Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 7 (19): 2794-2799, 2007
ISSN 1812-5654

Properties and Suitability of Wadi Zarieb Feldspars For Ceramic Industries in Egypt

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Abstract: Wadi Zarieb area lies 10 km to the south, midway on the Qena-Safaga paved road. Pegmatites are the most important rock type in the area that are the source of feldspars in the ceramic industries. Most of the pegmatite bodies that are invading granitoid rocks at Wadi Zarieb, central Eastern Desert, are classified as zoned pegmatites. They mainly consist of coarse-grained milky quartz core, intermediate Li-mica zone and wall zone of feldspars. Feldspars represent 45% of ceramic constituents that are the main fluxing components used in ceramic industries. The Wadi Zarieb feldspars were found to have good grinding ability only requiring 120-150 min to obtain the needed grain size with a release of both Na^+ and K^+ in the solution which, in turn, enhance the rheological properties of the ceramic slip. The total alkalis content (sum of $Na_2O + K_2O$) in Zarieb K-feldspars is more than 13%, whereas the uranium content is ranging between 1 and 2 ppm. The thorium content is not exceed 7. Then, the geochemical data reveals that Zarieb K-feldspars are good flux in ceramic industries. The results of the physical tests illustrated by water absorption %, shrinkage and bending strength beside their good resist for thermal shock suggest that the feldspars of the studied area can be used for wall and floor ceramic industry. Finally, the economical aspects of the Wadi Zarieb K-feldspars were compiled to give an idea of to what extent costs can be saved in ceramics production by using this feldspar source. This assumption is supported by the self-separation of feldspars in zoned pegmatites that are delivered as rock raw materials which are used as they are without any upgrading or treatments.

Key words: Pegmatites, feldspars, ceramic industry

INTRODUCTION

Ceramic industry in Egypt or ceramic industry in the world depends on the knowledge of raw materials, chemical and physical properties of the minerals and their aggregates present in ceramic raw materials as well as their behavior during manufactories (Konta, 1979). Ceramic tiles are thin slabs made from clays, silica, fluxes, coloring materials and other raw materials. They use as covering for floors, wall and/or facades.

In general, ceramic industry pass through seven successive stages, (1) dressing of raw materials, (2) batching, (3) grinding, (4) pressing, (5) glaze processes, (6) standard relating to ceramic tiles and (7) firing.

Feldspars are an important glaze raw material used as the main flux in ceramic industries. Feldspar is a source for the simultaneous introduction of SiO_2, Al_2O_3, Na_2O, K_2O and CaO and is the most suitable material for introducing alkaline oxides into glazes. The main feldspathic minerals are: (1) Orthoclase or microcline K_2O, Al_2O_3, $6SiO_2$., (2) Albite Na_2O, Al_2O_3, $6SiO_2$ and (3) Anorthite CaO, Al_2O_3, $2SiO_2$.

Glazes are thin glassy coatings usually 0.15 to 0.5 mm thick formed in place on a ceramic body, after blending the raw materials, spreading the mixture on the surface and firing at a high temperature. Glazes are usually applied to make the bodies non-porous, smooth, glossy, mechanically stronger and chemically more resistance. They improve the aesthetic appearance of ceramic ware glazes are required to fit different ceramic bodies, to mature at different temperatures and to exhibit various specific properties, which explains the great variety of grazes.

Konta (1979) and Singer (2001) suggested that the suitability of feldspars for Ceramic industries depend on five parameters: (1) total alkalis (Na_2O+K_2O%) at least 9%, (2) uranium content less than 4 ppm (3) grinding ability less than 240 min (4) suitability of physical parameters (water absorption less than 17%, shrinkage less than 6.5% and bending strength over 17 nuten cm^{-2}) and (5) resistance for thermal shocks. The present study aims to study the suitability of Zarieb feldspars for ceramic industry in Egypt.

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GEOLOGIC SETUP

Wadi Zarieb area lies between latitudes 25° 59` and 26° 01` N and longitudes 34° 11` and 34° 14` E covering about 10 km^2 (Fig. 1 and 2). The area lies 10 km to the south, midway on the Qena-Safaga paved road. Many authors (Ashmawy, 1979 ; Bishadi *et al.*, 2000; Heikal *et al.*, 2001) have subsequently studied the Abu Zarieb area from both the geological point of view and its geochemical inspection. The basement rocks, of Precambrian age, cropping out in the area are classified into: (1) younger granites (youngest), (2) younger gabbros, (3) older granitoids and (4) metavolcanics (oldest). The emplacement of the granitic pluton is followed by injection of dykes and veins of different shapes and composition, invading all the rocks cropping out in the studied area. These dykes are mainly represented by mafic dykes, quartz-feldspars porphyry dykes, pegmatites and aplites.

The pegmatite bodies invading the host granitic rocks are classified as zoned pegmatites (Fig. 3 and 4). They are very coarse- grained and consist of (1) milky quartz core (2) intermediate zone of albite and Li-mica pockets (lepedolite) and (3) wall zone of microcline-microperthite plus graphic quartz. This mica is often lepedolite and filling the bockets with about 30-40 cm in diameter. The accessory and secondary minerals are fluorite, zircon and sphene.

MATERIALS AND METHODS

The chemical analyses for the major oxides, minor and trace elements were carried out in the laboratories of Analyses Department in Nuclear Materials Authority of Egypt (NMA). The mechanical and physical tests for feldspars were carried out in the laboratories of Ceramica Cleopatra Group Company.

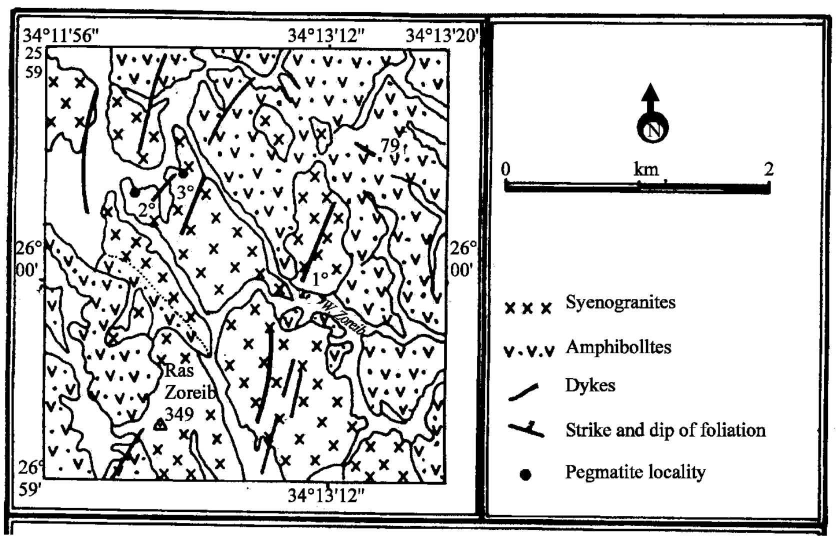

Fig. 1: Geological map of Wadi Zarieb area, central Eastern Desert, Egypt

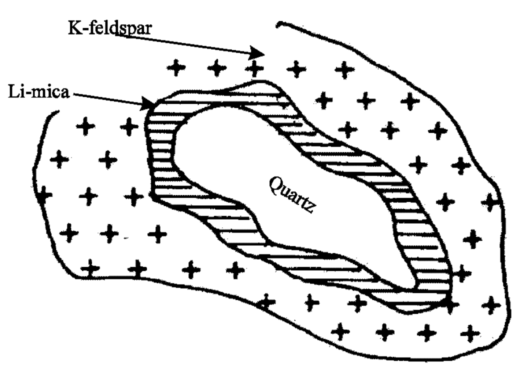

Fig. 2: Sketch map for the studied zoned pegmatites at Wadi Zarieb area

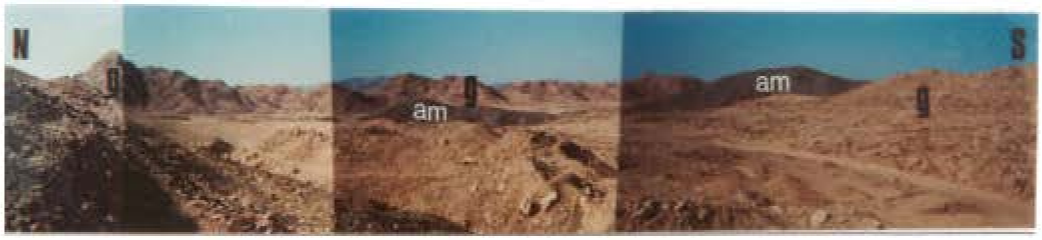

Fig. 3: Panoramic view of granite-hosting pegmatites (G) and its contact metamorphosed zone of amphibolites (am) at Wadi Zareib Looking E-W

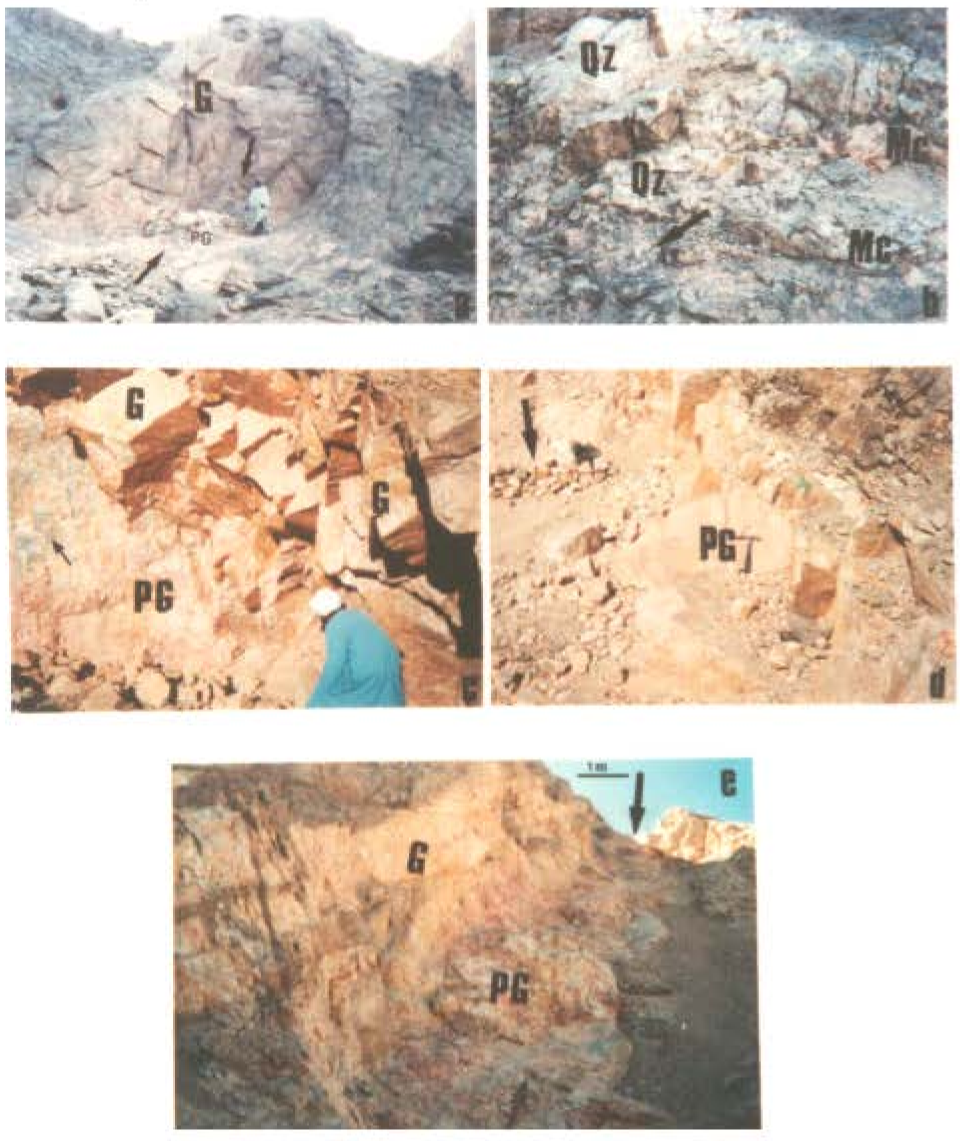

Fig. 4a: Zoned pegmatite body (arrows) is hosted by alkali granite (G) at first locality of Wadi Zareib. Looking SE: (b) Close-up view of the same pegmatite body showing mineral zones; microcline outer zone (Mc) and quartz inner zone (Qz). Note macro-graphic texture (arrow) nearby quartz zone. Looking WNW: (c) Unzoned pegmatite body (PG) invades alkali granite host (G) at the second locality of Wadi Zarieb. Note megagraphic texture (arrow). (d): An old quarry remanents (arrow) in the second locality of pegmatite body (PG) (e) Unzoned pegmatite body (PG) is hosted by alkali granite (G) at the third locality of Wadi Zareib. Looking NE. Bar scale 1 cm = 1 m

RESULTS AND DISCUSSION

The studied feldspars, of wall zone of Zarieb zoned pegmatite, are exposed to four tests that are chemical test, grindability, physical tests (shrinkage, water absorption and bending strength) and determination of the resistance to thermal shocks.

Geochemical classification and chemical test: The studied feldspars are petrographically classified into microcline perthite with minor amount of orthoclase perthite. Both orthoclase and microcline perthites contain plagioclase and quartz crystals poikilitically especially along their peripheries. They are generally of string, patchy and/or flame- like types. They are often cracked; most of the cracks are empty but rarely filled with iron oxides, muscovite and epidote. They enclose muscovite, zircon, apatite and iron oxides.

Table 1 shows the results of the chemical analysis of seven alkali feldspar samples. The are chemically classified as potash feldspars. Generally, they are characterized by their high silica contents with an average value of 67.14%. The potash content is very high that are ranging between 10.44 and 12.70% with an average 11.8%. The soda content is very restricted (ranging from 2.73 to 3% with an average 2.89%) that represents the minimum value in the formation of perthites (Deer *et al*., 1966). They also have low Nb, Pb, Zr, Th and U and high Ba and Rb contents.

The sum of alkalis content ($Na_2O + K_2O$) is more than 13%, whereas the uranium content is ranging between 1 and 2 ppm. These data are suggesting that this feldspar type is a very good type for ceramic industry according to Singer's assumption in his principle study. This assumption is supported by the self separation of feldspars in zoned pegmatites that are delivered as rock raw materials which are used as they are without any upgrading or treatments.

Grindability and particle size analysis: Grinding is reducing the dimensions of materials. To get very homogeneous masses and more complete chemical reactions in short time. The results of particle size analysis of the study feldspar type after each milling cycle are shown in Table 2. From the previous table, it can be concluded that 120-150 min is sufficient for milling in order to reach the grain size needed in the range between 45 and 32 μm.

Whereas the release of K^+/Na^+ ions during the milling process affects the rheological behaviour of a ceramic slip, the analysis of the study on K^+/Na^+ ions concentrations at different milling times represent an important factor for the use of such raw materials in a ceramic recipe.

Physical tests: The quality of ceramic tiles is controlled by many tests. These tests were done for feldspar to adapt the quality of feldspars for ceramic industry. These tests include shrinkage, water absorption and bending strength according to international standard limits Table 3. These tests were applied on biscuit feldspar sample that prepared as follow (Gouda, 2003):

Table 1: Major oxides (wt%) and trace elements (ppm) analyses of microperthite from Zareib pegmatite, central Eastern Desert, Egypt

Sample No.	1	2	3	4	5	6	7
SiO^2	65.81	65.87	65.50	69.80	65.560	67.45	70.01
TiO^2	0.01	0.01	0.01	0.01	0.010	0.010	0.01
$Al^2 O^3$	18.35	18.50	18.10	15.70	17.840	16.06	15.62
$Fe^2 O^3$	0.19	0.18	0.21	0.41	0.210	0.21	0.45
MgO	0.01	0.01	0.01	0.01	0.010	0.01	0.02
CaO	0.02	0.13	0.10	0.07	0.10	0.10	0.07
$Na_2 O$	2.97	2.98	2.80	2.80	3.00	2.95	2.73
$K^2 O$	12.10	11.61	12.70	10.50	12.60	12.60	10.44
LOI	0.44	0.50	0.43	0.47	0.58	0.43	0.47
Total	99.90	99.80	99.85	99.77	99.90	99.81	99.81
CIPW norms							
Q	4.98	3.84	13.97	26.57	14.23	16.17	27.00
Or	60.06	69.16	75.55	62.54	75.03	75.00	62.16
Ab	25.24	25.37	0.01	0.01	0.01	0.01	0.01
An	0.10	0.65	0.01	0.01	0.01	0.01	0.01
Trace elements (ppm)							
Nb	4.00	2.00	6.00	5.00	6.00	5.00	4.00
Rb	300.00	300.00	300.00	331.00	360.00	362.00	351.00
Ba	125.00	205.00	222.00	256.00	199.00	201.00	186.00
Y	58.00	50.00	59.00	49.00	44.00	46.00	52.00
Zr	7.00	10.00	9.00	12.00	9.00	8.00	10.00
Sr	2.00	2.00	5.00	8.00	5.00	8.00	10.00
U	2.00	1.00	1.00	2.00	2.00	2.00	2.00
Th	7.00	5.00	4.00	7.00	7.00	7.00	7.00

Table 2: Particle size analysis of Zarieb feldspars after different grinding time

	Grinding time (min)					
Particle size (μm)	30	60	90	120	150	180
+67	66	61	16	0	0	0
+45	22	24	66	79	69	33
+32	5	6	8	8	16	48
+25	3	4	4	6	6	8
+15	2	3	3	4	5	6
+11	2	2	3	3	4	5

Table 3: International standard limits for shrinkage, water absorption and bending strength (Konta, 1979)

Characters	Ceramic wall	Ceramic floor
Shrinkage (Shr.)	0 - 0.3%	5-6.5%
Water absorption (E)	14-17%	Less than 3%
Bending strength (BS)	Over 17 nuten cm^{-2}	Over 27.5 nuten cm^{-2}

1 Weight 250 g grind feldspars.
2 Add 5% (12.5 g) Spanish kaolin to increasing the plasticity and not change of ceramic body or physical characters of feldspars.
3 Take the mixture for grinding 80 min and put the slap in the drier about 90 min at 100°C.
4 Make hand grinding with little amount of spray water.
5 Pressing the sample at 300 bar and passed to the glaze line.
6 Firing of sample at 1200-1220°C for about 47 min. After the preparation of biscuit sample the physical tests were started by determination of water absorption over their determination of the bending strength and finally the determination of shrinkage.

Water absorption determination (E): Water absorption can be determined by the following formula

$$E = (M_2 - M_1)/100M_1$$

Where, M_1 is the weight of the dry tile. and M_2 is the weight of the humid tile.

Determination of the bending strength (BS): Bending strength can be determined after the result that expressed by the formula:

$$BS = 3FL / 2BH^2$$

Table 4: Water absorption %, shrinkage and bending strength for feldspars of W. Zarieb

Sample No.	Water absorption (%)	Shrinkage	Bending strength
1	2.3	11.8	55.8
2	3.1	11.5	60.2
3	2.9	8.5	33.6
4	2.2	10.1	50.2
5	3.1	9.2	47.5
6	3.1	9.5	47.7
7	3.1	9.2	48.5
8	3.1	10.0	47.5
9	2.3	10.7	50.5
10	2.5	10.0	75.8

Where, F is the applied bending strength (in newton)., L is the distance between the supporting rollers (inter-axis) (in mm) B is the tile width. and H is the minimum thickness of the measured long the breaking edge (in mm).

Determination of shrinkage (Shr.): Shrinkage is the rate of change in length and width for inspection sample. Shrinkage is directly proportional to the total alkali content and inversely proportional to water absorption and bending strength. It expressed by the formula:

$$Shr. = (L_2 - L_1) / L_1$$

Where, L_1 is the length after ignition and L_2 is the length before ignition

Ten samples from Wadi Zarieb were chosen for physical tests for feldspars. The results illustrated by water absorption %, shrinkage and bending strength (Table 4). Accordingly, from these results, the feldspars of the studied area can be used for wall and floor ceramic industry.

Determination of the resistance to thermal shocks: The test is made on at least 5 samples for 10 cycles from 105 to 110°C at 15-20°C. The biscuit samples are kept in a stove for about 20 minutes at 105 to 110°C and then rapidly put in cold water (15-20°C), keep them for 15 min and start the cycle up again-after 10 tests examine the biscuit sample with the naked eye, identifying the defects which have arisen. The studied biscuit samples of Zarieb feldspars are good resist for thermal shock.

CONCLUSIONS

Wadi Zarieb area lies between latitudes 25° 59` and 26° 01` N and longitudes 34° 11` and 34° 14` E covering about 10 km^2. The area lies 10 km to the south, midway on the Qena-Safaga paved road. The basement rocks, of Precambrian age, cropping out in the area are classified into: (1) younger granites (youngest), (2) younger gabbros, (3) older granitoids and (4) metavolcanics (oldest).

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REFERENCES

Ashmawy, M.H., 1979. Basement geology of Wadi Ambagi, Wadi Zarieb district, Eastern Desert, Egypt. M.Sc. Thesis. Tanta University, pp: 287.

Bishadi, M.A., M.Z. Mostafa and M.M. Mamoun, 2000. Properties and grindability of Egyptian Red Sea for ceramic industries. Tile and Brick Int., pp: 238-245.

Deer, W.A., R.A. Howie and J. Zussman, 1966. An introduction to rock forming minerals. Longmans, London, pp: 517.

Gouda, M.A., 2003. Petrographical, mineralogical and geochemical studies on granitic-pegmatitic rocks of Wadis Abu had and Hawashiya, Ras Gharib District, North Eastern Desert, Egypt. M.Sc. Thesis. Al-Azhar University, pp: 250.

Heikal M.T.S., A.F. Moharem and E.R. El-Nashar, 2001. Petrogenesis and radioactive inspection of Li-mica pegmatites at Wadi Zareib, central Eastern Desert, Egypt. The second international conference on the Geology of Africa, Assiut, Oct. 2001, pp: 227-305.

Konta, J., 1979. Ceramic monographs, Handbook of Ceramics, Verlag Schmid Gmb, H Freiburg., pp: 800.

Singer, S.S., 2001. Industrial Ceramics. London: Longman, 2nd Edn., pp: 1200.