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Fatma Arslan, Ayhan Ali Sirkeci

A. Ekrem Yüce, Gülay Bulut, M. Olgaç Kangal, K. Tahsin Perek, Fırat Burat

Mustafa Özer, Onur Güven, Hüseyin Baştürkcü, Ünzile Yenial

Zeynep Yeşilyurt, Esra Tanısalı, Yusuf Enes Pural

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FOREWORD

Mineral processing is an art of treating raw ores in order to separate valuable minerals from the waste rock as well as preparing mineral products for specific needs. It is the first process that most ores undergo after mining in order to provide concentrated material for the downstream metallurgical processes. The primary operations are comminution and concentration, but there are other important operations in a modern mineral processing plant, including sampling and analysis and dewatering. In mineral processing, a number of unit operations are required to prepare and classify ores before the valuable constituents can be separated or concentrated and then forwarded on for use or further treatment. Mineral processing education at the Istanbul Technical University has started as a division of the "Mining Engineering Department" which was founded as a part of the Mining Faculty in 1953. The division was re-organized as a Mineral Processing Engineering Department of the same faculty in 2007, in order to meet the requirements of engineering education. It is the first and only one in Turkey.

The first Balkan Mineral Processing Congress was held in Varna, Bulgaria in 1973. The “XVIIth Balkan Mineral Processing Congress – BMPC 2017” is organized by ITU Mineral Processing Engineering Department and the Turkish Mining Development Foundation between November 1 and 3, 2017, in Antalya-Turkey. “BMPC 2017” will bring together a large number of academicians from Turkey and many other countries as well as the authorities from the companies that are operating in the mining, mineral processing, and extractive metallurgy industries in order to create an opportunity to evaluate the future of the sector. In this context, BMPC represents a technical platform for the safe and sustainable future of the mining and mineral processing industries in Balkan Countries. We are inviting you to become a part of this global challenge by attending our congress through participation, presentation, exhibition and supporting our activities. In this respect, Antalya with its dynamism and diversity presents a unique opportunity for the attendees. We assure you that we will provide all means to make you enjoy and benefit from this extraordinary event.

The Congress will gather over one hundred professionals and academics from all over the world to exchange knowledge and experience, to present the results of scientific research and to discuss innovations in the mineral processing industry. Universities specializing in mineral processing, a number of important mining companies, major leading providers of services and technologies will participate in the Congress.

We are very pleased to welcome you to attend and we are sure you will enjoy the Congress from both scientific and social points of view. Looking forward to meeting you in Antalya!

Prof. Dr. Fatma Arslan | Prof. Dr. Ayhan Ali Sirkeci

FOUNDATION'S FOREWORD

As Turkish Mining Development Foundation, we are happy to be organizer of 17. Balkan Mineral Processing Congress. I would like to express my sincere thanks to the Balkan Scientific Committee, Turkish Organization Committee, to the Sponsors, exhibitors and all the attendees. Our special gradidute to Istanbul Technical University, Mining Faculty and Mineral Processing Department.

We wish successful and fruitful congress and sunny days in Antalya.

With kind regards,

Prof. Dr. Güven Önal

President of Turkish Mining Development Foundation

Balkan Scientific Committee Member

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THE BENEFICATION OF KIRŞEHIR NEPHELINE SYENITE AS CERAMIC RAW MATERIAL

M. Çınar[a]; E. Durgut[b]; H. Calışkan[a]; Y. Yıldırım[c]

[a]*Çanakkale Onsekiz Mart University, Graduate School of Natural and Applied Sciences, Mining Faculty, CANAKKALE-TURKEY*
[b]*Çanakkale Onsekiz Mart Üniversitesi, Çan Vocational School, Mining Technology, CANAKKALE-TURKEY*
[c]*Kaleseramik Research and Development Center, CANAKKALE-TURKEY*

ABSTRACT

Nepheline syenite is an important raw material for ceramic processing technology as a flux substantial. However, contamination that is coming from host rock can cause quality problems. In this study it is aimed that separation of Kırşehir nepheline syenite's impurities which generates production defects in ceramic tile manufacturing.

In dry magnetic separation experiments particle size, feed rate and blade angle was observed and, Fe_2O_3 content was decreased to 0.36%.

Acidic, natural and alkaline pH with different amounts of R801, R825 and DER NA7 collectors were studied in flotation experiments. The optimum result for the flotation tests was found in natural pH with R825 and DER NA7 and Fe_2O_3+TiO_2 content was declined from 2.0% to 1.5% and CaO content was diminished from 3.1% to 0.4%.

Sintering tests were performed 1170ºC temperature and 48 minutes sintering conditions. -10 mm raw material's shrinkage was 8.29%, water absorption was 0% and color value was L: 53.68; a: 6.24; b: 7.98. Concentrate material with R825 and natural pH's shrinkage was 7.95%, water absorption was 0% and color value was L: 44.01; a: 7.60; b: 8.97.

Roughness analysis was done to see difference of the raw and flotation concentrate sintered specimens.

Key words; Nepheline Syenite, Ceramic Raw Material, Separation, Sintering.

1 INTRODUCTION

In ceramic tile processing technology raw materials are prepared by wet grinding, sieving and mixing as mentioned in the recipes. After all of these processes wet mix recipe is granulated by spray dryers. Then the body granule is sent to the shaping, glazing and firing stages (Sacmi 2002).

Basically clay minerals, feldspars, quartz and besides that dolomite, magnesite, talc, bauxite, calcite etc. are used in glazed porcelain and floor tile ceramic bodies. Clay minerals give the body plasticity to ease shaping, increase the dry bending strength and provide forming of glass, mullite phases based on the firing cycle at the same time (Sanchez et al. 1990).

Quartz and feldspars are used as filler and fluxing agents respectively (Kamseu et al. 2007).

Nepheline syenite is important sodium and potassium feldspar source for floor tile bodies however iron, titanium, mica minerals which are found in the mineralogical structure induce negative impacts on the production quality (Saklar et al. 2003).

It is crucial to remove such impurities for better production and less ceramic tile wastes. Dry magnetic separation is a technique for separating iron minerals that cause adverse effects on the ceramic body color (Gökalp et al. 1993).

Coloring minerals such as iron, titanium, biotite etc. are also eliminated from feldspars by using flotation method. Some researchers suggest that two stages of flotation to eliminate mica and heavy minerals from the feldspars. In first stage mica minerals are removed with amine type collectors while sulphonates are used for heavy mineral separation in the second stage (Seyrankaya 2003).

Generally, as activator hydrofluoric acid and as collector cationic amines are used for quartz and feldspar separation by flotation method. However, there are some constraints about usage of hydrofluoric acid due to the health threats (Demir et al. 2003).

On the other hand, non-hydrofluoric acid flotation methods are also investigated for feldspar beneficiation (Gaied et al. 2015).

Impurities from raw materials have different effects on the final ceramic tile product. Iron and titanium minerals decrease the whiteness color value of the ceramic tile body. Mica minerals make holes on the glaze after firing. High quartz percentage means less feldspar and fluxer needs for the body recipe. In this study it is aimed that to take out such impurities from Kırşehir nepheline syenite for enhancing the ceramic product quality.

2 EXPERIMENTAL STUDIES

2.1. Material Characterization

In this research -10 mm of crushed Kırşehir nepheline syenite was used for the experimental study. The material was taken from Kaleseramik Yozgat Factory. Firstly, XRF and XRD analysis were done in order to characterize the material.

The chemical compositions of Kırşehir nepheline syenite -10 mm raw material were obtained by XRF that was illustrated in Table 1.

Table 1.Kırşehir Nepheline Syenite -10 mm Raw Material Chemical Composition

*LOI	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O
2,51	61,25	21,54	0,17	0,93	2,26	0,23	4,26	6,52

*LOI: loss of ignition

The material was also analyzed by X-Ray diffraction to describe the mineralogical structures. Figure 1 shows the X-Ray diffraction patterns of Kırşehir nepheline syenite which give the peaks of microcline, albite, muscovite, quartz and montmorillonite.

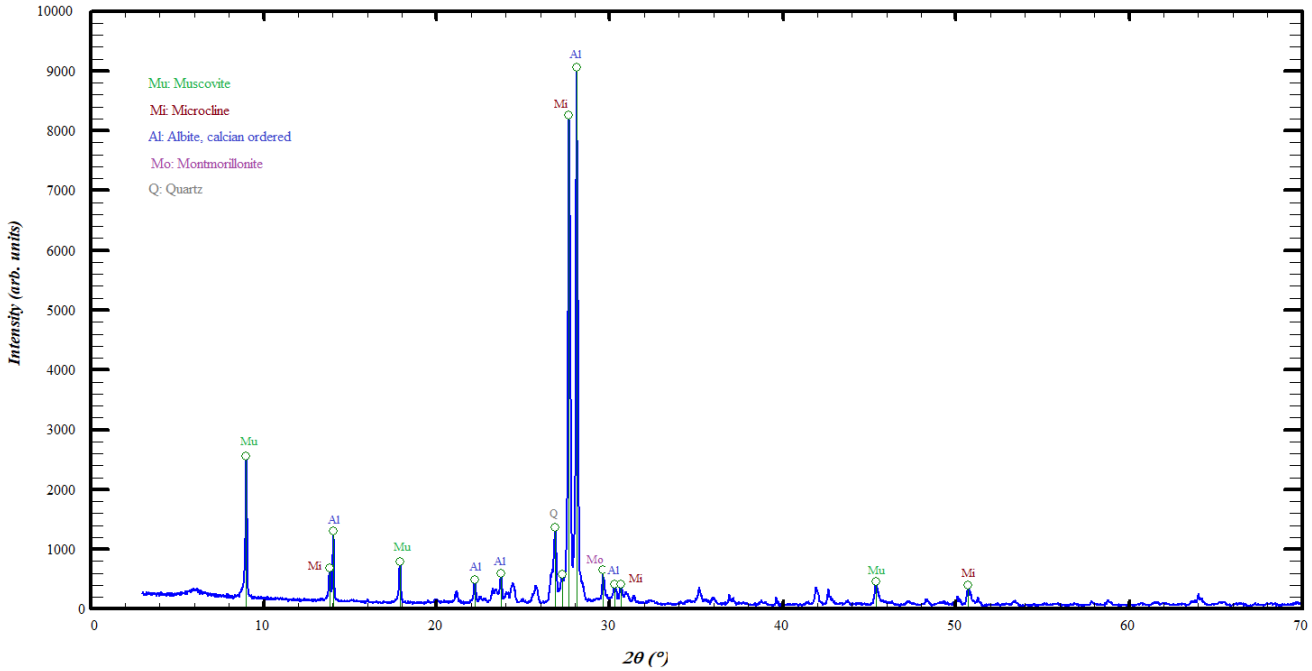


Figure 1.Kırşehir Nepheline Syenite XRD Analysis

2.2. Dry Magnetic Separation Experiments

Kırşehir nepheline syenite was crushed from -10 mm to -2 mm grain size for dry magnetic separation experiments. Then -2 mm of crushed raw material was classified to -2+1, -1+0.425, -0.425+0.250, -0.250+0.150 mm ranges and dry magnetic separation tests were done with specified size ranges by changing belt speed (rpm). Dry magnetic separation experiments were done with High Intensity Roll Magnetic Separator which has 0.5 t/h capacity and 18000 Gauss (for 0.5 mm belt thickness) magnetic induction property.

Figure 2 shows %Fe_2O_3 results of dry magnetic tests with different size ranges and belt speed.

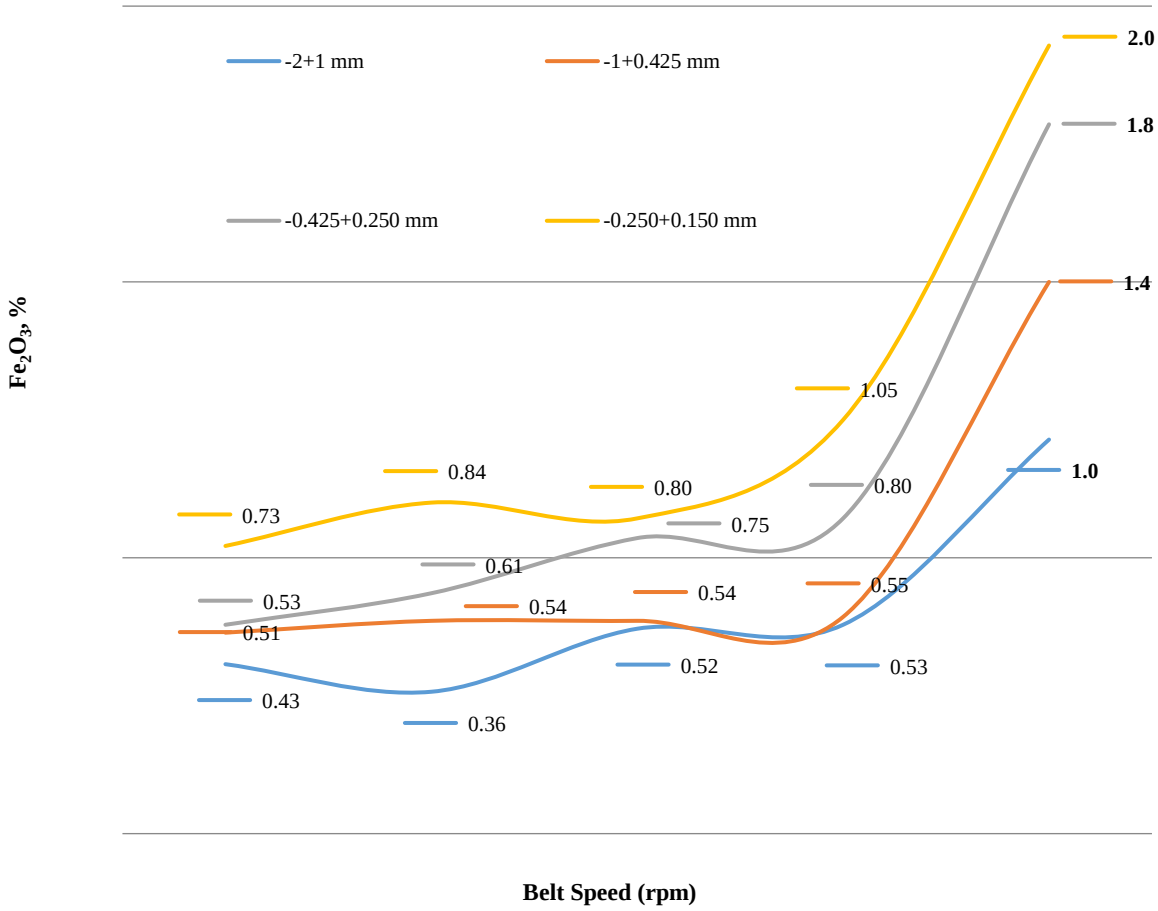


Figure 2. Dry Magnetic Test Results for Specified Size Ranges

Given the obtained results indicated on the Table 2, dry magnetic separation helped to reduce for all sizes, yet the Fe_2O_3 content from 1 to 0.36% was achieved for -2+1 mm size range 200 rpm belt speed.

2.3. Flotation Experiments

Flotation tests were operated using -0.150+0.038 mm sieved Kırşehir nepheline syenite in Denver flotation machine. 150 gram of material was mixed with 800 grams of water in 1.5-L flotation cell. Both conditioning and flotation processes were performed at the same impeller speed of 1200 rpm and water solid ratio of 15% by weight. In the first stage 5 minutes of conditioning cycle and then 3 minutes for each collector addition was applied. R801, R825 and DER NA7 were used as collectors in flotation tests. For increasing and decreasing the pH caustic and sulphuric acid were utilized respectively.

The purpose of the flotation test job was to investigate amount and type of the collector and the pH value on the separation ferrous and mica minerals from nepheline syenite.

Table 2. Flotation Tests Feed Material and Concentrates Chemical Analysis

SAMPLE INFO		LOI	SiO_2	Al_2O_3	$TiO_2+Fe_2O_3$	CaO	MgO	Na_2O+K_2O
Feed Material		3.7	58.0	22.4	2.1	2.8	0.5	10.1
Flotation Reagents	**pH**	**Flotation Concentrates**						
R825	Acidic	2.3	60.2	23.7	2.0	0.4	0.4	10.9
	Natural	2.8	59.9	23.5	1.9	0.6	0.5	10.4
	Basic	2.5	59.9	23.5	2.1	0.6	0.5	10.8
R801	Acidic	2.0	60.8	23.5	2.1	0.5	0.4	10.6
	Natural	2.8	60.4	22.6	2.2	1.1	0.4	10.3
	Basic	2.8	60.3	22.1	2.2	1.3	0.4	10.6
DER NA7	Acidic	2.4	60.4	23.6	2.0	0.4	0.4	10.6
	Natural	2.3	60.9	23.7	1.5	0.4	0.4	10.7
	Basic	2.2	61.2	23.1	1.8	0.4	0.4	10.6

As shown in Table 2 concentrate which was taken from DER NA7 with the Natural pH flotation test, gave the least $TİO_2+Fe_2O_3$ ratio compared to the other flotation tests. In this test $TiO_2+Fe_2O_3$ ratio was decreased from 2.1% to 1.5% compared to the feed material. However CaO ratio was decreased dramatically in all flotation tests. Besides the minimum CaO ratios were obtained in flotation test that was done with DER NA7 and R825 at all pH values.

i. Sintering and Roughness Analysis

Technological tests of specimens were also carried out to investigate the sintering behaviors. After applying the size reduction, weathering applied to reach the 6% moisture in samples. Then, the samples were sieved through 3 mm sieve hence the granules were obtained in laboratory. The granules were pressed to having 5 cm diameter tablets at 360 kg/cm^2. After that, the tablets were dried and sintered in the conditions of glazed porcelain that is at 1170°C, 48 minutes. After thermal treatments, the water absorption of the samples (according to the ISO 10545-3), linear shrinkage that is the difference in the length of the test specimen before and after firing (according to the ISO 10545-2) and color values were measured. Sintering behavior of the -10 mm raw material and concentrate that was taken from R825 flotation test samples at natural pH were determined by sintering in the conditions of the glazed porcelain floor tile sintering conditions. The result is given in Table 3.

Table 3. Sintering Behaviors of the Samples

Sample Information	Unit	-10 mm Raw Material	Concentrate from R825 Natural pH Flotation Test
Max. Firing Temperature	°C	1170	1170
Firing Cycle	Min.	48	48
Linear Shrinkage	%	8.29	7.95
Water Absorption	%	0	0
COLOR VALUES	L	53.68	44.01
	a	6.24	7.60
	b	7.98	8.97

Surface roughness is described as the shorter frequency of real facials corresponding to the troughs. Variation in surface roughness causes a series of peaks and troughs of varying heights, depths, and spacing. It was intended to see differences on the sintered surfaces of the -10 mm raw material and concentrate from R825 flotation test samples at natural pH with the roughness test. The mean roughness Ra matches the arithmetical mean of the absolute values related to the profile deviation y within the reference length l. Rq is the root mean square average of the roughness profile ordinates. The mean roughness depth Rz is the arithmetical mean of single roughness depths of successive sampling lengths le.

Table 4. displays Ra, Rq and Rz values for unglazed and glazed sintered specimens.

Table 4. Surface Roughness Test Results

Surface Roughness	Ra (µm)	Rq (µm)	Rz (µm)
-10 mm Raw Material (Unglazed)	3.03	3.85	22.86
R825 Concentrate (Unglazed)	2.74	3.45	18.52
-10 mm Raw Material (Glazed)	0.51	0.62	2.64
R825 Concentrate (Glazed)	0.48	0.60	2.56

As seen from Table 4, R825 concentrate gave the smooth surfaces for the glazed and unglazed specimens compared the -10 mm raw material sintered tablet. Ra, Rq, Rz values for unglazed -10 mm raw material's sintered tablet were 3.03 µm; 3.85 µm; 22.86 µm while glazed -10 mm raw material sintered tablet were 0.51 µm; 0.62 µm; 2.64 µm. Ra, Rq, Rz values for unglazed R825 concentrate were 2.74 µm; 3.45 µm; 18.52 µm while glazed R825 concentrate were 0.48 µm; 0.60 µm; 2.56 µm.

3 RESULTS AND DISCUSSIONS

Dry magnetic tests were done to take the magnetic minerals from the raw material. FeO content came under to 0.73% from 2.0% with dry magnetic tests but the lowest value (0.36% FeO) was gained with -2+1 mm size range 200 rpm belt speed.

In the flotation experiments it was aimed to separate with iron bearing minerals so as to enhancing the after sintering color value of the material. R825 and DER NA7 were used for iron treatment from quartz in flotation experiments (Bulut et al.). However, there was no change % FeO rate, on the other hand CaO rate was decimated in the flotation tests that were done with the R825 and DER NA7 collectors.

After CaO treatment with R825 collector in the flotation tests sintering behaviors of the feed material and concentrate were observed. Contrary to what is believed color of the concentrate was blackened compared to the feed material after sintering because it was aimed to take iron bearing materials out from the feed material, the reason of the color darkening was the depreciation in the CaO rate of the concentrate.

Calcination or calcining is a thermal treatment process to bring about a thermal decomposition. $CaCO_3$ forms calcium oxide and carbon dioxide which when heated. Thermal decomposition of the $CaCO_3$ material with impurities lower than 0.3% was found between 635°C and 865°C (Halikia et al.). Roughness analysis was made to see the effect of CaO rate on the sintered tablets. As a result, Ra, Rq and Rz values were lowered from unglazed to glazed surfaces. More importantly roughness values were declined with CaO content decrease.

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