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Utilisation of Granite Sawing Mud and Borax Tailings as A Ceramic Material

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ÖZET: Bu çalışmanın temel amacı: granit kesimi esnasında işlem atığı olarak ortaya çıkan granit kesim çamurunu karakterize etmek, sintcrlenme davranışını belirleyerek seramik amaçlı kullanılabilirliğini incelemektir. Bu amaçla yine bir işlem atığı olan boraks zenginleştirme tesisi atıkları (DSM elek üstü atığı) farklı oranlarda granit atığına ilave edilerek, farklı sıcaklıklarda sinterleine deneyleri yapılmıştır. Deneyler sonunda, granitin teorik yoğunluğuna yaklaşan yoğunlukta hatasız malzemeler üretilmiştir. H25°C'de pişirilen numunelerin iyi bir şekilde sinterlendiği. su emme oranlarının %3'iin altında, eğme mukavemetlerinin 27 MPa üstünde olduğu tespit edilmiştir.

ABSTRACT: The main objective of this study is to characterize the granite sawing mud and investigate the possible usage as a ceramic material. For (his puipose, different amounts ol" Borax concentrator plant tailings (DSM sieve disposal) were added to the granite mud and sintering study was conducted at different temperatures. As a result, defect free dense materials were produced at nearly theoretical density of natural granite. It was observed that, samples were succesfully sintered at I I25°C. Water absorption was found to be less than 3% and fiexural strength was higher than 27 MPa.

I INTRODUCTION

Granite is a natural slone which contains Quartz and Feldspar as main mineral phases and illite, mica, muskovite, ilmenite, apatite, biotite as accessory phases. Due to its good hardness and low water absorbtion. it is used for covering floors and walls of the buildings. Cutting of granite generates important amount of waste material. However, this waste material not only contains granite fines but also contains metallic iron and lime which arc used for cutting process of granite. Resulting cutting residue is called as sawing mud which is filter pressed and dischaiged from the cutting system. There are only a few studies about the utilisation of the granite sawing mud. Most of these studies are related with the vitrification of the granite mud with other industrial wastes in order to immobilize the ha/ardous components in these wastes (Pelino, 2000 and Pisciclla, 2001). Fritting and crystallization of glass-ceramic glaze was studied (Romero, 2002). Granite sawing mud was used in porcelanized stoneware composition as a replacement of feldspar (Hernandez, 2001). Injection molding of granite powders were studied for production of wear parts such as thread-guide (Felix, 2001). Granite fine from the quary was used in self-compacting concrete applications as a filler material (Ho, 2002). Granite sludges were used in brick and floor tile type ceramic formulations (Ferreira, 2002) However, there is still very limitted knowledge about the utilization of granite sawing mud.

Every year almost 150.000 tons of boron containing fine clay tailings are produced in Etibor Kırka Borax Company's Concentrator Plant in Turkey (Ediz, 2002). Évaluation of this clay and carbonate containing boron tailings are classified into three group; (i) utilization in ceramic and construction industry. (ıi) recovery of the boron from tailings and (iii) enviromentally safe disposal of tailings (Bentli, 2002).

The main objective of the research is investigated the properties of granite mud and the sintering behaviour of the samples which are produced from granite mud and borax tailings.

2 MATERIAL AND METHOD

In order to know the properties of the materials, characterization study was conducted on the as received granite mud. Chemical and mineralogical structure of granite mud was determined. Three series of samples were prepared with adding 0 %, 5 % and 10 % boron tailing to the granite mud. The dried granite mud and the boron tailings were wet mixed in porcelain ball mill and homogenized for 6 hours. After drying, powder mixture was sieved from 250 (im for granulation. Prismatic samples, which have 55 xlO x 8 mm (length, height, width) in size, were shaped at 40 bar pressing pressure with 10% water content. Shaped samples were dried at laboratory conditions for 1 day. then oven dried at 105°C. Then, dried samples were fired at 1100"C, I125"C, 1150 and I175"C temperatures for 30 minutes.

The fired samples were tested for the determination of bulk density, water absorbtion and appereant porosity by water absorption test. Firing shrinkage amounts of the samples were measured. Flexural strength of the fired samples was measured with 40 mm span length. Table 1. shows the chemical analysis of borax tailing and granite mud. Mineralogical composition of the borax tailings are given below (Emrullahoğlu. 2002):

Dolomite	CaMg (CO,h
Montmorillonite	$NaCaMgFeSiAlOOH\text{-}nH_20$
Calsite	CaCO,
Ortochlase	KAIShOs
Sanidin	(Na,K)AlSi,Os
Sodyum Borate	$Na_2B_40_7$

Table I. Chemical analysis of Borax tailing (Ediz. 2002) and granite mud.

Oxide	Borax tailing	Granite mud
SiO	15,83	62,44
A1-.0,	1,06	13,69
CaO	20,66	3,16
MgO	19,84	032
K,0	0,63	3,99
Na.O	2,58	3,29
Fe^Ch	0.24	12,51
B^Ch	3,99	—
L.O.I	34,75	0,1

Particle size distribution is given in Table 2.

Table 2. Particle size distribution of granite mud.

Particle size	wt/(
< 163 M m	100 %
<22um	75%
< 7 uni	50 %
< 2 um	25%

According to the XRD analysis (Fig. I) it was found that: granite sawing mud contains quartz, chlinochlore, muskovite, ortochlase, albite and kalsite as a main mineral phases.

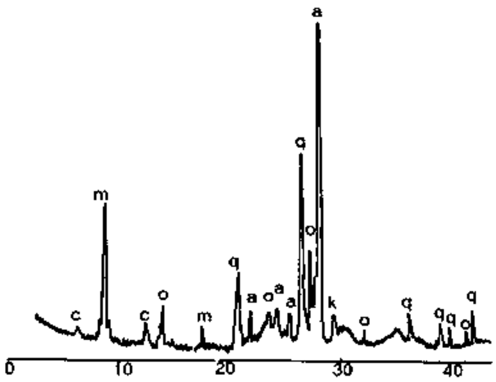

Figure 1. Mineral structure of the granite sawing dust. (c:chlinochlore, m:muskovite, o:ortochlase, q:quartz. a:albite. k:kalsite).

3 RESULTS AND DISCUSSION

Samples which were produced with only the granite mud (G) could be fired without any problem up to 1175°C. However, melting and deformation were observed when borax tailing were added to the granite mud and fired at 1175°C. Decrease in the flexural strengths was observed after 1125°C for the granite mud samples (Fig 2.). 5% borax tailings containing samples (G+5%BA) were fired without any problem up to II50°C but sudden melting behavior was observed at I175°C. 10 % borax tailings containing samples (G+10%BA) were showed a sudden decrease in strength at 1125°C as similar to samples without tailing addition. According to these results, it was concluded that I125°C temperature is the optimal firing temperature for these samples. Because, technical properties of the samples were decreased at sintering temperatures higher than 1125^, such as flexural strength. At higher temperatures bloating of the samples starts and controlling the firing becomes difficult. Increase in the fluxing oxide content with the addition of borax tailings is the main reason for the bloatings.

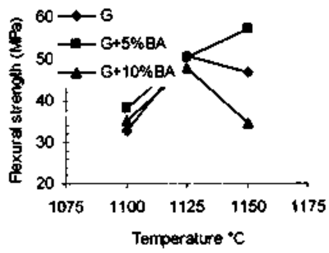

Figure 2. Change in the flexural strengths with firing temperature.

Firing shrinkage Al (%), water absoption (wa %), apperant porosity (Ap.p. %) and bulk density (D_{h}„n) of the samples which were fired at I I25°C are given in Table 3.

Firing shrinkage, flexural strength and bulk density values depend on the amount of the boron tailing addition. They were higher at 5% tailings addition level, but decreased with 10% tailing. Water absorption values were substantially lowered upon tailings addition (Table 3).

Table 3. Some properties of the samples which were fired at 1125"C. (wa: water absorbtion. Ap.p.: apurant porosity. Dhuii,: bulk density)

	G	G+5%BA	G+109ÎBA
C/r) Firing Shrinkage	9,1	9,6	9,0
wa^{c}/c	0.98	0,1	0,08
Ap.p. %	2.4	0,21	0.18
Dlnilk (gr/cm)	2,35	2,39	2,31

Low level of boron tailing addition possitively affect the sintering behaviour, but after a certain level properties detoriate. High amount of glassy phase formed in samples which contained 10% boron tailings and surface was closed. As a result, the gas which remains in the sample caused bloating. By this way, firing shrinkage and flexural strength were reduced. In other word, this makes it possible to choose the optimum firing temperature depending on the addition ratio. This effect can be seen clearly in Table 3. Sample G+10%BA has lower water absorption than the other groups but has also lower bulk density.

A metallic iron impurity which originated from the cutting process is found to have no negative effect on the properties. But, combined effect of fine granite powders and magnetic effect of metallic iron impurities creates agglomeration of the powders. This makes the processing steps difficult. Structural heterogenity was observed between the metallic iron and ceramic matrix interphase according to the mierostruclural investigations. This was mainly due to the different thermal expansion coefficients of the metallic iron and matrix material.

4 CONCLUSIONS

In this study, effect of different amount of boron tailing addition on the properties of granite sawing mud was determined under different firing temperatures. Granite sawing mud was easily shaped by pressing with the addition of boron tailing (DSM sieve disposal). 5 ^{c}k addition was found to be optimal to help the pressing and supply enough flux material for the enhance densificalion. Further addition caused bloating of the samples. Properties were negatively affected at higher firing temperatures. It was determined that, samples can be succesfully sintered al II25°C. Water absorption was found to be less than 3% and flexural strength was higher than 27 MPa.

Samples which contain boron tailing additions were sintered without any problem at a relatively low firing temperature of 1125°C. Choosing the correct amount of the additon has great importance, otherwise bloating of the samples was observed and especially strength values were adversely affected. As a result of this study, it is assumed that, addition of these materials to the tile formulations will cause an improvement on the properties. Dark color formation after sintering due to the impurities which comes from the accessory minerals of granite and effect of metallic iron impurities on the glaze quality should be taken into consideration. As a result, granite sawing mud can be considered as a potential candidate material for the tile industry and the next investigations will be focused on this direction.

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