EFFECT OF PORTUGUESE CLAYS ON THE PROCESSING AND CHARACTERISTICS OF PORCELAIN TILE BODIES AND FLOOR TILES

H. Goerg(*), F. Heyder(**), K.-H. Dominicini(**)

(*)ARGIGUS, Comercio de Argilas Lda, P-2400 Leiria
(**)Fachhochschule Koblenz, Dept. of Ceramics,
D-56203 Höhr-Grenzhausen

1. DIFFICULTY AND PROBLEM

The growing production of unglazed porcelain tile and porcelain tile with a surface finish requires a highly vitrified, strong ceramic material with an attractive design.

Technologically this is achieved by using a fine milled, easily coloured, raw materials composition, with a great vitrification capacity. This requires using raw materials with abundant fluxes (feldspars, clays). The clays also provide additional green mechanical strength. Other requirements to be met regarding raw materials quality are favourable rheological properties and a low carbon content to avoid black coring.

In porcelain tile compositions, plastic clays are used preferably from Germany, England, France and the Ukraine. The ARGIGUS company markets high quality, white plastic clays from Portugal for the European floor tile industry. The present work examines the suitability of these clays for porcelain tile production and compares their properties on substituting them for a Ukrainian clay.

2. RAW MATERIALS AND SUBSTITUTION TESTS

The tests using Portuguese clays were carried out with a porcelain tile composition resembling the body composition used in industry, based on the body composition detailed in Table 1.

A series of high quality Portuguese white clays were used as replacement materials for the Ukrainian clay. These materials and their chemical analysis have been set out in Table 2.

Feldspar	38	% solid matter
Pegmatite	16	% solid matter
Kaolin	20	% solid matter
Clay	26	% solid matter
Of which:		
Ukrainian clay	21	% solid matter

Table 1. *Composition of the reference porcelain tile body.*

Following a process often used in industry, the whole amount of Ukrainian clay in each composition was replaced by a respective Portuguese one. The reference mixture U, and the compositions with the respective substitutions were milled for 12 h in laboratory porcelain mills until an aqueous slip was obtained, which was subsequently dried, granulated and used to press laboratory test specimens.

Nº	Type of raw material Trade name	SIO_2	AL_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O
01	Clay Ukraine "R"	68,8	25,3	1,0	1,4	0,4	0,5	0,3	2,3
02	Clay Argigus 114-51	64,8	29,8	1,9	0,7	0,1	0,6	0,1	2,0
03	Clay Argigus 114-71	64,7	30,3	1,5	1,0	0,1	0,5	0,1	1,8
04	Clay Argigus 1140	67,8	28,2	1,2	0,4	0,1	0,2	0,1	2,0
05	Clay Argigus 1101	61,9	31,5	2,5	0,9	0,2	0,9	0,1	2,0
06	Clay Argigus 1111	61,5	32,5	1,9	1,5	0,2	0,7	0,1	1,6

Table 2. *Chemical analysis of the substituting raw materials (% solid matter, fired specimens)*

After firing the respective specimens at 1200°C in an electric laboratory kiln for 90 min, the material properties reported in Table 3 were obtained.

Composition		U	51	71	1140	1101	1111
Water Absorption According to EN 99	%	1,59	2,60	3,02	4,74	0,80	1,05
Bulk density	g/cm^3	2,34	2,29	2,28	3,30	2,39	2,38
Apparent porosity	%	3,73	5,95	6,87	6,32	1,93	2,51
Mechanical strength	N/mm^2	37,3	21,5	19,9	10,6	19,6	31,6

Table 3. *Characteristics of the stoneware materials obtained by just replacing the clay.*

No changes were found in the results obtained under laboratory conditions for the slip and pressing properties, or in the firing colour on comparing the starting U composition with the compositions containing the substitutions. Using a constant firing curve and temperature (1200°C), clay mixtures 114-51, 114-71 and standard clay 1140 yielded less favourable vitrification results, while clays 1101 and 1111 sintered better. Mechanical strength was generally lower than that of starting composition U.

The importance of the chemical and mineralogical composition of a stoneware body (e.g. proportion of clay-quartz-feldspar) in this case required adjustment, especially in the alkali content to obtain similar products. To produce a porcelain tile structure, milling time was also lengthened.

Using mixtures 114-51 and 114-71 of ARGIGUS clay and a minor compositional adjustment with regard to the alkali bearers (taking into account the price of the raw material), test specimens were formed under laboratory conditions at 1200°C with a constant firing schedule (electric laboratory roller kiln).

At the same ignition loss (7.7%) of the studied compositions, taking into account the influence of compaction in pressing on shrinkage generally and in firing, the resulting materials properties are presented in Table 4.

	Composition with 114-51	Composition with 114-71	
Feldspars	39	39	% solid matter
Pegmatite	17	18	% solid matter
Kaolin	20	20	% solid matter
Clays	24	23	% solid matter
Of which 114-51	19		% solid matter
Of which 114-71		18	% solid matter

Table 4. Composition of the body on replacing the clays and keeping a constant proportion of clay-quartz-feldspar constituents.

Composition / Characteristics of the material		U2	114-51	114-71
Firing colour Grey-white	L*	68.1	70.2	71.7
	a*	1.8	1.2	1.6
	b*	9.7	9.9	10.0
Water absorption EN99	%	1.09	0.14	0.19
Bulk density	g/cm^3	2.40	2.44	2.41
Apparent porosity	%	2.60	0.35	0.46
Mechanical strength EN100	N/mm^2	11.0	16.2	19.6

Table 5. Characteristics of the laboratory materials obtained on replacing the clay and keeping the body's chemical composition constant (constant proportion of clay-quartz-feldspar constituents).

3. SUMMARY AND CONCLUSIONS

The substitution usually practised with raw materials, as in the example of the Ukrainian clay by a Portuguese clay, generally produces compositional changes in the resulting body, and at first the properties of the products obtained tend to be unfavourable.

A scientifically accurate substitution of a clay and the general body composition showed that white Portuguese clays represent a potentially excellent material for porcelain tile manufacture. With the respective milling of the compositions, water absorption was obtained under fast-firing conditions.

On the basis of the difficult granulation of the pressing powder in the laboratory, the mechanical strength data found in the study can only be used to show the trend. The absolute data for these compositions will improve with industrially produced granulates and less forced firing curves. The firing colour measurement (Hunter-Lab system) run on the Portuguese clays showed a light firing colour, which did not differ from that of the starting composition.

The unlimited potential use was thus confirmed of these white clays, especially with regard to critical quality parameters such as water absorption, green mechanical strength, and firing colour in porcelain tile compositions The material was shown to compare excellently with a currently used Ukrainian clay.