Al-Azhar Bulletin of Science

Volume 29 | Issue 2 Article 8

12-1-2018
Section: Earth science

SUITABILITY OF FELDSPAR-SAND DEPOSITS AS RAW MATERIALS FOR THE PRODUCTION OF CERAMIC TILES AT WADI EL-YATIMA – WADI EL-TULEIA DISTRICT, CENTRAL EASTERN DESERT, EGYPT

M. El-Mezayen
Geology Department, Faculty of Science, Al-Azhar University, PO Box 11884, Nasr City, Cairo, Egypt

M. El-Desoky
Geology Department, Faculty of Science, Al-Azhar University, PO Box 11884, Nasr City, Cairo, Egypt

D. Abayazed
National Research Centre, El-Buhouth St., Dokki, Cairo 12622, Egypt

M. El-Bery
Quality Control Manager, Ceramica Cleopatra, Cairo, Egypt

Follow this and additional works at: https://absb.researchcommons.org/journal

 Part of the Life Sciences Commons

How to Cite This Article

El-Mezayen, M.; El-Desoky, M.; Abayazed, D.; and El-Bery, M. (2018) "SUITABILITY OF FELDSPAR-SAND DEPOSITS AS RAW MATERIALS FOR THE PRODUCTION OF CERAMIC TILES AT WADI EL-YATIMA – WADI EL-TULEIA DISTRICT, CENTRAL EASTERN DESERT, EGYPT," *Al-Azhar Bulletin of Science*: Vol. 29: Iss. 2, Article 8.
DOI: https://doi.org/10.21608/absb.2018.60529

This Original Article is brought to you for free and open access by Al-Azhar Bulletin of Science. It has been accepted for inclusion in Al-Azhar Bulletin of Science by an authorized editor of Al-Azhar Bulletin of Science. For more information, please contact kh_Mekheimer@azhar.edu.eg.

Al Azhar Bulletin of Science Vol. 29, No. 2 (December), 2018, pp. 19-31

SUITABILITY OF FELDSPAR-SAND DEPOSITS AS RAW MATERIALS FOR THE PRODUCTION OF CERAMIC TILES AT WADI EL-YATIMA – WADI EL-TULEIA DISTRICT, CENTRAL EASTERN DESERT, EGYPT

Ahmed M. El-Mezayen[1], Hatem M. El-Desoky[1], Salwa D. Abayazed[2], Assem M. El-Bery[3]

1. Geology Department, Faculty of Science, Al-Azhar University, PO Box 11884, Nasr City, Cairo, Egypt.
2. National Research Centre, El-Buhouth St., Dokki, Cairo 12622, Egypt.
3. Quality Control Manager, Ceramica Cleopatra, Cairo, Egypt.

ABSTRACT

The function of feldspar in ceramic bodies is that of a flux and it takes a part in physio-chemical reactions with other crystalline phases. Two formulations were studied on laboratory scale and on production simulation of tile making process, compared with standard one. The tiles made up of feldspar-sand as raw materials and fired between 1125°C (wall tile) and 1185°C (floor tiles). The properties of wall tiles were found to have the water absorption are of 13.43 - 16.25%, bulk density are of 1.65-1.68 g/cm^3, apparent porosity are of 22.24-26.82%, linear shrinkage are of 0.01-0.06%, bending strength are of 18.45-23.08 kg/cm^2 and loss on ignition are of 3.6-6.0% for wall tiles. Meanwhile, the results of floor tiles were found that the water absorption are of 0.88 - 6.76%, bulk density are of 1.67-1.69 g/cm^3, apparent porosity are of 5.11-15.17%, linear shrinkage are of 5.24-6.8%, bending strength are of 22.7-39 kg/cm^2 and loss on ignition are of 3.6-6.0%. Among the studied compositions and firing temperatures, tiles (wall & floor) made from a blend containing 29% (wall)-45% (floor) feldspar and 10% (wall) quartz, calcium carbonate 7% (wall), Aswan clay 54% (wall), ball clay 50 % (floor) and talc 5% (floor); and fired at 1125°C (wall) to 1185°C (floor), were found to have the best properties for the production of ceramic tiles. This is an indication that Wadi El-Yatima – Wadi El-Tuleia feldspar-sand deposit is suitable raw materials for the production of ceramic tiles.

Keywords: Ceramic tiles, Wadi El-Yatim, Wadi El-Tuleia, feldspar-sand, Eastern Desert, Egypt.

1. INTRODUCTION

The study area is located in the southern part of the Central Eastern Desert, Egypt, between latitudes 25°7' - 25°12'N and longitudes 34°16' - 34°22'E. The feldspar-sand covers about 60 km^2 (Fig.1). The area is reached by the Idfu - Marsa Alam asphaltic road then accessible by a desert road 5 km to the north located 70 km west Marsa Alam City on the Red Sea coast.

Demand for ceramic tiles is increasing day to day and the researchers are becoming interested in developing lucrative tiles with mechanical strength for household uses as well as for decoration purposes (**Lee and Iqbal, 2001**). Although tiles are extensively used in building structures, they are faced with problems including cracking and spalling (**Mahaboonpachai and Matsumoto, 2005).** Among ceramic floor and wall tiles, porcelain tile is one of the most important materials, in which the quantity and the quality of the clay that the body contains play a key role in the final properties of the materials. Ceramic bodies composed of mix of clays and feldspars. These products are manufactured by using high number of fluxing agents such as sodium or potassium feldspar, talc, ceramics frits together with clay, kaolin and silica sand in lesser quantity.

The clay gives plasticity to the ceramic mixture; flint or quartz (SiO_2), maintains the shape of the formed article during firing; and feldspar, serves as flux. The thermal, dielectric and mechanical properties of the products can be improved by varying the proportions of the three main ingredients (**Abadir *et al*., 2002** and **Peter *et al*., 2006**).

Ceramic raw materials are normally composed of two groups of materials: plastic and non-plastic. The plastic material is predominantly based on clays and sometimes kaolin, which are essential to the development of plasticity as well as allowing for satisfactory green and dry mechanical strength. The non-plastic part is associated with inert (silica and

alumina), fluxes (Soda or Potash in Feldspar) and flux-inducing materials (calcite) non-plastic raw materials decrease plasticity. Some non-plastic materials (pegmatite, feldspar, calcite, bone ash etc.) put forth a melting effect in the mud due to the effects of addition ratio and firing temperature thus increasing the sintering rate **(Kibici, 2002).** The correct mixture of these materials enables the products to exhibit the desired technological properties and easy processing with the lowest possible cost.

The microstructure directly affects the technical properties of the final product. Ceramic sector is one of the oldest and most rapidly developing sectors in Turkey and it has a significant contribution to Turkish economy (**Bilim, 2014).** Ceramic tiles are produced by firing raw materials such as quartz, clay, feldspar at high temperatures. Ceramic tiles are classified into two groups as wall and floor tiles. Floor tile recipes are made up of about 50% clay, 40% feldspar and 10% quartz **(Elci, 2015)**.

2. MATERIALS AND METHODS

The studied samples were crushed to 200-mesh in ball mill then quartered and analyzed by using X-ray florescence (XRF) technique at the Central Laboratory in Nuclear Materials Authority (NMA), Egypt. The major oxides and minor elemental chemistry of the raw materials samples of Wadi El-Yatima – Wadi El-Tuleia district is presented in Table 2.

Forty-one samples of feldspar-sand deposits were classified according to the sum of K_2O+Na_2O into ten composite samples. The composite one containing sample number (32, 33, 39, 35), composite two containing sample number (31,19,37), composite three containing sample number (34, 28, 38), composite four containing sample number (29, 36, 40, 41), composite five containing sample number (29, 36, 40, 41), composite sex containing sample number(7, 8, 15), composite seven containing sample number(11, 13, 14, 16), composite eight containing sample number(9, 10, 12, 21, 23), composite nine containing sample number(2, 3, 17, 27) and composite ten containing sample number (10, 4, 22, 24, 25, 26) (Table 1). Preparation two recipes depend on manufacture of ceramic tiles (wall and floor; Table 2). Composite sample from one to ten was adding once time to recipes 1 with constant the ratio of Ball clay (50%) and Talc (5%). another once is adding from one to ten Composite sample to

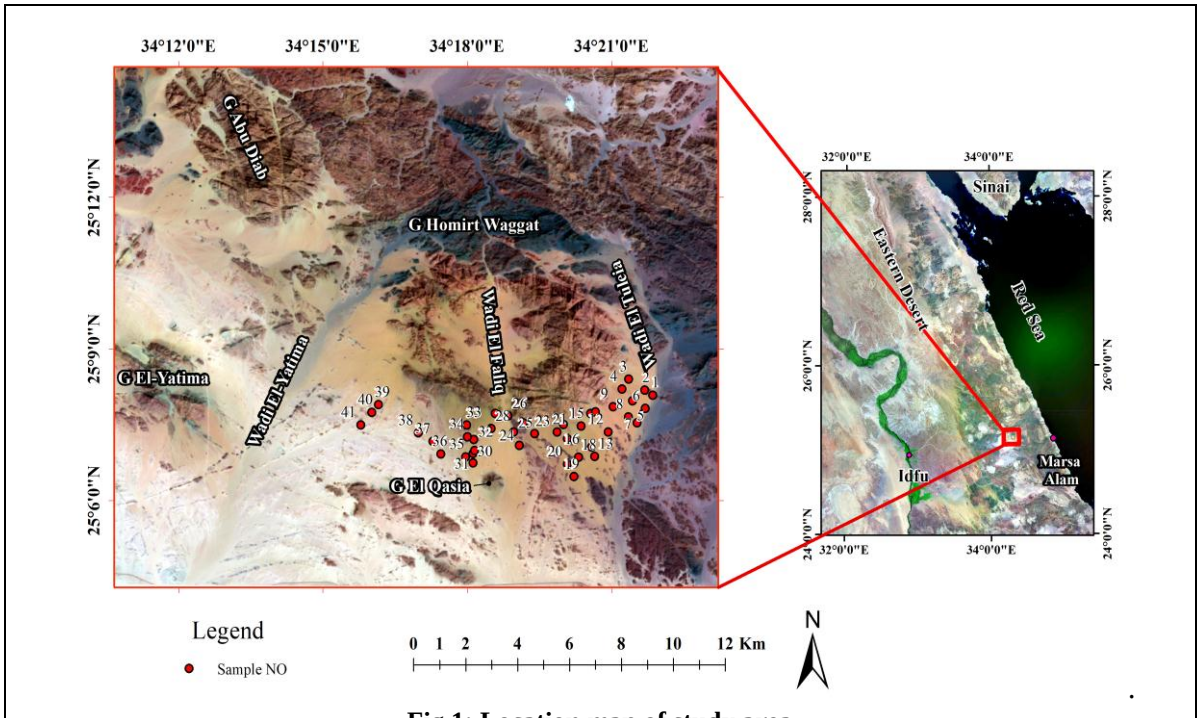

Fig.1: Location map of study area

recipes 2 with constant of $CaCO_3$(7%), Sand glass (10%) and Red clay (45%). accordingly, the change of composite sample for every recipe we have ten samples for floor and ten samples for wall.

Thermogravimetric analysis (TGA) is a technique for measure the changes in weight of a sample as it is heated, cooled or held at constant temperature at the laboratories of the Central Metallurgical Researching and Development Institute (CMRDI). Its main use is to characterize materials with regard to their composition. The clay minerals are composed of layer lattices of holding water on their external surface. This adsorbed water is proportional to the fineness of the particles and the relative humidity. It is not tightly bound and can be removed at fairly low temperature.

The burnt products were taken to X-ray diffraction XRD-SEM analyzer (**Rikagu D-max 2200, Japan**) at the laboratories of the Central Metallurgical Researching and Development Institute (CMRDI) to determine the formation of ceramic phases and minor constitutes. On the other hand, prepared samples investigated under the Scanning Electron Microscope with accelerating voltage 30K.V, magnification 14x up to 1000000 and resolution for Gun.1n).

2.1. Physical and Mechanical Characteristics

Physical properties in terms of firing shrinkage are water absorption, bulk density and apparent porosity (Table.3) and (Table.4) which are determined according to (ISO 10545-3).

I. Principle

Water absorption is the impregnation of dry tiles with water and then suspension in water. Calculate of physical properties by using the relationships between the dry, saturated and suspended masses.

II. Apparatus

1- Dry oven capable of being operated at (110±5) °C. Microwave, infrared or other drying systems may be used provided that has been determined that the same results are obtained.

2- Heating apparatus. Constructed of suitable inter material, in which boiling takes place.

3- Source of heat.

4- Balance accurate to 0.01% of mass of test specimen.

5- Deionize or distilled water.

6- Desiccator.

٧- Wire loop, halter or basket, capable of supporting specimens under water for making suspended mass measurements.

9- Glass beaker or similar container of size and shape such that the sample, when suspended from the balance by the wire loop, is completely immersed in water, with the test specimen and the wire loop being completely free of contact with any part of the container.

III- Procedure

1- Dry the tiles in the oven adjusted to 110°C until constant mass reached, until the difference between two successive weightings at intervals of 24h

Is less than 0.1% cool the tiles in the desiccator over silica gel or another suitable desiccant but not acid. Weight each tile and recorded the results to the corresponding accuracy.

2.2.1. Boiling Methods

Take place the tiles vertically, with no contact between them, in the heating apparatus so that there is a depth of 5cm of water above and below the tiles, maintain the water level at 5 cm above the tiles throughout the test. Heat the water until it boils and continues to boil for 2 hours then remove the source of heat and allow the tiles to cool to room temperature, still completely immersed in 4 hours. Water at ambient temperature or refrigerating coils may be used to cool the test specimens to room temperature. Prepare the chamois leather by

wetting and wringing out by hand. Place it on a flat surface and lightly dry each side of each tile in turn dab any relief surfaces with the chamois leather. Immediately after this procedure, weigh each tile and recorded the results

2.2.2. Suspended Weight

After impregnation of test specimens, determine the mass m^3 of each specimen while suspended in water. Carry out weighing by placing the specimen in wire loop halter or basket that suspended from one arm of the balance. Before actually weighing counterbalance the scale with the wire loop, halter or basket in place and immerse in water to the same depth as used when the specimens.

2.2.3.1. Water Absorption

water absorption is used to determine the amount of water absorbed under specified conditions. For each tile, the water absorption E expressed as percentages of the dry mass is calculating by using the following equation: -

$$E = (M2-M1)/M1$$

Where M1 is the mass of the dry tile

M2 is the mass of the wet tile

2.2.3.2. Apparent Porosity

The percentage of volume of voids over the total volume of rock. In ceramics this refers to the intrinsic porosity of the mineral particles and calculated by using the following equation.

$$A.\ P = (M2-M1)/(M2-M3)$$

M3 is the mass of the suspended tile impregnated by immersion

2.2.3.3. Bulk Density

The bulk volume of the ceramic body is generally defined as including the volume of compact solid material (excluding voids) and the volume of both closed and open pores. The bulk density is the mass to bulk volume and calculated by using the following equation.

$$B.\ D = M1/(M2-M3)$$

2.2.3.4. Breaking Strength

Breaking strength: force expressed in newtons, obtained by multiplying the breaking load by the ratio (span between support rods)/ (width of test specimen).

$$B.\ S= 3/2FL/b$$

F: is breaking load, in newtons, L: is the span in millimeters, between support rods and b: is the width of the test specimen, in millimeters

Suitability for Ceramics Industry

The feldspar-sand suitability for ceramics industry must be characterized by the following: accessibility, amiability for upgrading, quartz/feldspar ratio and low iron oxides content and radioactivity. Consequently, the studied alluvial placer sediments need upgrading by the following treatment methods to be suitable for ceramics industrial uses.

3. Preparation of Samples

Recipes of body composition were formulated with variable percentage of it components (Table 2). to study of effected of feldspar sand deposit on the end product samples. Preparation of Samples consists of five stages grinding, mixing, forming, drying and firing.

1- Grinding

Grinding may be referred to breaking down the relatively coarser material produced by crushing to the ultimate fineness. The studied feldspar-sand samples were grinding by using hummer mill and screened on a 0.5mm wedge wire screen and vibrating shaker. The under-size material is used as feed to mixing.

2- Mixing

300 grams of each two mixes were accurately weighed and wet ground in laboratory porcelain mill, whereas the proportion of materials: balls: water was 1:1:1. Sodium tripolyphosphate (STPP) was added to the slurry in the ball mill at 0.5% of the dry materials. This was enough to let the slip pour

Table 1: Chemical analysis of composite samples and materials.

Material Analysis	SiO_2	TiO_2	Al_2O_3	MnO	$Fe_2O_3^{tot.}$	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	LOI	Sum	K_2O+Na_2O
composite 1	62.98	0.68	14.05	0.07	4.67	1.90	6.58	2.10	3.31	0.30	0.17	0.39	2.51	99.76	5.42
composite 2	70.55	0.42	12.78	0.06	2.71	1.25	3.14	2.57	4.22	0.20	0.07	0.03	1.84	99.82	6.79
composite 3	71.19	0.38	12.44	0.05	2.60	1.01	2.95	2.51	4.59	0.17	0.06	0.02	1.82	99.80	7.10
composite 4	69.84	0.37	14.03	0.05	2.47	1.18	2.58	2.88	4.37	0.19	0.06	0.02	1.72	99.81	7.26
composite 5	70.22	0.38	12.66	0.04	2.46	1.31	3.01	2.96	4.77	0.16	0.05	0.02	1.73	99.84	7.74
composite 6	70.78	0.33	12.61	0.05	2.28	1.06	2.86	2.97	5.07	0.16	0.06	0.02	1.58	99.84	8.04
composite 7	71.69	0.29	12.84	0.04	2.47	0.83	2.07	3.02	5.20	0.13	0.05	0.01	1.2	99.88	8.23
composite 8	70.66	0.31	12.92	0.05	2.52	0.89	2.33	3.14	5.22	0.13	0.07	0.02	1.53	99.83	8.36
composite 9	70.44	0.32	13.11	0.05	2.38	0.85	2.31	3.19	5.56	0.13	0.06	0.02	1.39	99.85	8.75
composite 10	73.59	0.16	12.63	0.03	1.72	0.42	1.02	3.14	6.07	0.09	0.03	0.02	0.92	99.88	9.21
$CaCO_3$	0.44	0.02	0	0	0.07	0.17	54.96	0.11	0	0.52	0.34	0.16	43.2	99.99	-
Sand glass	93.67	0.24	3.41	0	0.16	0.15	0.37	0	0	0.02	0.12	0.04	1.78	99.96	-
Red clay (Aswan)	57.92	1.9	23.41	0.03	5.51	0.31	0.34	0.48	0.96	0.06	0.03	0.03	8.98	99.96	-
Ball clay	65.99	1.87	20.25	0	1.99	0.7	0.06	0.47	0.09	0.09	0.05	0.05	8.36	99.97	-
Talc	47.52	0.52	8.37	0.14	8.58	19.8	5.2	0.64	0	0.07	0.13	0.04	8.78	99.79	-

from the mill. The grinding times was 25 minutes for each mix of wall tile recipes and for floor tile was 45 minutes.

3- Forming

The dry masses were finely powder and pass through 1mm sieve after slip preparation, water was adding to powder at 6.5% the semi-dry powder was again passed through 1mm screen to homogenous. A portion of each of semi-dry powders was then pressed into 50*5*100mm rectangular shaped at a pressure of 250 kg/cm^2 by laboratory manual hydraulic press. This rectangular was used for measuring modulus of rupture**.**

4- Drying

Disks were formed to use for measuring all physical parameters both rectangles and disks were dried at 110^{o}C down to less than 0.5% water content.

5- Firing

The used firing technique is conventional firing. The dry samples were fired at different temperature 1125^{o}C for wall recipes and 1185^{o}C for tile recipes body.

Table 2: Composition of the recipes.

Raw material	Recipes 1		Recipes 2	
	Wt.(gm)	Wt.%	Wt.(gm)	Wt.%
Composite (1:10)	135	45	87	29.0
Ball clay	150	50	-	-
Talc	15	5	-	-
$CaCO_3$	-	-	21	7
Sand glass	-	-	30	10
Red clay (Aswan)	-	-	162	54

4. RESULTS AND DISCUSSION

4.1. Mineralogical fraction of feldspar sand deposits

The mineralogical study of stream sediments is based on examination of fine and very fine sand fractions. The light fraction is mainly composed of quartz and alkali or potash feldspars. The quartz is colorless and feldspar is red in color. Quartz grains are monocrystalline and show uniform to slightly undulose extinction. Feldspar fresh grains are angular to subangular and the identified heavy minerals in the -0.25+ 0.125 and -0.125+ 0.063 mm grain size fractions comprise opaques (hematite), biotite, chlorite, zircon, rutile and staurolite in a decreasing order of abundance. The opaque minerals are represented only by hematite.

Rutile grains are of lath shape, angular, subhedral and rounded deep red, reddish brown and golden yellow varieties. It is characterized by its very high relief and sometimes contains solid inclusions. Biotite and chlorite are occurring in all examined samples as tabular grains. Pleochroism is marked in biotite with high absorption. Chlorite after biotite occurs as yellow to pale yellow olive color. Zircon is the more common non-opaque heavy mineral in the studied samples Zircon grains are prismatic euhedral crystals, broken eroded prismatic crystals with perfect edges, rounded, long and short crystal forms. **Staurolite** recorded in most studied samples is prismatic, angular to sub angular grains of pale brown, straw yellow and golden yellow color.

4.2. Mineralogical constituents

The mineralogical analyses are in accordance with the chemical analyses. The detected phases in the all tested fired recipes at 1125^{o}C are quartz, albite as major components and hematite, microcline as a trace mineral (Fig.5). These minerals were suitable for ceramic wall tile. recipes which fired at 1185^{o}C the detected phases are quartz, albite, mullite as major minerals. These minerals were suitable for ceramic floor tile (Fig.4).

According to the SEM photomicrographs of the studied fired samples, the samples were classified into two grades: -

The first phase

The photomicrographs show smooth texture and less void space, this is expected due to the high of floor tile recipes (Fig.2) quality of these samples which coincide with the result of water absorption, crushing strength and bulk density. These phases floor tile samples this fired at 1185^{o}C and cycle 60 minutes.

The second phase

The photomicrographs of wall tile recipes show coarse textures and have more void space; it could be evidence to bloating phenomena. This may cause the decrease of the resistance to crushing strength and bulk density and increasing in water absorption and apparent porosity. wall tile samples fired at 1125^{o}C and cycle 45 minutes (Fig.3).

4.3. Thermal Properties of The Studied Recipes

During the past few years, the methods of thermal analysis have been widely accepted in analytical chemistry. The term thermal analysis incorporates those techniques in which some physical parameter of the system is determined and/or recorded as a function of temperature (**Chatwal and Anand, 2002**). Thermal analysis has been used to determine the physical and chemical properties of polymers, electronic circuit board, geological materials and coals (**Willard *et al*., 2012**).

4.3.1. Thermogravimetric analysis

Thermogravimetric analysis (TGA) is a thermal analysis technique which measures the weight change in a material as a function of temperature and time, in a controlled environment. (Table.5) and (Table.6) explain the loss of weighted with increase of temperature. This can be very useful to investigate the thermal stability of a material, or to investigate its behavior in different atmospheres (Inert or oxidizing). It is suitable for use with all types of solid materials, including organic or inorganic materials.

This enables phase transitions to be determined (e.g. melting point, glass transition temperature, crystallization etc.). (Fig.7) and (Fig.8) illustrate Behavior and change of weighted with increasing of heated.

When clays and shales heated to 1100^{o}C, kaolinite decomposed by first order kinetics according to the following sequence of steps: -

This means that the reaction rate is proportional to the concentration of the substances reacting.

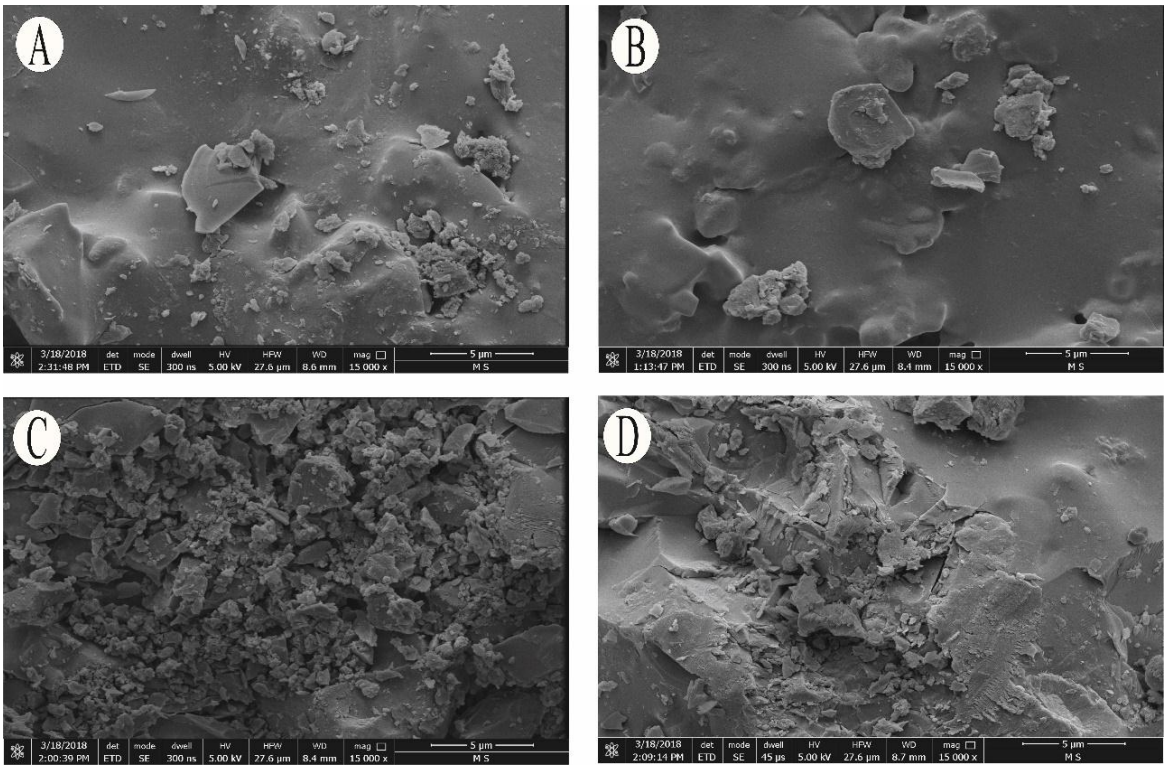

Fig.2(A-D): Close up view of SEM photomicrograph showing recipes 1 fired at 1185°C A) Composite 5, B) Composite 7, C) Composite 9, D) Composite 10.

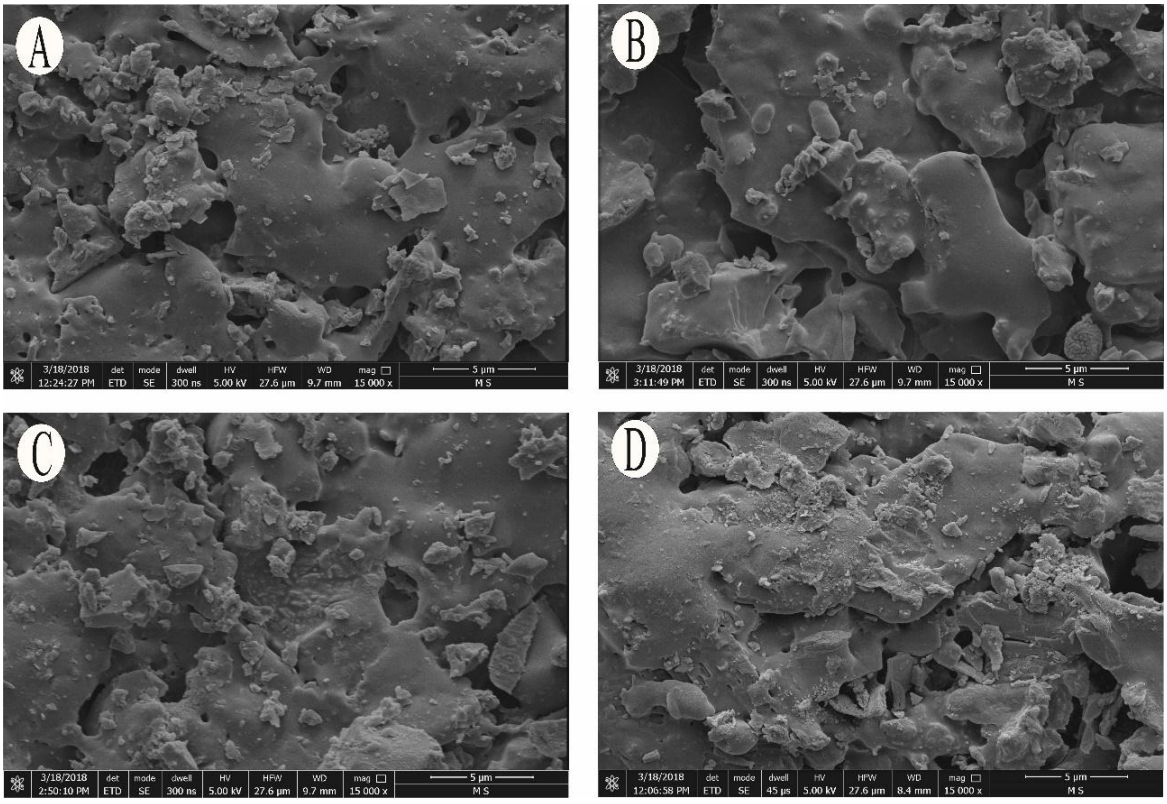

Fig.3(A-D): Close up view of SEM photomicrograph showing recipes 2 fired at 1125°C.A) Composite 4, B) Composite 5, C) Composite 7, D) Composite 8.

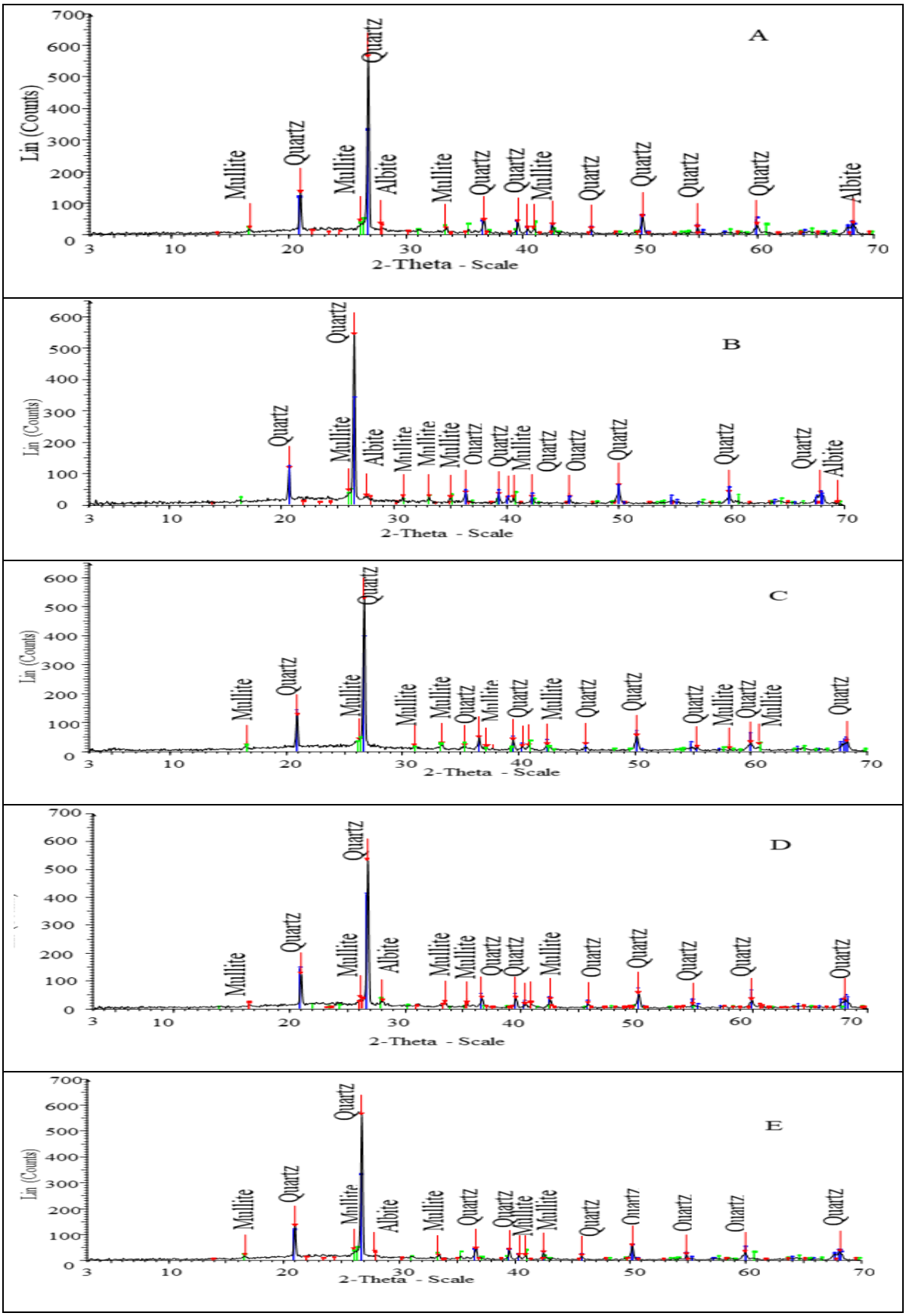

Fig.4(A-E): X-ray diffraction pattern of floor tile fired at 1185°C. A) sample 2, B) sample 7, C) sample 5, D) sample 9, E) sample 8.

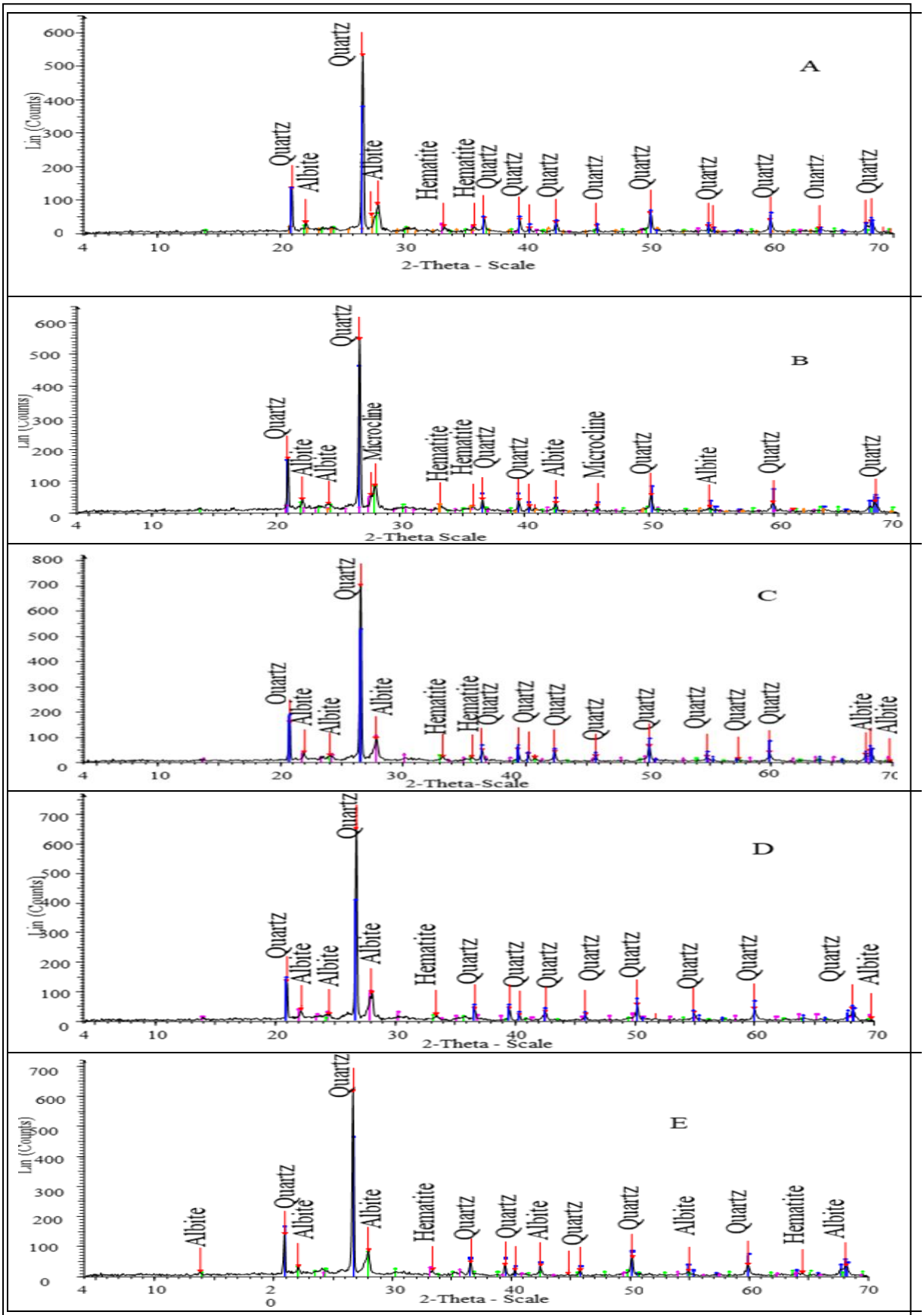

Fig.5(A-E): X-ray diffraction pattern of wall tile fired at 1125°C. A) sample 7, B) sample 2, C) sample 4, D) sample 5, E) sample 1.

Table.3: Physical and mechanical properties of recipes١.

Composite NO	Water absorption	breaking strength	S.H	Bulk density	Apparent porosity
1	1.98	28.9	5.68	1.68	15.17
2	0.88	35.9	5.78	1.67	10.71
3	2.05	32.7	6.38	1.67	11.85
4	2.53	33.9	6.28	1.67	12.64
5	3.03	34.2	5.24	1.67	14.3
6	2.73	22.7	6.43	1.68	13.05
7	1.07	35.3	6	1.69	8.62
8	5.14	39	6.49	1.68	8.68
9	6.76	29.4	6.63	1.69	11.44
10	3.03	26.7	6.8	1.68	5.11

Table.4: Physical and mechanical properties of Recipes٢.

Composite NO	Water absorption%	breaking strength(N/cm^2)	S.H %	Bulk density (g/cm$^{2)}$	Apparent porosity %
1	16.25	22.96	0.02	1.67	26.18
2	15.8	18.45	0.02	1.65	26.13
3	15.64	21.14	0.02	1.65	26.12
4	16.88	20.77	0.01	1.68	26.06
5	19.46	19.73	0.04	1.68	26.82
6	13.43	19.84	0.06	1.59	23.95
7	15.41	20.07	0.02	1.66	24.4
8	16.05	23.08	0.01	1.67	22.4
9	14.69	21.69	0.02	1.65	26.82
10	15.76	21.96	0.02	1.66	24.4

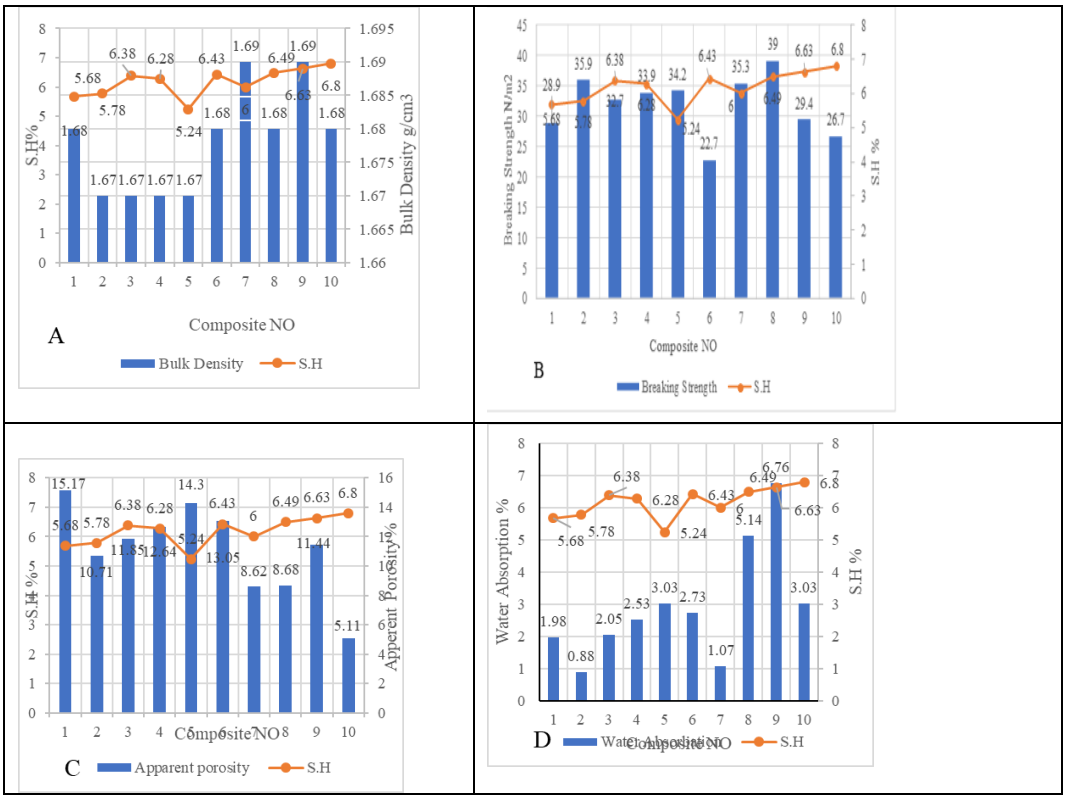

Fig.6(A-D): Relationship between shrinkage and some physical properties for wall tile fired at 1125° C A) Bulk Density g/cm^3, B) Breaking strength N/m^2, C) Apparent porosity %, D) Water Absorption %.

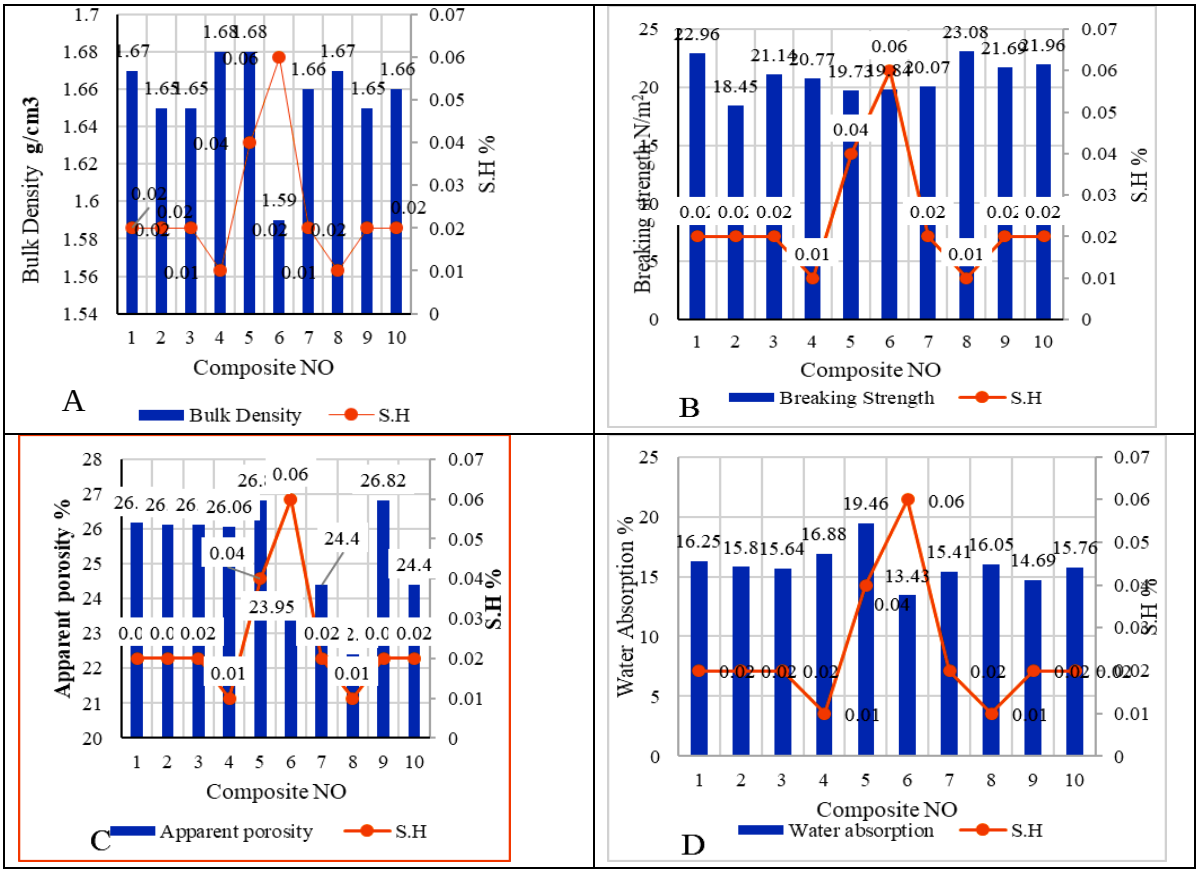

Fig.7(A-D): Relationship between shrinkage and some physical properties for Floor tile fired at 1185° C A) Bulk Density g/cm^3, B) Breaking strength N/m^2, C) Apparent porosity %, D) Water Absorption %.

Phase Transformation

The evolution of the physically adsorbed water by the mineral particles takes place until 100ºC (H_2O (l) → H_2O (g)). At 573ºC, α-β quartz inversion of free silica occurs. At 600 ºC, the characteristic peaks of kaolinite have disappeared. In fact, between ~ 450 and 600 ºC, kaolinite loses the OH groups of the gibbsite sheet leading to the formation of amorphous metakaolinite according to:

$$2SiO_2.Al_2O_3.2H_2O \xrightarrow{500^oC} 2SiO_2.Al_2O_3 + 2H_2O$$

Kaolinite → Metakaolinite

At 800 ºC, the peaks of quartz and albite are still seen. At 1000 ºC, peaks of mullite appear (**Chen *et al.*, 2000**). In this temperature range, the silicate lattice totally collapses, followed by reorganization of the metakaolinite structure and the formation of amorphous silica. A spinel structure is formed and then quickly transformed to mullite according to:

$$2SiO_2.Al_2O_3 \xrightarrow{900^oC} SiO_2 + 2SiAl_2O_4$$

Metakaolinite → amorphous spinel

$$SiO_2 + SiAl_2O_4 \xrightarrow{1100^oC} 1/3(3Al_2O_3.2SiO_2) + 4/3(SiO_2)$$

Amorphous spinel → mullite + cristobalite

the studied recipes samples were showed by DTG and TGA thermograms. In this study, inspected by TGA and DTG analysis, as revered from the extracted charts as following:

Table.5: Show the pattern weight with difference temperatures for floor tile.

Transformation/ Sample NO	(0-400) °C Kaolinite	(400-700) °C Metakaolinite	(700-1400)°C (mullite or cristobalite)
2	-1.11%	-4.6%	-0.39%
3	-2.81%	-3.36%	-0.75%
4	-1.30%	-4.07%	0.13%
6	-3.63%	-2.12%	-1.30%
7	-3.11%	-4.00%	0.00%

Table.6: Show the pattern weight with difference temperatures for Wall tile.

Transformation/ Sample NO	0°C - 600°C Kaolinite	600°C -750°C Metakaolinite	750°C -1100°C (mullite or cristobalite)
6	-7.38%	-6.08%	-4.31%
8	-8.06%	-3.66%	-0.45%
9	-9.24%	9.10%	
10	-4.32%	4.46%	

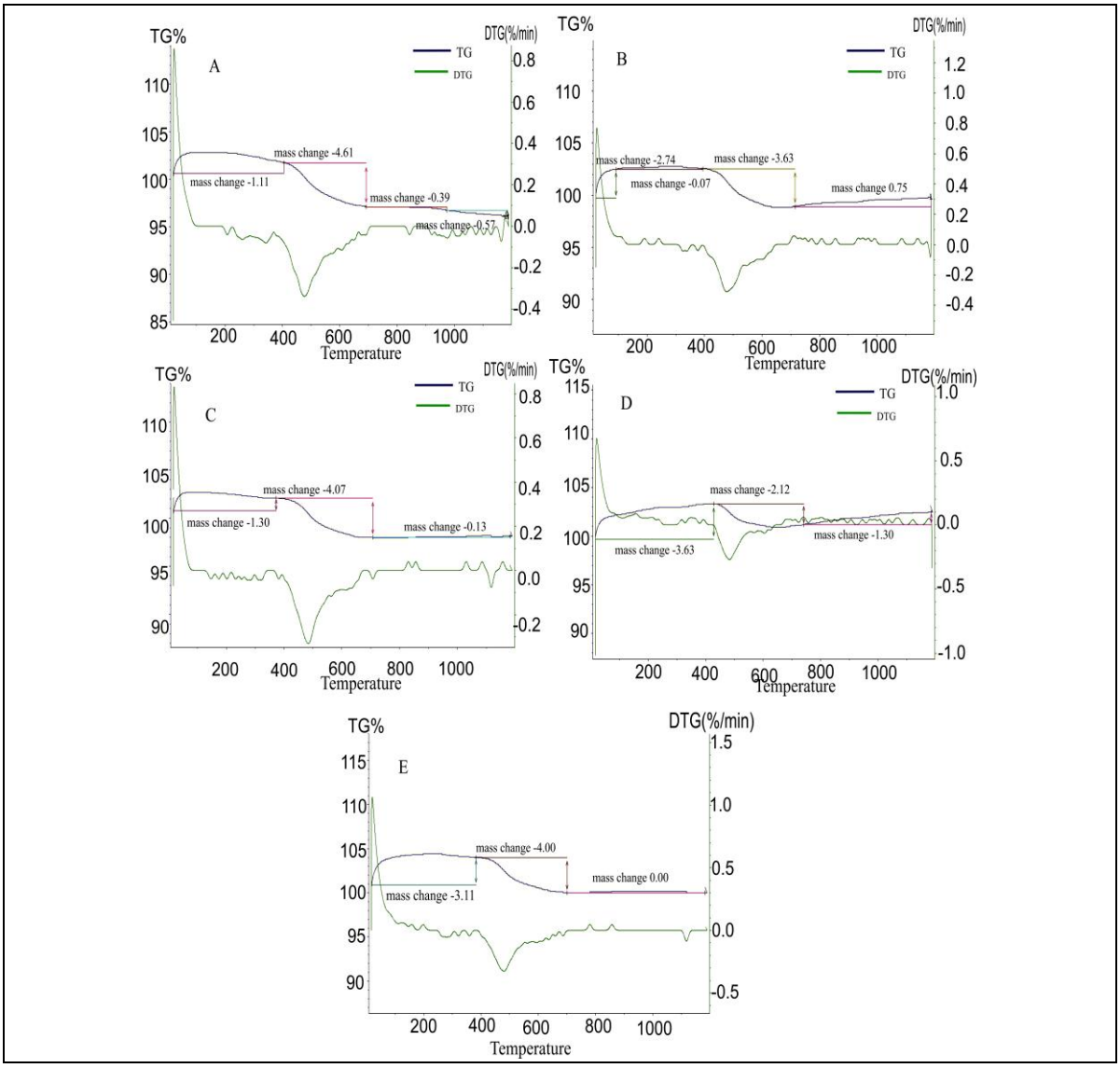

Fig.7. A-E): DTG and TG pattern of floor tile A) sample 2, B) sample 3, C) sample 4, D) sample 6, E) sample 7.

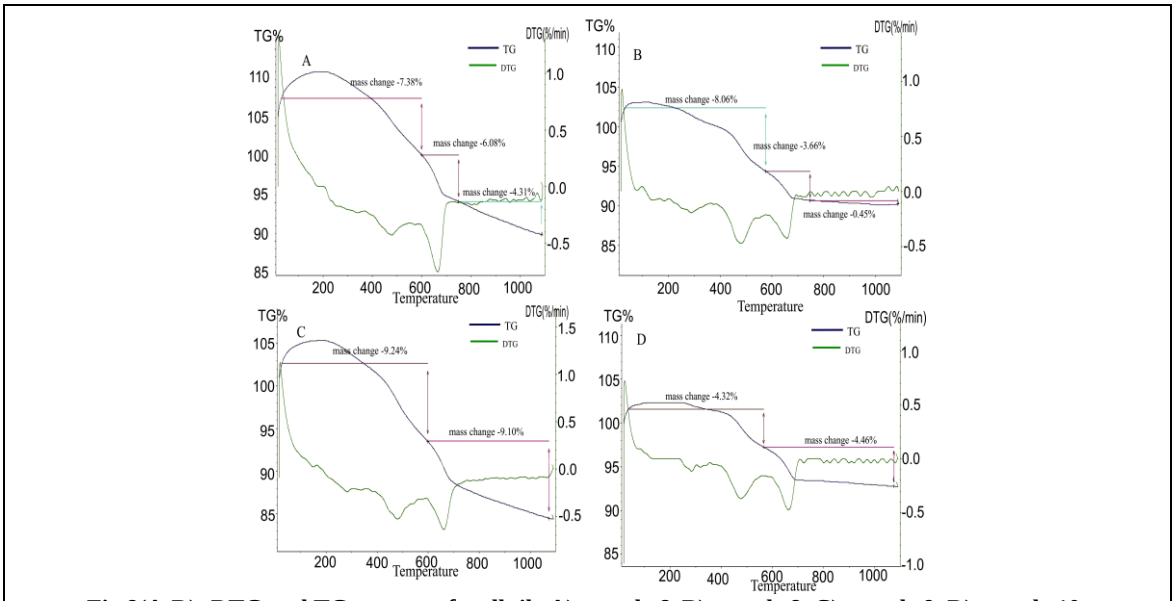

Fig.8(A-D): DTG and TG pattern of wall tile A) sample 6, B) sample 8, C) sample 9, D) sample 10.

CONCLUSION

The study highlighted the feasibility of feldspar-sand deposits surrounding Wadi El-Tulia and Wadi El-Yatima as fluxing material in the manufacture of vitrified ceramic (wall-floor) bodies. The results of different technique which are be made: -

1. The Mineralogical properties of the fired samples divided into two type according to type of recipes. recipes 1 which fired at 1185°C produces minerals as quartz, albite, mullite as major minerals and recipes 2 which fired at 1125°C quartz, albite as a major components and hematite, microcline as a trace mineral.

2. The Scanning electron microscope (SEM) produced two type of phase according to texture of fired sample. First phase are coarse texture and second phase are smooth texture.

3. Thermal properties by DTG and TGA indicate that the recipes are transforming from kaolinite to metakaolinite at 400°C and from metakaolinite to mullite or cristobalite at 950°C for recipes 1. On the other hand, recipes 2 show kaolinite to metakaolinite at 600°C and from metakaolinite to mullite at ranges from 750°C - 1100°C.

4. The physical and mechanical characteristics of the studied two recipes show recipes 1water absorption ranges from 0.88 to 6.76 and breaking strength ranges from 26.7 to 39.0 **N/cm^2**and shrinkage ranges from 5.24 to 6.8 for recipes 1. Recipes 2 water absorption ranges 13.43 to 19.46, breaking strength ranges 18.45 to 23.08 **N/cm^2** and shrinkage ranges from 0.01 to 0.06.

Based on (**Konta.,1979)**, all samples of recipes 1 is suitable for used as floor tiles and recipes 2 used as wall tiles.

According to **(ISO 13006),** the ceramic tiles with respect to water absorption were classified into four types. So, all recipes 1 located in **Annex H** (normative) low water absorption $0.5\% < E \leq 3\%$ individual maximum 3.3% expect sample 8 which have water absorption 5.14% and sample 9 which have 6.76% in group **Annex J** and for recipes 2 in group **Annex J.**

REFERENCES

Abadir, M.F., Sallam E.H., Bakr I.M., 2002. Preparation of porcelain tiles from Egyptian raw materials, *Ceramics International*, **28 (3),** 303–310.

Bilim, T.c., 2014. Sanayi ve teknoloji bakanliii sektörel raporlar ve analizler serisi, 4.

Chatwal, GR, Anand, SK., 2002. Instrumental Methods of Chemical Analysis. Fifth Edition: Himalaya Publication House, P.2.701 2.749-2.751.

Chen, C.Y., Lan, G.S., Tuan, W.H., 2000. Microstructural evolution of mullite during the sintering of kaolin powder compacts. Ceramics international, 26 (7), 715-720.

Elci, H., 2015. Utilisation of crushed floor and wall tile wastes as aggregate in concrete production. Journal of Cleaner Production, 1-11.

ISO 13006: 1998(E). Ceramic tiles-Definitions, classification, characteristics and marking

ISO 10545-3: 1995(E). Determination of water absorption, apparent porosity, apparent relative density and bulk density

Kibici, Y., 2002. "Seramik Hammaddeleri ve Teknolojik Özellikleri" 21.

Konta, J., 1979. Ceramic Monographs, Handbook of Ceramics, VerlagSchmidGmb, H Freiburg, pp: 800.

Lee, W.E., Iqbal, Y., 2001. Influence of Mixing on Mullite Formation in Porcelain. J. Eur. Ceram. Soc., Vol. 21, No. 14, pp. 2583-2586.

Mahaboonpachai, I., Matsumoto, T., 2005. Investigation of Interfacial Resistance between Concrete and Polymer-Cement Mortar and Development of Constitutive Material Model for the Interface. j appl mech, Vol. 8, pp. 1-9.

Peter, W.O., Stefan, J., Joseph K.B. 1., 2006. Characterization of Feldspar and Quartz Raw Materials in Uganda for Manufacture of Electrical Porcelains, *Journal of Australia Ceramic Society*, **41(1)**, 29-35.