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Bodies and glazes for sanitaryware production with the introduction of extra-european raw materials

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R.M. Ricerche Minerarie S.r.l. of Lozzolo (VC) and S.R.C. Engineering S.r.l. of Dormelletto (NO) presented the results of a study on the introduction of Indian raw materials in vitreous china body and glaze compositions for the production of sanitaryware appliances. These Indian clays and feldspars derive form a recent technical-sales agreement between R.M. and the Indian company EMJAY enterprises Pvt. Ltd of Madras. The tests have been carried out in the laboratory and on the pilot production line of S.R.C. Engineering S.r.l., a consulting company, recently been conceived from the broadening of the activity that Mr. Rodolfo Grassi has been carrying out for over 50 years in the ceramics sector. The results of the study have highlighted the advantages of using the DWT clay, thanks to the minimum residue left following sieving and of the excellent response to the fluxes, and of using MKH (potassium) and MKG (potassium sodium) feldspars that give the possibility to vary the melting characteristics of the glazes according to the firing cycle needs.

1 - INTRODUCTION

The subject of this work is the result of laboratory studies regarding the introduction of Indian raw materials in bodies and glazes for sanitaryware production. The research was made in the laboratory and pilot plant of S.R.C. Engineering, Dormelletto (NO) and in the laboratory of R.M. Ricerche Minerarie, Lozzolo (VC).
The possibility to have at disposal raw materials coming from India has been possible for the commercial and technical agreement signed between R.M. Ricerche Minerarie and the Indian Company EMJAY Enterprises Pvt. Ltd. (Madras,Tamil Nadu State, Southern India).
R.M. Ricerche Minerarie is a mining company established in 1981 and specialized in the exploitation of clay and feldspatic deposits.

Fig. 1 - New laboratories of R.M. Ricerche Minerarie at Lozzolo (Vercelli Province, Northern Italy).

G.P. Bertolotti, R.M. Ricerche Minerarie S.r.l.

R.M. Ricerche Minerarie mining tradition is previous to the foundation of the company; in fact the father of the present owner started to exploit Lozzolo clays ever since the fifties.
Recently in Lozzolo headquarters new laboratories have been completed for the detailed studies of raw materials and ceramic compositions and where it is possible to make the most important ceramic and technological tests.
S. R. C. Engineering is focused on consultant services for the ceramic industry and, thanks to a deep specific experience of its members, mainly oriented to the sanitaryware and tableware production processes.
S.R.C., thanks to the laboratory and pilot plant for semi-indua-

strial tests, is able to offer a wide range of services from production know-how to technical and management training of customer 's personnel.
One of the activities of S.R.C. Engineering is related to the application of the most modern I.T. technologies to the production management thanks to systems developed by the same S.R.C. Among these ones, a system for the total

Fig. 2 - Bar code system for production management.

production management of sanitaryware production by means of bar code ceramic labels directly applied to the cast pieces.
RM Ricerche Minerarie S.r.l cooperates with S.R.C. Engineering for the development of new projects related to the sanitaryware production from the mining exploitation to the development of new typologies of raw materials and the optimization of their final quality.
Emjay Enterprises, established in 1993 in Tamil Nadu State (Southern India), is principally a technological Company with its core competence in the areas of project management, sourcing and processing of ceramic raw materials. EMJAY operates selected clay and feldspar mines with proven reserves of consistent quality and is regular supplier of raw materials to ceramic factories in India and Far East Countries.

Fig. 3 - Emjay Feldspar mine in Andhra Pradesh, Southern India.

2 - THE INDIAN RAW MATERIALS

A detailed analysis of several available mineral deposits in India and a preliminary laboratory control of the resulting raw materials permitted us to identify 4 Indian locations interesting for sanitaryware production.
The selected raw materials are the following:

— MKH Feldspar (Hyderabad, Andhra Pradesh State)
— MKG Feldspar (Gudur, Andhra Pradesh State)
— DWT Ball Clay (Eluru, Andhra Pradesh State)
— TBC Ball Clay (Thangadh, Gujarat State)

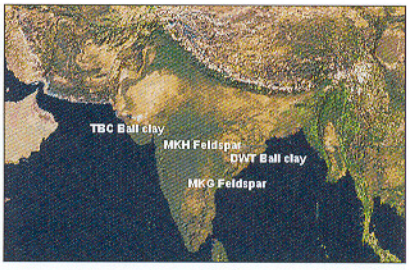


Fig. 4 - Location of indian clay and feldspar deposits suitable for sanitaryware production.

2.1 - Chemical and mineralogical analysis

The following Table I synthetizes the chemical and mineralogical composition of the indian raw materials.
Rietveld methodology has been used for the quantitative mineralogical analysis.
The clay TBC has not been utilized for the experimentation as the high level of organic substances, besides a positive effect on the deflocculant total demand, can influence the plaster working

Table I - Results on laboratory tests for Vitreous-China body slip and glaze.

Chemical analysis

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	P.F.
MKH Feldspar	65,9	18,4	0,05	0,01	0,05	-	2,34	12,8	0,22
MKG Feldspar	66,0	19,9	0,03	-	1,13	0,01	6,04	6,44	0,21
DWT Ball Clay	54,8	29,21	1,12	0,9	0,76	0,67	0,21	1,19	10,7
TBC Ball Clay	59,0	25,0	0,58	0,2	0,50	0,60	0,3	0,5	12,88

Quantitative mineralogical analysis (Rietveld Method)

MKH Feldspar	%
Quartz	2
Sodium Feldspar	20
Potassium Feldspar	75

MKG Feldspar	%
Quartz	4
Sodium Feldspar	50
Potassium Feldspar	32
Illite	8

DWT Ball Clay	%
Quartz	27,7
Kaolinite	57,3
Illite	12,0
Anatase	1,0
Sodium Feldspar	1,0
Alunite	1,0

TBC Ball Clay	%
Quartz	37,4
Kaolinite	53,8
Illite	5,0
Sodium Feldspar	2,0
Anatase	1,5

1. Appearance:	pale gray blocks
2. Moisture:	2.0%
3. Particle size analysis	
Residue on sieve	
Span mm 0.300	0.15
Span mm 0.200	0.26
Span mm 0.150	0.31
Span mm 0.120	0.31
Span mm 0.100	0.41
Span mm 0.075	0.93
Span mm 0.060	1.26
Span mm 0.040	1.29
Span <0.040	96.08
Total	100.00

Table II - Results of experimental evaluation of the DWT clay.

mould surface if used in the slip composition in percentage higher than 2-3%.

2.2 - DWT Clay

DWT Ball Clay belongs to wide sub-horizontal clay deposits of Cretaceous Age ("Raghavapuram shales and clays") visible at few kilometers from Eluru town, Andhra Pradesh State.

2.2.1 - LABORATORY DATA SHEET
The experimental evaluation of the DWT clay has been performed following the standard tests utilized in S.R.C. laboratory. The obtained results are synthetized in the following Table II.

Fig. 5 - DWT Ball Clay Mine, Eluru Andhra Pradesh.

2.2.2 - SENSITIVITY TO ELECTRO-LYTES WITH GALLENKAMP VISCOSIMETER AT DENSITY G/L 1600
The sensitivity test to electrolytes has underlined an optimum answer to the deflocculant agents of the DWT clay, as it appears on the obtained sensitivity curve.

2.2.3 - RESULTS
The M.O.R., shrinkage, water absorption and bending tests performed using plaster moulds with dimensions and shapes following S.R.C. standards and the plasticity test, have given the following Table IV.
The sample examined has a total residue on sieve 0.12 mm span of 1.03%.
So there is no loss of material during last phase sieving.
Sensitivity to electrolytes (sodium silica) is very good. Consequently using this clay in ceramic body slip brings to a possible reduction of the percentage of deflocculant to be added to the composition.
Plasticity and M.O.R. is in the average of standard Vitreous-China body compositions.

Pfefferkorn Plasticiy	27.4
M.O.R. Kg/sqcm	15.06
Shrinkage of dry material	5.80 from suspension at density = g/l 1600
Fired at SK 6a/7	9.20
Total	15.00
Shaping	12
Water absorption at SK 6a/7	6.10%
Colour	Ivory

Table IV - Results of DWT clay.

2.3 - MKG Feldspar

Near the town of Gudur are present very interesting pegmatitic deposits of lenticular shape well known and exploited for the presence of level rich in mica (Nellore mica belt).
The area of pegmatites outcrop is wide (100 km x 20 km) and many exploitation fronts show high quality and purity feldspars.
The experimental evaluation of the MKG Feldspar has been performed by firing in laboratory muffle a set of material samples according to the S.R.C. standards with the following Table V.

Table III - Sensitivity curve.

Analisi chimica

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	P. F.
54,8	29,2	1,12	0,9	0,76	0,67	0,21	1,19	10,7

Analisi mineralogica quantitativa

	%
Quarzo	28
Caolinite	57
Illite	12
Anatasio	1
Albite	1
Alunite	1

Fig. 6 - MKG Feldspar.

Appearance of the raw material:	rocks white/ pale gray
Appearance of fired material at : SK 6a/7	pure brilliant and greified areas white/semi transparent white

Table V - Experimental evaluation of the MKG feldspar.

Appearance of the raw material:	colour from pale gray/rose
Appearance of fired material at : SK 6a/7	mainly brilliant pure white/white semi transparent

Table VI - Experimental evaluation of the MKH feldspar.

2.4 - MKH Feldspar

It's a wide deposit composed of a very pure feldspar with high Potassium content located approximately at 50 Km South West from Hyderabad.
From geological point of view the deposit belongs to very old granite rocks intruded in gneisses and mica schists of Archean Age.

Fig. 7 - MKH Feldspar.

The experimental evaluation of the MKH Feldspar, like the previous one, has been performed by firing in laboratory muffle a set of material samples with the following Table VI.

Table VII - Vitreous china body composition.

Vitreous-China composition (RM 11.1):	Percentage
Ball clay (U.K.)	18
DWT clay	10
China clay (U.K.)	22
MKG feldspar	28
Quartz	22
Total	100

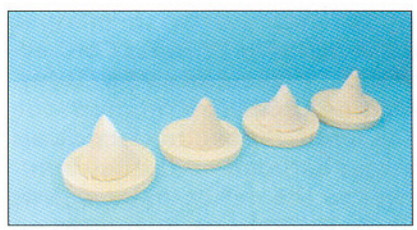


Fig. 8 - Feldspars fired specimen.

Table VIII - Body preparation parameters.

1ª Phase:	Water dispersion of the clays
Density g/l	1500
Dry/water ratio	53.75/46.25
Sodium silica (d. 1.39)	0.08%
Gallenkamp viscosity	346°
2ª Phase:	Addition of kaolin/water to the 1ª Phase suspension
Density g/l	1560
Dry/water ratio	57.90/42.10
Sodium silica (d. 1.39)	0.08%
Gallenkamp viscosity	344°
3ª Phase:	Addition of preground feldspar/ quartz at fineness 6400 to the 2ª Phase suspension
Addition of water up to density g/l	1810
Sodium silica (d. g/l 1.39)	0
Gallenkamp viscosity at 1' - 6'	322°/292°
Gallenkamp viscosity after 24 hours	318°/290°
Thickness development at 30' - 60' - 90'	mm 6 - 8 - 9.8

3 - EXPERIMENTATION - BODY SLIP

On the basis of the tests made on the single raw materials, it has been possible to develope and verify in laboratory a Vitreous-China body composition for sanitaryware production as reported in the following Table VII.

Body laboratory preparation
The body preparation has been made in 3 phases as reported in the following Table VIII.

4 - RESULTS

The shrinkage, M.O.R., water absorption and bending tests made using mould plaster of dimensions and shapes according to the S.R.C. standards, have given in the following Table IX.

Shrinkage of crude material	2.40
Shrinkage of material fired at SK 6a/7	9.40
Total shrinkage	11.80
M.O.R. Kg/sqcm	16
Water absorption SK 6a/7	0.50%
Shaping	52 mm

Table IX - Technical characteristics of the body.

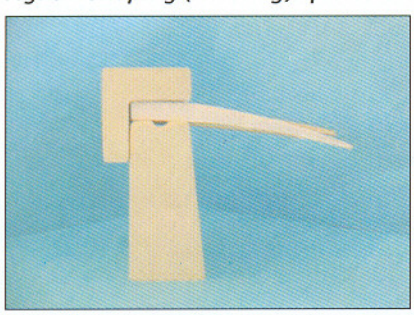
5 - EXPERIMENTATION – GLAZE

On the basis of the evaluation on the single feldspars, it has been possible to develope and test in laboratory a white glaze composition for Vitreous-China for sanitaryware production as reported in the following Table X.
The application of the glaze on samples of the RM 11.1 body slip has produced standard values as far as brightness and colour are concerned. The firing cycle (heating phase) is as follows Table XI.

h 1	200°
h 2	440°
h 3	600°
h 4	760°
h 5	900°
h 6	1215°

Table XI - Values of brightness.

Fig. 9 - Shaping (bending) specimen.



Composition of a single firing glaze for Vitreous-China at SK 6a/7 (RM 21.2)	Percentage
Sodium/potassic feldspar	24
Potassic feldspar	16
Kaolin	7
Quartz	22,5
Calcium carbonate	16,5
Zinc oxide	2,5
Wollastonite	1,5
Zirconium silicate	10
Total	100

Table X - Glass composition.

6 - CONCLUSIONS

DWT ball clay

The introduction in the composition of DWT clay has allowed to obtain a body slip with very low percentual quantity of deflocculant.
In 3rd Phase - final body slip - with the relieved viscosity - we have obtained a satisfactory thickness and a fast drying time of the thickness.
It is possible then to consider a preparation with further lower percentage of deflocculant and consequent viscosity of 300/310° with the result of a further lower thickness development time.
The physical characteristics of the fired body slip are those of a standard Vitreous-China body slip.

MKH and MKG Feldspars

The main advantage of using the two feldspars MKH and MKG derives from the possibility to change the rate sodium potassic feldspar / potassic feldspar relating to the different firing diagrams.
A fast firing diagram, as that of a roller kiln, can require a glaze composition with a high percentage of sodium potassic feldspar, while a slower firing diagram requires mainly potassic feldspar.
The result of both solutions is an equal viscosity value of the glaze during fusion, allowing to mantain constant, in relation to the glaze, the quality characteristics of the planned production.
On the basis of the tests performed on the analyzed Indian raw materials it is possible to consider helpful and interesting their use for a sanitaryware production of a similar quality as the one requested by the European market.

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