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Use of granite sawing wastes in the production of ceramic bricks and tiles

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Abstract

Granite process industry generates a large amount of wastes, which pollute and damage the environment. This work aims to characterize and evaluate the possibilities of using the granite sawing wastes, generated by the process industries from Paraíba State, Brazil, as alternative ceramic raw materials in the production of ceramic bricks and tiles. Samples of granite sawing wastes were collected from companies located in Paraíba State. Their characterization were carried out with the determination of density, particle size distribution, surface area (BET), chemical composition, and by DTA, TGA, XRD, and SEM. In a second part of the work, tests in ceramic compositions were conducted in order to evaluate the suitability of addition of wastes in ceramic compositions used in the production of ceramic bricks and tiles. The results showed that the granite wastes have physical and mineralogical characteristics that were similar to those of conventional ceramic raw materials. The ceramic bodies produced from reformulated ceramic compositions had technological characteristics in agreement with the Brazilian standardizations for ceramic bricks and tiles.

Keywords: Porosity; Plasticity; Clays; Traditional ceramics; Waste materials; Tiles

1. Introduction

The use of wastes after detecting their potentialities is considered today as an activity that can contribute to the diversification of products, decrease of final costs, besides providing alternative raw materials to a series of industrial sectors.

Recycling of wastes, generated by the industries, as alternative raw materials is not a new thing and has been done successfully in a lot of countries. The reasons that motivate these countries generally are: the exhaustion of the natural resources; the conservation of not renewable resources; improvement of the population health and security;[1] preoccupation with environmental matters; reduction in wastes disposal costs.

The construction industry is the most indicated technological activity sector to absorb solid wastes,[2] such as the wastes from the granite industry, due to the large quantity of raw materials used by the sector as well as by the large volume of final products in construction. The use of wastes as alternative raw materials in the ceramic industry, which embodies part of the construction industry, can contribute to diversify the offer of raw materials in the production of ceramic bricks and tiles and reduce the costs in a building, which is of primary importance in a country with a high deficit of houses, like Brazil.

Granite mining and process industry are one of the most promising business areas of the mining sector, with a mean growth in the world production of approximately 6% per year in the last 10 years. The international trading is approximately US$ 6 billions per year and around US$ 13 billions, taking into account tools, equipments, etc.[3] Although this industrial sector generates a large amount of wastes in the form

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of a mud, basically composed of SiO_2, Al_2O_3, F_2O_3 and CaO, due to the sawing and polishing processes. Which can cause serious damages in the environment, such as soil and underground water contamination, if not efficiently treated before disposal.[4]

Brazil is one of the biggest granite world producers, either in the form of block or as processed products. Brazilian Northeast Region is an area that concentrates a large quantity of process industries, which are responsible by the disposing of hundred of tons of wastes in the environment per year. This scene is even more aggravated by the increasing production in the last decade, getting attention from all society with the destination of disposal wastes.

The recycling of granite wastes in the ceramic industry has attracted technological attention in the last years due to the possibility of reduction of the production costs, use of residues as a secondary raw material in the production of very stable glassy phases (glass and glass–ceramic industry), and by the opportunity in overcoming some problems in the production of bricks and tiles with the incorporation of granite sawing wastes in their formulations. All these benefits are largely due to the reproducibility of the chemical composition and particle size distribution of these wastes. In this way, some works have been published regarding to the use of granite wastes in the fabrication of glasses and glass–ceramics,[5–8] porcelainized bodies[9] and production of bricks and roof tiles.[10,11]

Therefore, the aim of this work was to characterize and evaluate the suitability of use granite sawing wastes as alternative ceramic raw materials in the production of ceramic bricks and tiles.

2. Experimental procedures

In the development of this research, conventional ceramic raw materials and granite sawing wastes were used. The following conventional raw materials were used:

- red clay, from Santa Rita city, Paraíba State, supplied by *Companhia Industrial Cerâmica—CINCERA*, located in the Industrial Center of Santa Rita;
- ball-clay type clay, from Alhandra city, Rio Grande do Norte State, supplied by *Indústria Armil Minérios*, located in the Industrial Center of Campina Grande city, Paraíba State;
- quartz, from Morro do Careca hill, Parelhas city, Rio Grande do Norte State, supplied by *Indústria Armil Minérios*, located in Parelhas city;
- feldspar, from Parelhas, supplied by *Indústria Armil Minérios*, located at Parelhas;
- calcite, from Boa Vista city, Paraíba State, supplied by *Indústria Armil Minérios*, located in the Industrial Center of Campina Grande.

All these conventional raw materials have already been analyzed and are used regularly as raw material by the ceramic industries of the Northeast Region. Table 1 presents their chemical composition.

Table 1
Chemical composition of the conventional raw materials

Raw materials	Weight percent						
	LOI[a]	SiO_2	Fe_2O_3	Al_2O_3	CaO	Na_2O	K_2O
Red clay	11.03	44.41	13.65	26.45	–	3.12	3.51
Ball clay	12.20	49.34	6.87	20.50	3.50	2.40	3.00
Quartz	0.34	96.76	–	–	–	0.67	0.60
Feldspar	0.51	66.7	–	22.40	–	2.70	6.66
Calcite	39.27	1.55	–	–	53.48	2.70	–

[a] Loss on ignition.

Three samples of granite sawing wastes were selected and collected from process industries located at the Paraíba State. The granite wastes were obtained in the form of a mud, which were dried and used in the reformulation of ceramic compositions. The used wastes were:

- waste from *Poligran, Polimentos de Granitos do Brasil*, located in the Industrial Center of Campina Grande, identified by *Poligran*;
- waste from *Caxambu*, located in the Caxambu Farm, Cabaceiras city, identified by *Caxambu*;
- waste from *Fuji, Mármores e Granitos*, located in the Industrial Center of Campina Grande, identified by *Fuji*.

The wastes identified by Poligran and Fuji were generated in a process using a cutting machine with steel saws, whist the Caxambu was generated in a process using diamond cutting saws.

The wastes were characterized by determination of density, according to the picnometry method, using a picnometer model AccuPyc 1330 from the Micromeritics; particle size distribution, by wet sieving and sedimentation (according to Brazilian standardization[12]); surface area by the method of N_2 adsorption (BET) using He as flowing gas in a Micromeritics device, model ASAP 2370; chemical composition, wet process, differential thermal analyze (DTA) and thermal gravimetric analyze (TGA) using a BP Engenharia equipment, model RB 3000; X-ray diffraction (XRD) using a Siemens/Brucker equipment, model AXD 5005, with radiation Cu Kα (40 kV/40 mA); scanning electronic microscopy (SEM) and energy dispersive spectrometry (EDS) in a Leica equipment, model S 440.

Red clay and wastes (amount of 20, 25, 30, 35, 40, 45, 50, 55 and 60% in weight) were used in the formulation of bricks. The formulation of compositions for production

Table 2
Density of the granite wastes

Waste	Density (g/cm^3)
Poligran	2.69 ± 0.05
Caxambu	2.63 ± 0.05
Fuji	2.70 ± 0.14