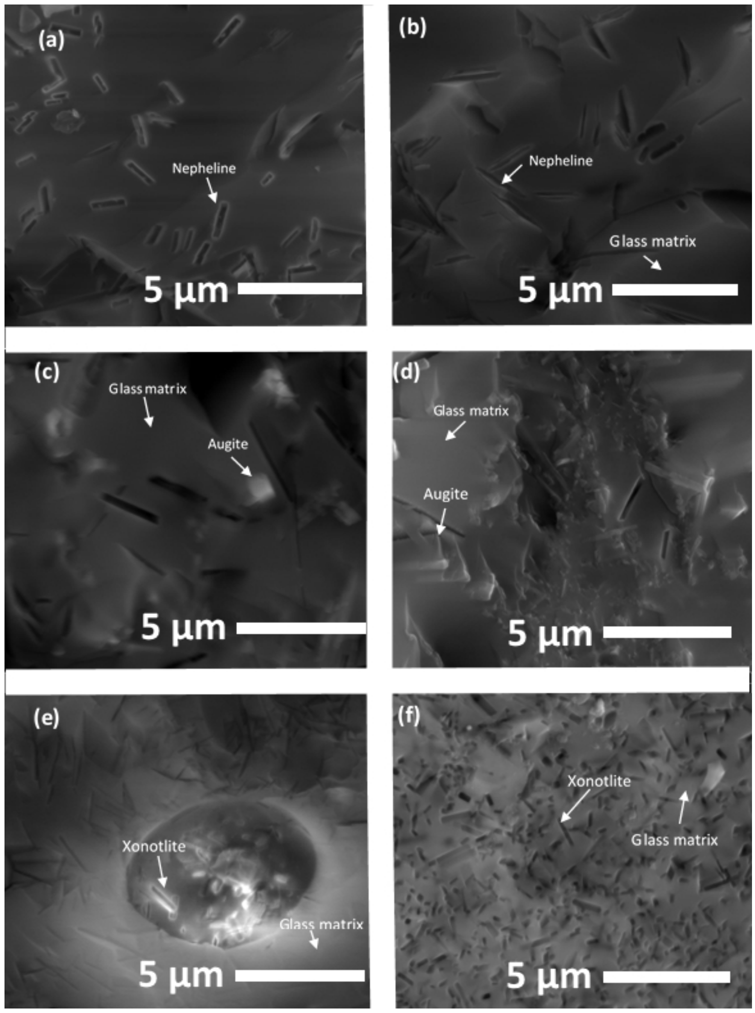


Fig. 9: SEM micrographs of (a) B-free, (b) B-content, (c) 2-MgF_2, (d) 3-MgF_2, (e) 4-CaF_2 and (f) 5-CaF_2 glasses heat treated at 800º C/2h.

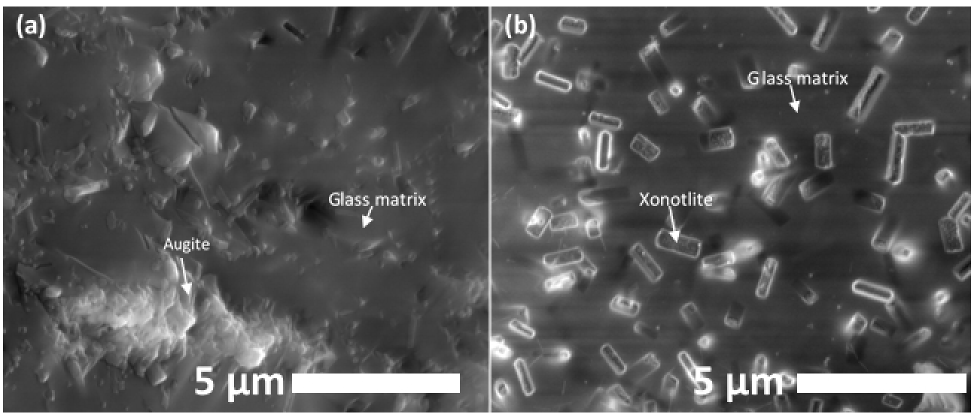


Fig. 10: SEM micrographs of (a) 3-MgF_2 and (b) 5-CaF_2 glasses heat treated at 850^{0}C/2h.

Characterization of Abu Khruq nepheline syenite

The result of the present crystalline phases was (5.5-6 Moh's scale) 650-750 kg/mm^2 for augite (Khater, et al. 2015), (5.5-6 Moh's scale) 650-750 Kg/mm^2 for nepheline (Wang, el al. 1993) and 5.5 Moh's scale for xonotlite. In the present work, the sintered B-free and B-containing glass samples at 750ºC/2h were higher than that in 2-MgF_2 and 4-CaF_2 samples at 800ºC/2h and 3-MgF_2 and 5-CaF_2 samples at 900ºC/2h. Micro-hardness values decrease by temperature of sintering accompany with crystal growth in the samples. However, many factors effect in the microhardness value such as crystal phase, residual glassy phase, porosity and their ratios in the sample. The decrease of the porosity due to the crystallization or the re-melting lead to increase the microhardness and vice versa and in our work the hardness of the surface decrease with increase in porosity in specimens (Marghussian, and Dayi Niaki, 1995; and Jang, and Matsubara, 2005).

Table 4: Microhardness and density for some selected glass ceramics.

Sample code	Heat treatment	Hv (Kg/mm^2)	Density g/cm^3
B-free	750^{o}C/2h	676.2	2.5213
B-containing		655.2	2.4815
2-MgF_2	800^{o}C/2h	466.5	2.1464
4-CaF_2		397.5	2.2333
3-MgF_2	900^{o}C/2h	396.5	2.3082
5-CaF_2		436.75	2.2192

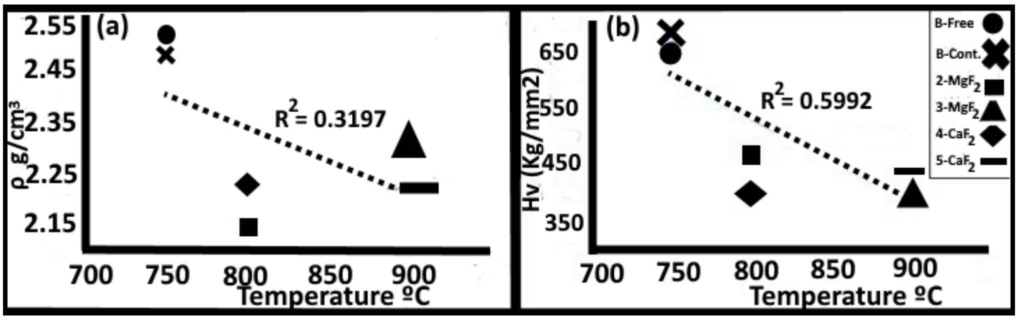


Fig. 11: a-density and b-Vickers hardness

CONCLUSIONS

Abu Khruq ring complex is made up of nepheline syenite, syenite and quartz syenite. Petrographical and Chemical analysis were achieved to define the chemical and mineral composition and to know the nature of the various rock types. The different types of alkaline syenitic rocks from outer and inner ring represent as a slightly down of Na_2O and enrichment of SiO_2 occurred toward outer ring. Also, the syenitic rocks have a consider value of Al_2O_3 (12.8 – 17.3 wt. %) and (Na_2O + K_2O) are above 8.5 wt. % which might mean developed magma from deep crustal source of mixed material from the mantle. According to plate tectonic theory, the different types of syenitic rocks placed in within plate anorogenic.

Sintered glass-ceramics were obtained from processed nepheline syenite-soda lime silicate glasses. Nepheline, augite, xonotlite and fluorite were crystallized phases through sintering process of these glasses. Fine grained microstructure was obtained in micro- and nano-sized in all sintered glass-ceramic samples, however, increase of sintering temperature lead to increase in crystal growth size and intensity of x-ray diffraction patterns. Vickers hardness was high in augite containing samples rises with blank sample at low temperature and decrease by increase amount of F^- and heat treatment.

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توصيف نيفلين سيانيت ابو خروج لتعويض زجاج الجير الصودي لتحضير السيراميك الزجاجي

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الخلاصة

تقع منطقة جبل ابو خروج بجنوب الصحراء الشرقية و تتكون من النفيلين سيانيت ، السيانيت و الكوارتز سيانيت . امكن من الدراسة البتروجرافية و التحليل الكيميائى معرفة التركيب المعدنى لمعرفة الطبيعة المختلفة للصخور الموجوده بالمنطقة .

من خلال الدراسة الجيوكيميائية تميزت الصخور السيانيتية الجوفية بزياده نسبة أكسيد الصوديوم و نقصان نسبة أكسيد السيليكون نحو الحلقة الداخلية و منتصف جبل أبو خروج ، مع نسبة عالية من اكسيد الألومنيوم (١٢.٨ –١٧.٣ كتله %) و التركيز القلوى بها أعلى من ٨.٥ كتله % وهذا يوضح نشأه المجما من القشرة على عمق كبير واختلاطها بأجزاء من الوشاح . بالنسبة للوضع التكتوني تقع الثلاث أنواع من الصخور السيانيتية المختلفة في نطاق داخلى للالواح غير المتصادمه .

تم تحضير الزجاج السيراميكى الملدن من المواد الأولية محلية طبيعية و هي النفليلن سيانيت و الكوارتز سيانيت مع اضافة حمض البوريك لخلطات الزجاج لتقليل درجة حرارة الانصهار و لزوجة صهير الزجاج . تم اضافة فلوريد الماغنسيوم و فلوريد الكالسيوم الى خلطات الزجاج كمحفز لعملية التنوه . تم تبلور النيفلين ، الأوجيت ، الزنتوليت ، الفلوريت فى العينات بعد عملية التلدين . أظهرت النتائج ان الزجاج (**B–free and B–containing**) يتبلور فيه معدن النفيلين في وسط زجاجى سليكيتى، بينما الزجاج اذي يحتوى على فلوريد الماغنسيوم يحفز تكوين معدن الاوجيت في وسط زجاجى سيليكتى ، و الزجاج الذى يحتوى على فلوريد الكالسيوم يكون معدن الزنتوليت و نسبة صغيرة من الفلورسبار في وسط زجاجى سليكيتى. و أظهرت نتائج النسيج البلورى الناتج، الذى تمت دراستة عن طريق المجهر الماسح الالكترونى أن كل العينات تحتوى على اشكال منشورية فى احجام النانو و الميكرو فى وسط زجاجى محيطه به . و قد اظهرت قيم صلادة فيكرز و الكثافة قيم ما بين ٣٩٦.٥ الى ٦٧٦.٢ كم/مم^{٢} و ٢.١٤ الى ٢.٥٢ جم/سم^{٣}، على الترتيب . خلص الباحثون الي ان الزجاج السيراميكى الناتج يمكن استخدامه فى مواد البناء .