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ARTICULOS CORTOS

Substitution of feldspar as a component of wall and floor tiles by other alkali-containing raw materials

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ABSTRACT.—Substitution of feldspar as a component of wall and floor tiles by other alkali-containing raw materials.

The study of the properties on ceramic tiles including tuff or perlite respectively in their compostions has been carried out in certain areas of the three-component systems:

- **Quartz sand-clay-tuff.**
- **Quartz sand-clay-perlite.**

Ten compositions were investigated modifying the raw material contents on 5% intervals:

a) **Volcanic tuff from 40 to 55%.**
b) **Clays from 25 to 35%.**
c) **Quartz sand from 15 to 30%.**

Fast single firing process was performed. The final results show, that it is possible to substitute the feldspar by other alkali-containing components (tuff, perlite) for the technology wall and floor tiles production for interior application.

RESUMEN.—Sustitución de feldespato por otras materias primas conteniendo alcalis, como componente de revestimientos y pavimentos cerámicos.

Se ha llevado a cabo un estudio de las propiedades de revestimientos y pavimentos cerámicos con la inclusión de toba y perlita en las composiciones originales, respectivamente, en ciertas áreas de los sistemas de tres componentes:

- **Arena de cuarzo-arcilla-toba.**
- **Arena de cuarzo-arcilla-perlita.**

Se han investigado diez composiciones variando la materia prima en intervales del 5% de la manera siguiente:

a) **Toba volcánica desde el 40 al 55%.**
b) **Arcillas desde el 25 al 35%.**
c) **Arena de cuarzo desde el 15 al 30%.**

Se ha utilizado el proceso de cocción rápida. Los resultados finales muestran que es posible sustituir el feldespato por otros componentes alcalinos, tales como toba o perlita, para la producción de pavimentos y revestimientos cerámicos de interiores.

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1. INTRODUCTION

The fast firing process for production of wall and floor tiles implies high conditions to the composition and properties of the ceramic products to get an adequate microstructure in a short period of time (20-50 min.) at temperatures up to 1,200°C. The comparison of the physicomechanical characteristics and the period of service for ceramic tiles produced by the traditional and the fast firing methods, for similar values of water absorption index in various applications, does not demonstrate significant variations in the microstructure and phase composition, bending strength, linear expansion and the open/close porosity ratio (1,2). The processes for ceramic formation under fast firing conditions takes place with the presence of a liquid phase, being the qualitative indices of the final product dependent on its amount and properties, viscosity, wetting ability, and surface stress (3).

The aim of the present paper is to show the research carried out for finding a suitable substitute of feldspar materials as a component of ceramic bodies for floor and wall tiles produced by fast firing.

2. MATERIALS AND METHODS

Bulgaria has a limited feldspar resources, but considerable amounts of tuffs and perlites.

Possible substitutes of feldspar to 50% ratios in the ceramic bodies for fast firing have been previously investigated from very known volcanic tuffs and perlites from the southeast areas of Bulgaria. Otherwise, in the last sixties, bulgarian scientists have worked on the replacement of feldspar for tile ceramic production by using volcanic tuffs and perlites (4, 5, 6). These volcanic tuffs are mainly vitroclastic rocks of aleurite and rarely psephite mineralogical compositions.

The perlites show an acid rhiolite compositions and they are very hydrated. Melting behaviour of these natural raw materials is such that they melt at lower temperatures than felspars, being the melts more reactive and the sintering processes take place at higher velocities (6, 7).

The X-ray mineralogical analysis (fig. 1) shows a comparison between the mineral composition of tuffs and perlites and the corresponding pegmatites.

The DTA and TG curves of these raw materials under fast firing at 20°C/min. (fig. 2) depicts the quartz β-α phase transition at 576°C for perlite and pegmatite. Conversely, for tuffs the same transition is not observed, possibly due to the

TABLE I

MINERALOGICAL COMPOSITION OF RAW MATERIALS

Mineral phases	Raw materials (%)		
	Pegmatite	Volcanic tuff	Perlite
Volcanic glass	—	85-90	86-91
Feldspar	72-75	10-15	7-11
Quartz	25-28	1-2	2-4

lower silica content. It is normal for volcanic tuffs at 483 °C and for perlite at 504 °C to exhibit endothermal effects probably due to dehydration. This can be confirmed by the corresponding TG curves as can be seen in the same Fig. 2. Likewise, for the pegmatite there is not this kind of endothermal effects, as was also confirmed by the TG analysis.

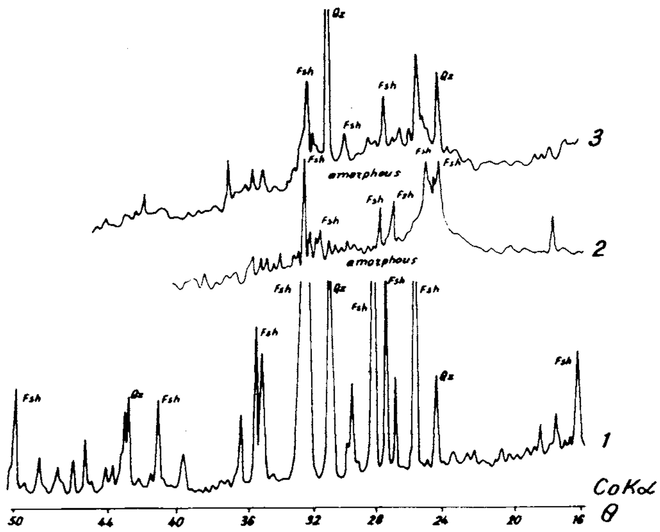

Fig. 1.—*X-ray structure analysis of: 1-pegmatite; 2-volcanic tuff; 3-perlite.*

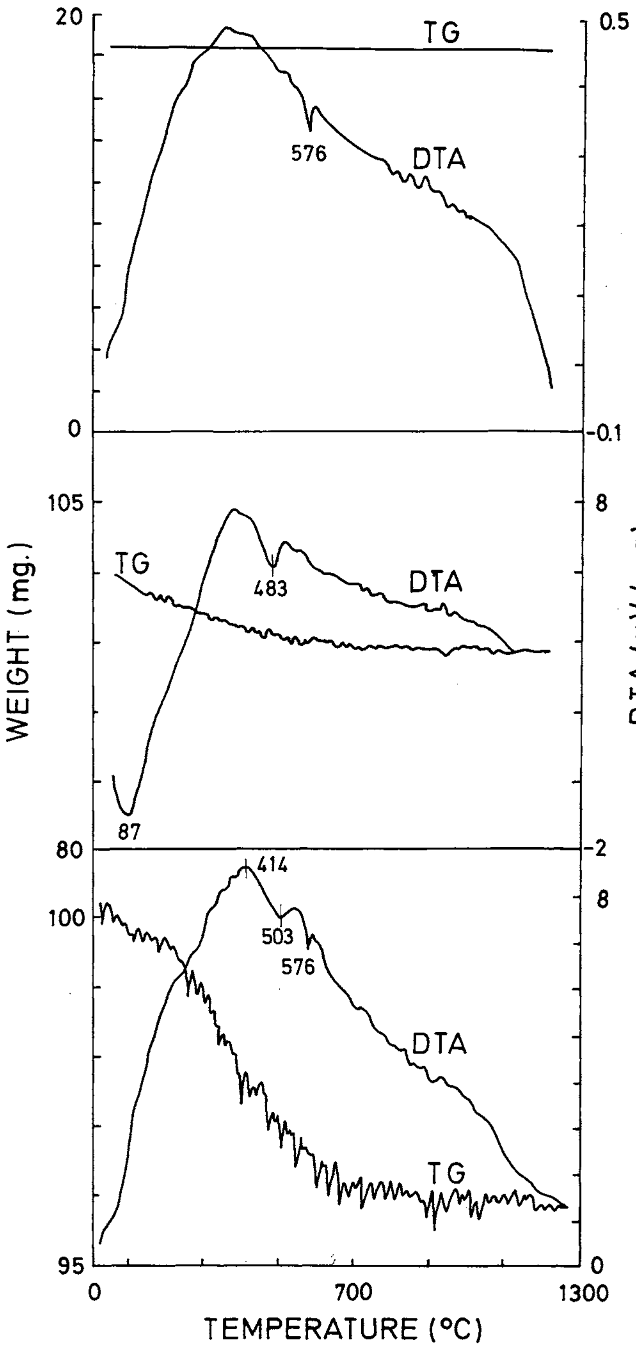

Fig. 2.—*DTA and TG curves for samples here investigated: 1.ª, pegmatite; 2.ª, volcanic tuff and 3.ª, perlite.*

The ceramic products properties with tuffs and perlites as substitutes of felspar have been investigated for the ternary systems:

— Quartz sand-clay-tuffs.
— Quartz sand-clay-perlite.

Ten compositions have been investigated with raw materials content changing at 5% intervals as follows:

— Volcanic tuff and perlite: from 40 to 55%.
— Clays: from 25 to 35%.
— Quartz sand: from 15 to 30%.

The table I shows the mineralogical analysis and the table II the chemical analysis of the indicated raw materials. The table III shows the formulated compositions compared with a conventional industrial composition.

3. RESULTS AND DISCUSSION

Samples of 200/8 mm tiles were produced by a double semidrying pressing at 160°C for 60 min and a fast single firing at the maximum temperature of 1,180°C. The results for the I and II compositions compared with a comercial (III composition) (table III) are shown in the next Figs. 4 and 5 and in the table IV.

The X-Ray analysis of the studied compositions shows the following mineral phases (Fig. 3): Quartz, mullite and glassy phase in the three considered compositions. Otherwise,

TABLE II

CHEMICAL COMPOSITION OF THE RAW MATERIALS

Nr.	Raw materials	Oxide Content (%)							
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O
1	Volcanic tuffs	71.40	13.00	1.47	—	1.88	0.85	4.69	1.85
2	Perlite	72.80	12.86	0.70	—	1.93	0.25	3.99	4.70
3	Pegmatite	72.70	16.50	0.20	—	1.10	0.20	0.20	8.80
4	Quartz sand	97.00	—	0.20	—	1.02	0.24	0.09	0.20
5	Clay	59.95	24.71	2.00	0.55	0.80	1.28	0.98	0.53

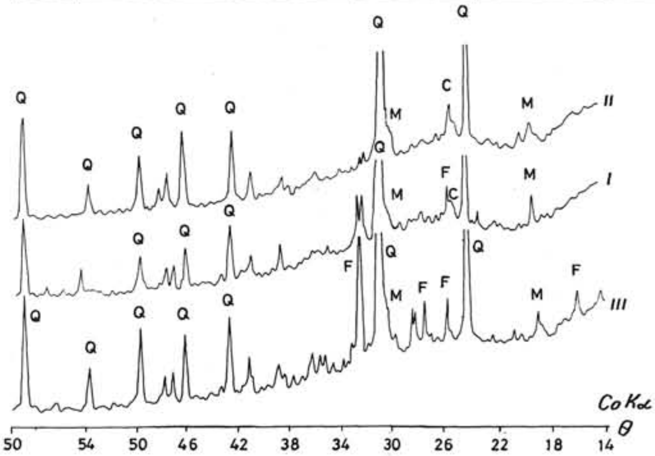

Fig. 3.—*X-ray phase analysis of compositions I, II and III.*

TABLE III

COMPOSITIONS I AND II COMPARED
TO A CONVENTIONAL INDUSTRIAL COMPOSITION

Nr.	Raw materials (%)	Compositions		
		I	II	III
1	Volcanic tuffs	50	—	—
2	Perlite	—	50	—
3	Pegmatite	—	—	34
4	Clay	25	25	35
5	Quartz sand	25	25	31

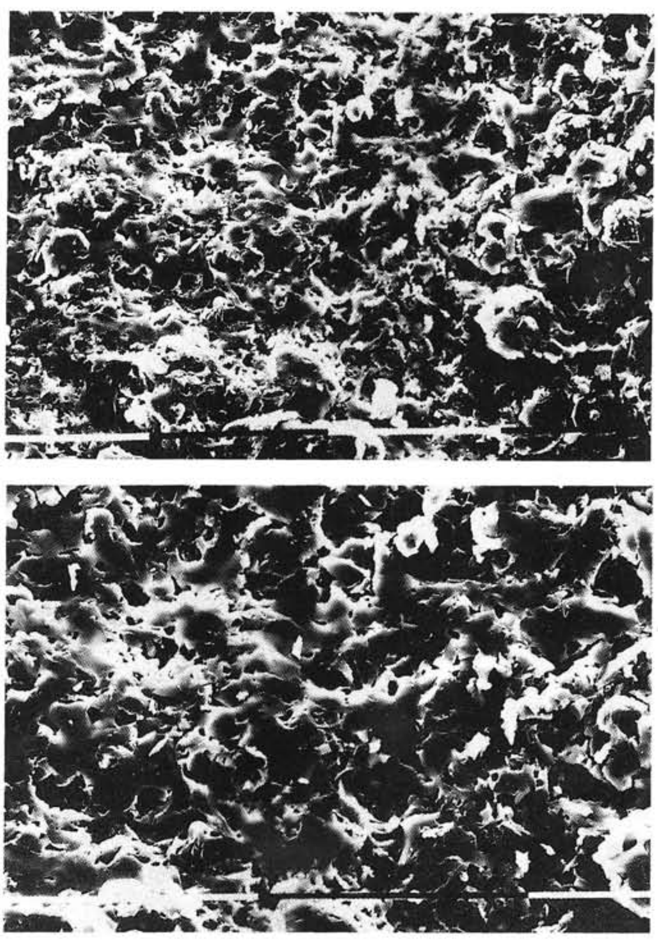

Fig. 4.—*Microstructure observed by SEM on III composition: a) x270 and b) x420 magnifications.*

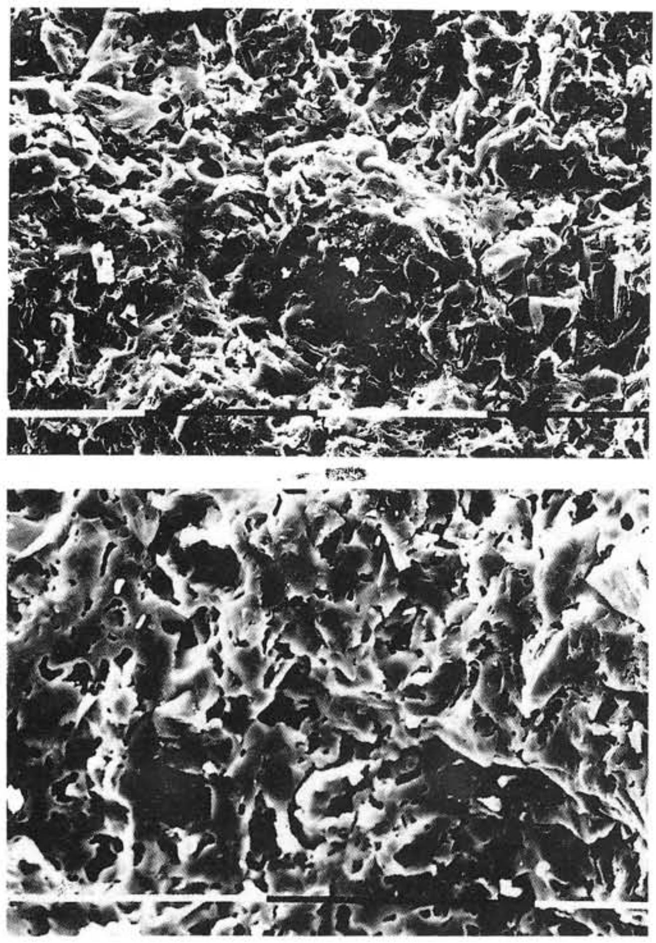

Fig. 5.—*Microstructure observed by SEM on II composition: a) x270 and b) x920 magnifications.*

TABLE IV

PHYSICO-CHEMICAL AND MECHANICAL PROPERTIES OF CERAMIC TILES PRODUCED FROM BULGARIAN FELDSPARS

Nr.	Properties	Measure	Compositions		
			I	II	III
1	Mechanical bending:				
	— Strength	MPa	—	—	—
	— Before drying	MPa	0.9	0.8	1.0
	— After drying	MPa	2.0	2.0	2.1
	— After firing	MPa	28.0	30.0	28.0
2	Water absorption	%	3.3	5.4	4.5
3	Linear compression	%	5.9	6.0	6.0
4	Thermal shock change 150°C – 15°C ± 5°C	number of cycle-over	15.0	15.0	15.0
5	Linear coefficient of thermal expansion	$10^{-6}deg^{-1}$	6.2	6.9	8.4

residual feldspar can be observed in the I and III compositions. These materials depict opaque glazes at their surface. The II composition material does not show this glazed surface due to the decreased feldspar content in the perlite mineral composition. On the other hand, some cristobalite phase in I and II compositions can be detected.

The Figs. 4 and 5 shows that similar microstructures can be obtained for II and III compositions, that is for a new fast firing product obtained from bulgarian perlite and for a comercial fast firing ceramic. However, the III composition (Fig. 4) is characterized by a more open porosity, while the II composition (Fig. 5) depict more isolated pores.

The similar phase and microstructure composition of the samples here considered implies, therefore, a similar physico-mechanical properties as is shown in the table IV. It is noteworthy to point out that I composition presents lower water absorption than the comercial material and that linear expansion coefficients obtained for the new proposed tuff and perlite compositions are lower than in the III comercial product.

Finally, the following conclusions can be stated from the above results:

1. Ceramics compositions formulated from bulgarian tuffs and perlites and processed by single fast firing give rise to similar phases and microstructures to comercial fast firing ceramics.
2. In some cases the properties of the final materials are improved with respect the commercial ones obtaining better quality of the final products.
3. Volcanic tuffs and perlites are suitable substitutes of feldspars for ceramic tiles production by single fast firing processing.
4. The above mentioned natural materials can solve an important raw materials problem for bulgarian ceramic industry and this can be also useful in countries or areas with low feldspar production.

4. REFERENCES

1. GHRUM-GRZIMAILO, C. S. and BERUSTEIN, P. I.: Structure and phase composition of ceramic tiles shells produced by fast and long period firing. *Glass and Ceramic,* 2 (1976) 16-18.
2. BERNSTEIN, P. I. and FINKE, V. A.: Physico-mechanical properties dependence of non-glazed tiles on firing continuance and temperature. *Glass and Ceramic,* 1 (1980) 13-14.
3. RHISTCHENCO, M. I. and LHISSANCHUK, G. V.: Industrial and technological ceramics properties improvement. *Technica, Harpov,* URSS (1987) 10-11.
4. VERGILOV, V.: Some possibilities for volcanic tuff application in Ceramics Industry. *Building Materials and Silicate Industry,* 6, (1961) 21-22.
5. GERASSIMOV, E., ILIEVA, I. and TABAKHOVA, M.: Investigation on volcanic tuff influence as a substitute of feldspar in porcelain masses. *Building Materials and Silicate Industry,* 6 (1983) 14-18.
6. GERASSIMOV, E., BACHVROV, S. and KHUKHUSHEVA: Perlite application in masses for ceramic tiles. *Building Materials and Silicate Industry,* 6 (1968) 15-17.
7. BAKHALOV, Z. and BACHVAROV, S.: Volcanic tuff application in household porcelain and tiles. *Building Materials and Silicate Industry,* 2-3 (1975) 21-26.

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