UTILISATION OF SULCIS COAL ASH IN THE PRODUCTION OF MASONRY BRICKS

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ABSTRACT The Sulcis Coal Ash, a waste product of Thermal Power Plants, may constitute a consistent resource of raw material for the Ceramic Industry. This material has been successfully utilized for production of bricks: the samples constitute a product with good technical characteristics. The paper represents furthermore an indication for the complete re-using of a waste material.

RIASSUNTO Le ceneri di combustione del Carbone Sulcis (Sardegna) possono costituire una notevole risorsa di materia prima per l'Industria Ceramica. Questo materiale può essere vantaggiosamente utilizzato per la produzione di laterizi, ottenendo un prodotto di buone caratteristiche. La nota rappresenta, inoltre, una indicazione positiva nel problema del riuso di un materiale di scarto dotato di potenzialità inquinante.

1. INTRODUCTION

The disposal of Coal Combustion Ashes constitutes a serious problem of environmental control (1) but, at the same time, the Ashes can be considered as a potential resource of raw-material in the Ceramic Industry (2).

The author has examined in previous papers (3), (4), the possibility of re-using Sulcis Coal Ash (Sardinia, Italy) in the preparation of Portland Pozzolanic Cement and Hydraulic Limes, owing to the good pozzolanic properties of the Ash (30% of the whole mass of Coal (5)) which will be produced in large quantities when the Sardinian Power Plants utilizes the Sulcis Coal as fuel (6).

In this paper the possibility of re-using the Ashes in the production of masonry bricks is examined; some elementary technical tests were carried out on samples fired at different temperature, and various considerations are expressed on the samples structure with particular regard to the nature of phases developed during the firing. The final considerations should give a positive answer to the problem of re-using the waste materials.

2. TESTING PROGRAM

2.1 Materials

The materials are the Sulcis Coal Ash and a slurry by-product of an Industry operating in Sardinia (ANIC SpA).

The chemical compositions of these materials are shown on Table 1. Both materials were finely grinded in a ball-mill; a paste was prepared with the granulometric fraction passing through the sieve of 5.600 mesh (DIN Normen 1170) in the following rates:

Sulcis Coal Ash	90% by weight
Slurry	10
Water	30% of the whole mass.

This paste (composition on Table 1) - with a ratio 1:3 between "basic" and "acid" components in order to promote the reactions of formation of aluminosilicates and mullite (7) (8) - was duly mixed. Cylindrical samples were obtained (height 2cm, diameter 4cm) from the paste by means of a hydraulic press at 5 MPa

of pressure. The samples were finally fired in an electric furnace at temperatures of 1,000, 1,100 and 1,200°C (10 hours of firing). The samples were introduced and taken out of the furnace at 20°C: the bricks had a dark-grey colour.

2.2 Tests

The following tests were carried out on the fired samples:

1. Firing-shrinkage, Table 1;

2. Saturation of CaO:CaO evaluation as in (9);

3. Compressive strengths utilizing a dynamometric press, Table 2 and Fig. 1.;

4. Porosity with an AMINCO-mercury porosimeter, Table 2 and Fig. 1.;

5. X- and IR-spectrographies with a GEC XRD-5 and Perkin-Elmer spectrometers, Figs 2 and 3.;

6. Photomicrographies of the samples with a Praktica camera and a Galileo metallographic microscope, Figs. 4, 5 and 6 (10);

7. Amount of mullitic phase (11), Table 3.

3. DISCUSSION

The most interesting characteristics of the samples are:

(a) Compressive Strnegths (Table 2 and Fig. 1);

(b) Low porosities - considering both low conformation pressure of the samples, 5 MPa, and composition of the raw-material, different from the typical composition of bricks (12).
This composition (like for CaO) allows, on the other hand, a wide variation (13).

The identification of the silico-aluminatic phases is important considering the range of firing temperature (1,000 - 1,200°C) different from the one utilized for brick making 900 - 950°C.

The most important compound in regard to the mechanical characteristics of the bricks is mullite (14): mullite is present in all samples as indicated on the X-graphies (Fig. 2.).

A confirmation of the formation of mullite comes from the IR-spectres (15), Fig. 3, because sillimanite X-ray spectre is very similar to the mullite one.

The mullite phase was furthermore evaluated in the samples (16): the mass % are shown on Table 3.

The amount of mullite phase increases with the firing temperature. The photo-micrographies show, moreover, an important connection between microstructures, porosities and compressive strengths (17) of the fired samples (Figs. 4, 5 and 6); the rise of the firing temperature from 1,000 to 1,100°C gives the product a very compact structure (Fig. 5) and a compressive strength of 74.60 MPa, greatly higher than the requirements of Italian Standards (18).

SULCIS COAL ASH		SLURRY	
Al_2O_3	16.00%	$(Al_2O_3 + Fe_2O_3)$	15.30%
Fe_2O_3	31.00	CaO	78.80
SiO_2	31.50	Mn_2O_3 and n.d.	5.94
TiO_2	1.50		
CaO	15.00		
ign.loss	0.60		
n.d.	4.40		

PASTE (90% SULCIS COAL ASH, 10% SLURRY BY WEIGHT)	
CaO	21.38%
SiO_2	28.40
TiO_2	1.35
Fe_2O_3	28.31
Al_2O_3	15.52
n.d.	4.55

TABLE 1. Chemical Compositions

SAMPLE	I	II	III	IV	V	VI
1	1,000	1.698	0.366	3.88	2.5%	1.01
2	1,100	2.050	0.098	74.60	2.5	1.01
3	1,200	1.180	0.113	27.10	5.5	0.60

Notes:

I : FIRING TEMPERATURE, ^{o}C

II : SPECIFIC WEIGHTS, g/ccm

III : POROSITY, ccm OF MERCURY PENETRATED IN 1.0 GRAM OF SAMPLE

IV : COMPRESSIVE STRENGTH, MPa

V : FIRING SHRINKAGE, % OF THE SAMPLE BEFORE FIRING

VI : NON-REACTED CaO,GRAMS/100g OF SAMPLE

TABLE 2. Characteristics of Fired Samples

SAMPLE	FIRING TEMP.	% MULLITE
1	1,000°C	13.00
2	1,100	45.00
3	1,200	47.00

TABLE 3. Amount of Mullitic Phase

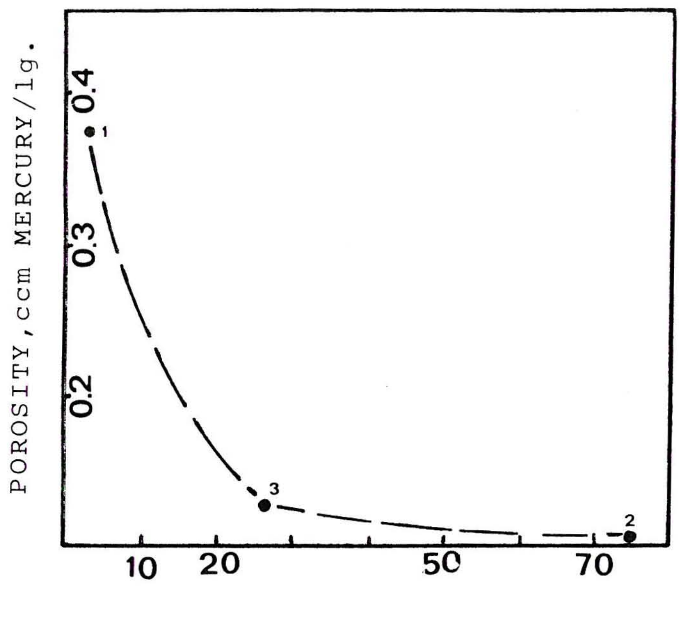
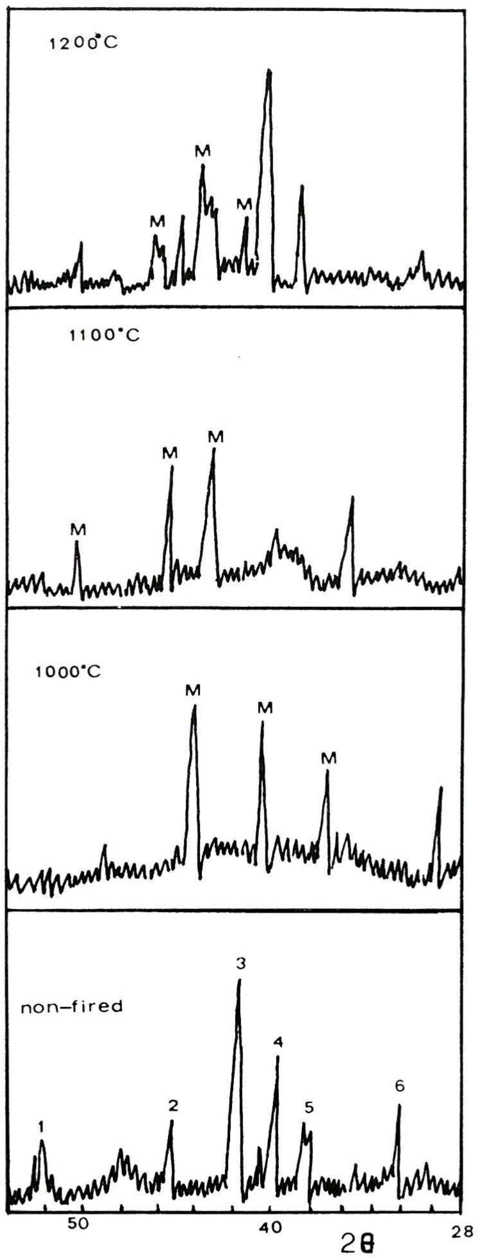


FIG. 1. COMPRESSIVE STRENGTHS V POROSITY



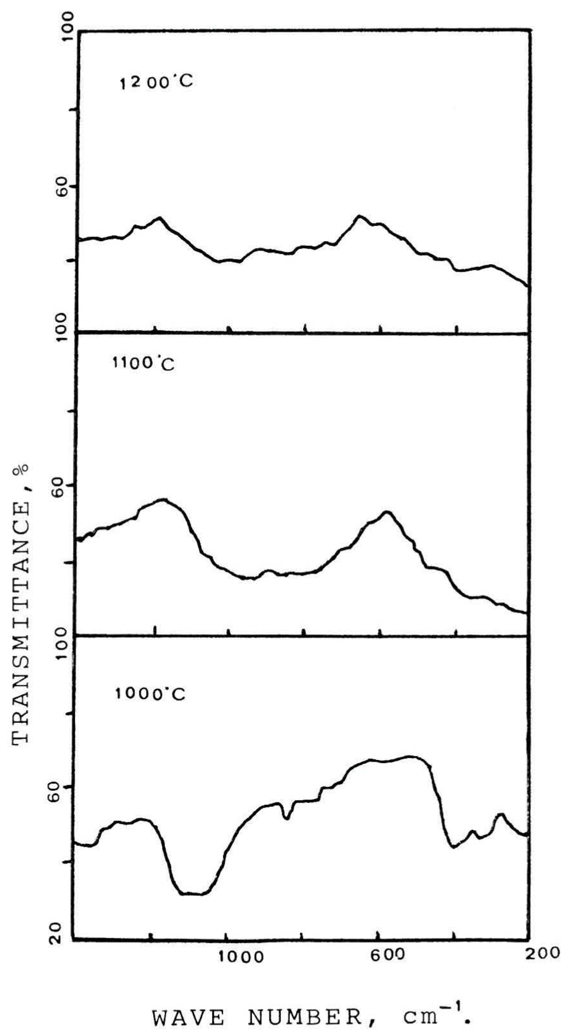


FIG. 2. X-RAY SPECTRES.
(RAD. Fe -k)

WAVE NUMBER, cm^{-1}.

FIG. 3. IR-SPECTRES.

NOTE (FIG. 2)

1 = Ca-carbonate; 2 = Ca,Na-aluminosilicate; 3 = Ca-aluminosilic;
4 = Fe-silicate; 5 = Ti-bioxyde; 6 = Ca-aluminosilicate;
M = mullite.

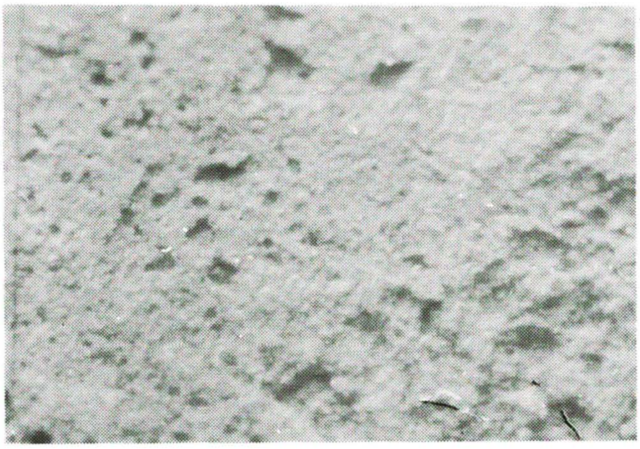


FIG. 4.

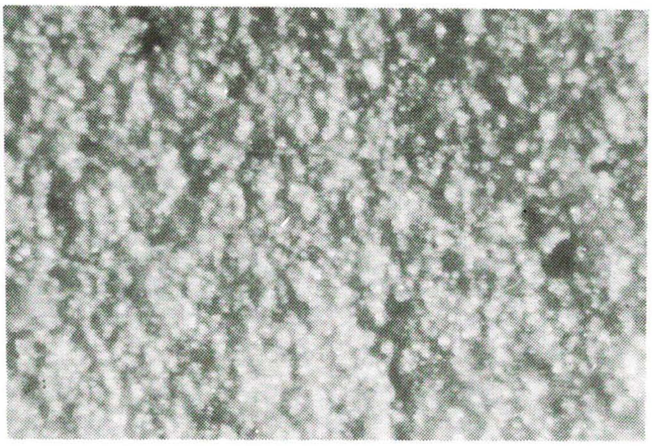


FIG. 5.

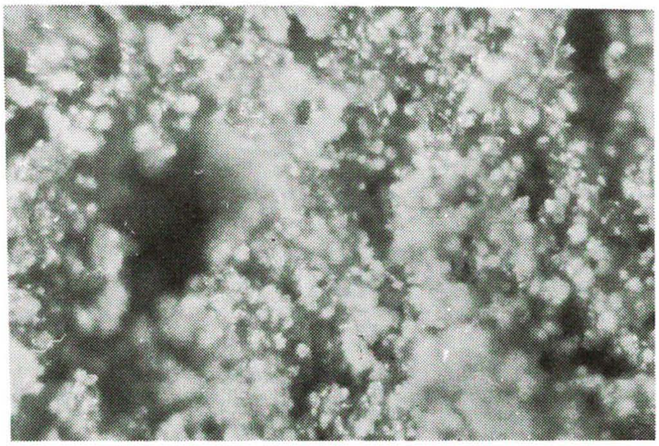


FIG. 6.

FIG. 4, 5 and 6: PHOTOMICROGRAPHIES.

FIG. 4 : SAMPLE FIRED AT 1,000°C

FIG. 5 : " " 1,100°C

FIG. 6 : " " 1,200°C

ENLARGEMENT : 300 X

The porosity, equally, decreases rapidly with the compaction due to the rise of temperature.

An increase of porosity is produced in the firing at 1,200°C, probably because the rise of temperature has caused holes and distorsions in the structural lattice of material (19).

This corresponds also to an irregular variation of the specific weights (20), Table 2, in connection with the porosities.

4. CONCLUSIONS

The materials fired at 1,100-1,200°C are made up of mullite and other vitreous and crystalline silico-aluminate phases.

Their good mechanical properties permit one to regard them as a positive answer to the problems of disposal and re-using the Sulcis Coal Ash, this Coal being the unique Italian solid fuel.

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