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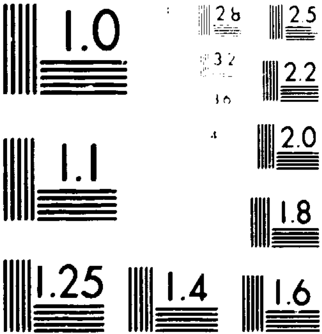
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org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COMMERCIAL EXPLOITATION OF CLAYS

By: J. Krejsa +

+ Ceramic and Glass Raw Materials Works, Sedlec, Czechoslovakia

CONTENT

I. Introduction

While considering trends in those ceramic raw materials which find their use in various industrial processes, it is perhaps helpful to start with the final commercial products being usually included in this category. When supposed that any solid, non-metallic product processed by subjecting it to the temperature above a red heat may be called a ceramic product, we must narrow the field under discussion and give some limiting terms. Commercial ceramic products are generally regarded as falling within one of the three following broad divisions:

a) Pottery and white ware

b) Structural clay products

c) Refractories and technical ceramics

What the materials for all the three divisions have in common is that either alone or in combination they must be capable of being formed into the required shape, and of undergoing a permanent chemical change during the appropriate application of sufficient heat with the result of obtaining a stable and resistant form of the desired product. Generally speaking, requirements of formability are usually due to a "plastic" body constituent which is capable of being moulded into the desired shape and of retaining that shape while being subjected to heat in the final treatment process. The body, however, consists of other significant constituents as that which "set hard" when subjected to the heat treatment, or that which assist this setting process, either by inducing it or by enabling it to take place at a lower temperature than would otherwise be the case. Sometimes even other constituent or constituents are added in order to contribute to some particular desired characteristics, such as better performance in a particular environment, or less expansion and shrinkage under heating and cooling, and so on.

There are four functions which a ceramic material may fulfil:

1) "skeleton" former
2) glass former
3) flux
4) special-property producer (modifier)

A distinction must be drawn between the functions of ceramic materials in the unfired body and their functions in the same body when fired, i.e. in the ceramic product. In the green state, the most obvious distinction is between "plastic" and "non-plastic" constituents of the body. The essence of ceramics, of course, is clay. Ability of clay to be formed into shapes when wet and to become permanently hardened when appropriatly heated is what gave rise to the art of ceramics in the first place.

II. General Remarks on Clays

- Essentially, the clay is a powdery form of a rock which has been broken into fine particles by the action of millions of years of decomposition by the forces of nature. Stated more scientifically, it is a hydrous silicate of alumina, that is to say, a compound of alumina and silica chemically combined with water. A theoretical formula for this substance might be read

  $Al_2O_3 \cdot 2\ SiO_2 \cdot 2\ H_2O$.

- Clay is very seldom found in this pure form. The forces of nature and numerous geological upheavals have caused that various impurities in the form of minerals and metal compounds have been added, and others, being soluble, have been leached out. Thus it is a variation of impurities in the basic formula that accounts for the different types of clay and, consequently, of clay bodies.

- Clays are usually classified into two basic types according to their geological origin. These are then subdivided by particle size and variation of impurities inherent in the native form of the clay. The two basic geological types of clay found in nature are
  - primary clays,
  - secondary clays.

1. Primary clays, sometimes known as residual clays, are those which are found in the same location as the parent rock from which they originated. They have not been moved by the forces of nature and are thus purer and truer to the theoretical formula. The primary clays are basically of one type, the kaolins.

2. Secondary clays are those which have been removed from the site of the parent rock by the forces of water, wind or glacial action. This transport of the clay by the forces of nature has had two essential effects on it. First of all, the action of water in streams full of rocks and pebbles tended to grind the coarse materials of the clay into smaller and finer particles and deposit them in beds along with various other eroded materials. This explains then the complex make-up of secondary clays as compared with the kaolins which remained on the site of the parent rock uncontaminated by other materials both organic and inorganic. Further it is to be expected that clays which have been transported by the action of nature contain many impurities such as iron compounds, mica, alkalis and carbonaceous compounds. Depending upon the variation of impure matter content, secondary clays can be further classified.

III. Classification of Clays and Applications of Major Clay Types

1. Classification of clays according to their origin and evolution of major types of clay deposits may be regarded from various points of view. For many purposes in the practice of the technologist the following classification seems to be instructive and useful for the first and basic implication of some general geological knowledge.

A. Primary (or residual) clays

I. Kaolins (white, firing white or light cream)

II. Red-burning residual clays (derived from different kinds of rocks)

B. Colluvial clays (practically landslide masses)

C. Secondary (or transported) clays

I. Deposited in water

a) Marine clays or shales (white-burning clays, ball clays and sedimentary kaolins, refractory clays or shales, impure clays and shales)

b) Lacustrine clays deposited in lakes and swamps (fire clays or shales, impure red-burning clays, calcareous clays, usually as surface deposits)

c) Flood-plain clays (usually impure and somewhat sandy)

d) Estuarine clays (mostly impure and finely laminated)

e) Delta deposits (variable purity, often lenticular)

II. Glacial clays (often stony, may be red- or cream-burning)

III. Wind formed deposits

B. Chemical deposits (some types of flint clays)

Another classification from the point of view of the technological use gives a more comprehensive idea about the behaviour and advantages of individual types of clays:

1. Kaolin
2. Ball clays
3. Fire clays
4. Stoneware clays
5. Earthenware clays
6. Slip clays
7. Bentonites (including fuller`s earth)

2. Some general remarks about the character and usage of clay groups

2.1 Kaolin - taking its name from the Chinese word meaning "high ridge" is without doubt the most plentiful and valuable of the primary clays. Kaolin is an extremely refractory clay with a melting point of over 1750°C. Kaolin is never used alone for making clay bodies because it is too difficult to shape due to its non-plastic quality and too resistent to fire into a hard, dense body at acceptable temperature ranges. Consequently, it is generally used in combination with various other clays and constituents which increase its plasticity and lower its maturing temperature. This is very necessary to produce a well shaped, hard, durable and dence body. Due to its whiteness and low shrinkage kaolin is often used to produce porcelain or white earthenware.

The major use of kaolin:

- a main ingredient in the production of porcelain and whiteware bodies
- a clay body additive to raise the maturing point of the clay

- a glaze ingredient to furnish alumina and silica
- a glaze ingredient for stabilizing glazes to prevent excessive flowing or running
- an ingredient of kiln wash to protect kiln shelves and furniture from glaze drippings.

2.2 Ball clays - are so named because they were first sold in that shape at English clay mines. As regards their properties, ball clays are practically the opposite of the kaolins. They are plastic, more fusible and have an iron content slightly higher than that of kaolin. It is just this property that actually makes them complementary in character. Consequently, they are often used in combination with each other to produce a workable and more practical clay body. Although ball clays are not as pure as kaolins, they are relatively free from iron and other mineral contamination and fire to body colours ranging from dense gray to light buff at about 1260°C. They can be used to lower the firing temperature of kaolins or to raise the maturing temperature of lower-firing clays, such as earthenware.

- Ball clays are used mainly to impart plasticity and workability to other less plastic clays. However, they are seldom used alone due to the excessive shrinkage during firing which is the result of their plasticity. Therefore ball clays are not usually added to clay bodies in percentages above 10% to 20%.
- In the green state ball clays are usually dark grey to bluish black, due to the presence of organic and carbonaceous matters. Although they are a product of a granite-type parent rock, through the actions of forces of nature, they were deposited in swampy areas where they became contaminated with decaying organic materials - hence their high carbon content and grey colour in the raw state. During firing, however, this organic matter burns out and does not affect the final colour of the fired clay.
- Ball clays are often used in glazes as a source of alumina and silica where they also act as a good binding agent. Such glazes, however, store badly if a ball clay high in carbon content is used, for the decaying

carbon tends to produce gas bubbles which leads to defects in the fired glaze (the growth of gas-forming bacteria may be usually prevented by adding some amount of formaldehyde).

The major use of ball clay:

- a plasticizing agent in clay bodies
- an agent to lower firing temperatures of the more refractory clays such as kaolin and fire clay
- a glaze ingredient to furnish alumina and silica
- a body ingredient in stoneware to raise firing temperatures and to increase plastic qualities
- a glaze stabilizer to prevent flowing
- a binding agent in glazes to improve their adhesive qualities.

2.3 Fire clays - obtained their name from their high refractory character which enables to fire them as high as at 1530°C without deformation due to fusion taking place. They may vary widely in properties: they may be high in mineral content and low in plasticity or vice versa, but their refractory quality remains intact. As such they are good source of materials for raising the firing temperature of low-firing clays, especially in stoneware bodies. In such cases they can be used in amounts up to 30%.

<u>The major use of fire clays</u>:

- a body ingredient to increase the firing range and temperature of other clays
- a body stabilizer to prevent deforming or distortion at vitrification levels
- a body ingredient to improve thermal shock resistance in some clay body types.

2.4 Stoneware clays - are plastic, workable clays which can be fired to vitrification point at temperatures of 1204°C to 1260°C. As such they represent an ideal material e.g. for pottery. In many parts of a country deposits of such clays can be found that are directly usable without additions of other constituents or alterations to the working body. They may range in colours from grey to buff to dark brown. As they are usually the result of sedimentary depositing in water, they can vary considerably widely in composition. In many cases they closely resemble fire clays. Their classification as stoneware clays often depends on whether they are suitable to be used in the making of pottery without considerable alterations to the natural material.

The major use of stoneware clays:

- a main body ingredient in stoneware clay bodies
- a clay body ingredient to increase the firing temperature of lower-firing clays without detracting from their plasticity
- a stabilizer in higher-fire earthenware clays.

2.5 Earthenware clays - are the most common of all the secondary clays to be found in the natural state. Earthenware clays make up a group of variously coloured clays in the temperature range from 925°C to 1150°C. Their low fusion point is the result of the mineral content, usually in the form of alkalis and iron oxides. Generally, they are red in colour but may range from red to greenish black to brown in the raw state. Their fired colour will then range from pink to dark brown, depending upon the iron content of the clay.

<u>The major use of earthenware clays</u>:

- a main body ingredient in earthenware clay bodies
- an ingredient in slip glazes to lower the melting point
- an ingredient to lower temperatures of more refractory clays such as fire clay
- a source of colour in clay [illegible]

2.6 Bentonites - are highly colloidal, plastic clays, found originally near Fort Benton/Wyoming. These clays are composed essentially of smectite minerals (montmorillonite group) with small amounts of quartz, feldspar, volcanic glass, organic matter, gypsum and pyrite.

Because of the general tending to swell

and particular exchangeable ions characteristics, bentonites are commonly divided into three major groups

- high swelling (or Na-bentonites)
- low swelling (or Ca-bentonites)
- moderate swelling (intermediate types)

From the practical point of view it is commonly used to classify bentonites by the geographic location of their deposits and by the purposes for which they are used. The term "bentonite" is based on mineral composition. Sometimes the term "fuller`s earth" is used which is based on the way of application. By no means, all clays sold as fuller`s earth are actually bentonites. The overlapping of the two terms is evident where both bentonites and fuller`s earths are used for the same purposes or products, such as in drilling muds, bleaching or clarifying fats and oils, and so on.

The major use of bentonites (and fuller`s earths):

- a main constituent of drilling muds
- a main constituent of foundry sand bonding matters

- a main constituent of iron-ore peletizing matters
- an ingredient to carriers for insecticides and fertilizers
- an ingredient to some special carriers in pharmaceutical and cosmetic products
- a main constituent of a bleaching matter applied both for mineral and vegetable oils.

2.7 When summarizing above mentioned general information about clay types and their occurence, it might be instructive to illustrate briefly the role of the clays and other silicate raw materials in traditional silicate industry branches. Such a survey is shown in Table No. 1.

The choice of an appropriate clay and other necessary raw materials in every production depends on several circumstances which in every case reflect generally all the positive and negative local production conditions in their complexity. As an example of that group of external conditions it might be quoted the following one:

a) The attainable level of the technology and the requirements on the final quality of the particular production.

b) The economic possibility to support the high quality requirements upon the particular production.

c) The availability of appropriate raw materials under favourable and economically stimulating conditions.

The importance of clay raw materials in the modern developed industry might be implied by the industrial application of kaolins. The data in Table No. 2 give a contemporary percentual consumption of this very valuable raw material. The world production of kaolin in 1978 has been estimated up to 16,9 million tons and has increased by approximately 27% since 1970 - from around 13 million tons. Most of the major producers have taken share in this growth and investment in new plants and equipment has increased both production capacity and improved the quality of the products. It must not be neglected that the international trade accounts for about one-fifth of the world's output of kaolin and has grown at an average rate of 8% per annum since the last 15 years.

Table No. 1 Usage of Clay in the Traditional Ceramic Industries

Industrial branch	Product	Raw material basis
Pottery	1. Glazed wall and earth tiles	1. Clays and glaze
	2. Domestic and sanitary earthenware	2. Clays, feldspar, flint, glaze
	3. Bone china (chinaware)	3. Clays, bone ash, flint, feldspar
	4. Porcelain (domestic, laboratory, industrial)	4. Clays, feldspar, flint
	5. Stoneware	5. Clay, fluxing agents
	6. Glazes and engobes	6. Clays, flint, feldspar, other fluxing agents
Structural clay industry (Heavy clay industry)	1. Building bricks of all types Hollow blocks Terra-cotta Roofing tiles Floor tiles	1. Clay, sand (chalk)
	2. Flower pots	2. Clay
	3. Unglazed drain-pipes Glazed pipes and accessories	3. Clay, glaze
Refractories	1. Fire clay bricks and raw fire clay	1. Fire clay (grog or pre-calcined clay)
	2. Insulating refractories	2. Clay and other refractory
	3. High alumina bricks	3. Fire clay, bauxite or bauxitic clays
	4. Retorts, crucibles, ladles, etc. for metallurgical industry and other applications	4. Clays, silica rock, graphite and other refractory materials
Electroceramics	1. Electrical ware	1. Clays, flint, feldspar

Table No. 2 **Usage and Approximate Percentual Consumption of the Kaolin Production by Various Industrial Branches**

1. Paper coating	33 %
2. Paper filler	18 %
3. Rubber	10 %
4. Paint	2,5 %
5. Fertilizers	2 %
6. Insecticides, fungicides	0,5 %
7. Other fillers and carriers	5,5 %
8. Fire brick and block	9,5 %
9. Other refractories	3 %
10. Portland and other cements	2,5 %
11. Pottery and stoneware	5 %
12. Chemicals	5 %
13. Other uses (detergents, soap, pharmaceuticals, etc.)	3,5 %

IV. Survey of Properties of Well-known European Clays

1. The principal kaolin producing countries are the U.S.A. and England; the account of their output makes around 60% of the world`s production. Ceramic industries are, however, also saturated by the production from other countries such as the U.S.S.R., Czechoslovakia, Germany (East and West) and India. These countries participate in the world kaolin production with around 20 to 25%. Undoubtedly, the most significant new producer entering the world`s kaolin market since 1970 has been Brazil. New production from other sources has been somewhat more modest in scale but new plant capacities in Spain, Indonesia, Argentina and Guayana encourage the same investment trends in further countries especially of America and Africa. The contemporary world production of kaolin is denoted by the following survey in Table No. 3.

   There are some most renowned European commercial types of ceramic kaolins quoted in Table Nos. 4a to 4c along with their chemical and technological properties. These types of kaolins are above all used in fine ceramic industries of traditional producers and further they find their applications in special branches of technical ceramic industries. Building products and materials are mostly based on the kaolins of a more or less lower quality.

2. With the same aim to illustrate a representative quality of good shales and fire clays, the characteristic chemical and technological data of these raw materials are quoted in Table Nos. 5 and 6a to 6c. The good shales from F.R.G., G.D.R., Czechoslovakia, Sweden and England show their refractoriness (pyrometric cone equivalent) from 34 to 36 SG.

Table No. 3 Estimated World Production of Kaolin in 1978

A r e a	Million tons
The United States of America	6,2
Central and South America	0,56
United Kingdom	3,8
Western Europe (except U.K.)	1,1
Eastern Europe (incl. U.S.S.R.)	3,4
Asia	1,6
Africa	0,12
Australia	0,12

Table No. 4 **Survey of the Most Eminent European Commercial Kaolin Types for the Ceramic Use**

		Chemical analysis							
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	$Na_2O + K_2O$	Loss of ignition
Sedlec Ia	ČSSR	46,85	38,02	0,85	0,25	0,65	0,15	0,40	12,62
Premier	ČSSR	46,03	37,88	0,89	0,29	0,71	0,04	0,29	13,87
Kolloid	ČSSR	46,35	38,72	0,87	0,15	0,24	0,02	0,15	13,51
Kaolin Ia/III	ČSSR	51,50	32,65	0,65	0,45	0,65	0,45	1,60	12,00
Tirschenreuth	FRG	47,60	37,24	0,60	0,51	0,26	0,18	1,81	11,80
Hirschau K1	FRG	48,10	36,60	0,40	0,30	0,10	-	1,50	12,10
Hirschau G 60	FRG	51,30	35,20	0,50	0,30	0,10	0,20	0,80	11,80
China Clay 2000	FRG	49,00	35,00	0,53	0,28	-	-	2,70	11,40
Kemmlitz "MEKA"	GDR	55,50	31,00	0,53	0,20	0,30	0,20	0,74	11,30
Börtewitz "Böka"	GDR	55,90	31,22	0,67	0,14	0,27	0,20	0,25	11,18
China Clay GROLEG	England	47,02	37,93	0,55	0,02	0,23	0,29	1,71	12,37
China Clay SP	England	47,52	37,70	0,50	0,05	0,21	0,10	1,30	12,62
Spain K 201	Spain	51,40	35,00	0,50	-	0,20	0,10	0,80	12,00

b)

		Rational analysis +		
		Clay	Quartz	Feldspar
Sedlec Ia	ČSSR	92,00	1,70	6,30
Premier	ČSSR	92,10	1,10	6,80
Kolloid	ČSSR	92,30	3,40	4,30
Kaolin Ia/III	ČSSR	90,00	8,00	2,00
Tirschenreuth	FRG	89,10	0,70	10,20
Hirschau K1	FRG	87,50	4,00	8,50
Hirschau G 60	FRG	83,00	10,00	7,00
China Clay 2000	FRG	81,00	1,00	18,00
Kemmlitz "MEKA"	GDR	80,00	17,00	3,00
Börtewitz "Böka"	GDR	81,00	17,00	2,00
China Clay GROLEG	England	87,20	2,70	10,10
China Clay SP	England	90,30	1,80	7,90
Spain K 201	Spain	89,00	10,50	0,50

+ Kallauner - Matějka method

c)

		Ceramic properties				
		Modulus of rupture DIN 51030 /kg/cm²/	Particle size 0 - 1 micron /%/	Particle size 0 - 2 micron /%/	Dry shrinkage /%/	Firing shrinkage /SC=1410°C/ /%/
Sedlec Ia	ČSSR	18,0	51,4	71,2	4,1	13,2
Premier	ČSSR	13,0	54,6	75,8	3,9	13,0
Kolloid	ČSSR	25,0	80,0	90,0	7,5	12,7
Kaolin Ia/III	ČSSR	31,0	-	-	7,0	9,30
Tirschenreuth	FRG	7,2	28,2	43,0	3,1	15,4
Hirschau Kl	FRG	2,0	23,5	42,6	1,8	8,0
Hirschau G 60	FRG	9,8	24,5	40,5	5,0	13,2
China Clay 2000	FRG	14,5	-	39,0	1,8	15,1
Kemmlitz "KEKA"	GDR	10,0	-	54,7	6,0	10,0
Börtewitz "Böka"	GDR	10,0	-	47,6	7,0	10,4
China Clay GROLEG	England	9,8	44,5	59,7	2,7	16,0
China Clay SP	England	12,5	57,5	75,6	4,6	15,2
Spain K 201	Spain	10,5	32,8	46,3	6,5	13,2

Table No. 5 Survey of Some European Shales

		Chemical analysis									
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O + Na_2O	loss of ignition	SC	
Rakovník "Extra"	ČSSR	54,8	43,1	1,1		0,2	0,1		1,0	35	fired
Rakovník "Ia"	ČSSR	56,20	38,80	2,2	1,07	0,3	0,4	0,5	1,03	33/34	fired
Rakovník "IIa"	ČSSR	55,21	38,82	2,16	2,18	0,33	0,42	0,50	1,0	33/34	fired
Nové Strašecí	ČSSR	45,00	38,00	1,8	1,1	0,43	0,46		13,1	34	clay
		51,78	43,72	2,07	1,27	0,49	0,53				fired
Neurode	GDR	50,15	47,04	1,88		0,32	0,02	0,11	0,55		fired
Aveyron	France	65,0	24,3	5,13		1,0	0,37		5,0		clay

Table No. 6 Survey of Some Well-known Fire Clays from Middle-European Area

		Chemical analysis							
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O + Na_2O	Loss of ignition
Klingenberg	FRG	53,80	32,10	1,70		0,30		0,70	11,90
Halle	GDR	65,80	23,90	0,50	0,40	0,15	0,05	0,81	8,30
"BM"	ČSSR	47,50	35,20	2,40	0,80	0,30	0,10	0,70	13,00
"CH"	ČSSR	49,30	34,40	1,40	0,70	0,90	0,30	2,40	10,60
"HC"	ČSSR	51,50	32,30	1,90	0,60	1,00	0,30	2,50	9,80
"KB"	ČSSR	63,00	23,70	2,00	0,30	1,20	0,30	2,00	7,50
"W-extra"	ČSSR	45,23	37,69	0,92	1,23	0,26	0,25	0,84	13,95

b)

		Rational analysis +		
		Clay	Quartz	Feldspar
Klingenberg	FRG	80,0	19,0	1,0
Halle	GDR	58,3	35,6	4,9
"BM"	ČSSR	89,9	6,6	3,5
"CH"	ČSSR	88,0	7,0	5,0
"HC"	ČSSR	85,0	10,0	5,0
"KB"	ČSSR	70,0	14,0	16,0
"W-extra"	ČSSR	94,0	0,4	0,6

+ Kallauner - Matějka method

c)

		Ceramic properties					
		Modulus of rupture DIN 51030 (kg/cm2)	Particle size 0 - 1 micron (%)	Particle size 0- 2 micron (%)	Dry shrinkage (%)	Firing shrinkage SC14=1410°C (%)	Melting point (SC)
Klingenberg	FRG	39,1	73,5	79,7	7,0	7,2	33
Halle	GDR	6,0	47,9	54,6	2,2	1,4	30
"EM"	ČSSR	28,4	91,0	94,1	6,2	13,2	33
"CH"	ČSSR	11,0			5,0	8,5	33/34
"HC"	ČSSR	8,0			4,8	6,5	32
"KB"	ČSSR	12,0			4,6	6,7	30
"W-extra"	ČSSR	5,0			5,3	17,9	34/35

They have a high content of clay substance, a slightly higher iron content, but a small amount of alkalis, calcareous and magnesium impurities. Fire clays, on the other hand, contain a high amount of kaolinitic minerals (80 to 95%) which results in a relatively high degree of refractoriness (32 to 34 SC). The natural plasticity of these types of clays is very appreciated.

3. Ball clays have found a very extensive use due to their plasticity. Some well-known representatives of this group are quoted in Table Nos. 7a to 7c. It may be seen that ball clays have a relatively small amount of alkalis and the lowest content of CaO and MgO. The firing colour is influenced by a relatively higher content of iron and titanium. Ball clays generally accept well all the non-plastic constituents of a ceramic body without suppressing the desirable shaping properties of the body.

Table No. 7 Survey of Some Well-known European Ball Clays

		Chemical analysis							
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O + Na_2O	Loss of ignition
Löthein	GDR	62,80	24,90	0,92	1,31	0,25	0,09	0,70	9,10
Goldhausen	FRG	62,90	26,51	0,66	1,09	0,24	0,17	1,62	6,82
Lämmersbach	FRG	64,34	31,29	0,62	1,65	0,16		2,06	8,24
"WI"	ČSSR	48,30	33,30	2,00	1,00	0,80	0,30	2,00	12,30
"IBN"	ČSSR	46,00	35,70	1,00	0,35	0,50	0,20	2,70	16,00
"KERO"	ČSSR	39,50	31,08	1,04	0,45	0,43	0,60	1,81	25,10
Ball clay "EWVA"	England	45,60	35,02	0,70	0,70	0,22	0,16	1,65	16,04

b)

		Rational analysis +		
		Clay	Quartz	Feldspar
Löthein	GDR	61,9	32,8	3,4
Goldhausen	FRG	59,3	30,4	10,3
Lämmersbach	FRG	59,1	28,6	12,3
"VI"	ČSSR	88,0	4,0	8,0
"IBN"	ČSSR	73,5	4,4	16,0
"HERO"	ČSSR	73,6	11,5	11,5
Ball clay "EWVA"	England	74,5	7,6	12,4

+ Kallauner - Matějka method

c)

	Ceramic properties						
	Organic content	Modulus of rupture DIN 51030 (kg/cm2)	Particle size o - 1 micron (%)	Particle size 0 - 2 micron (%)	Dry shrinkage (%)	Firing shrinkage (SC 14 = 1410°C) (%)	Water absorption (%)
Löthein GDR	1,9	21,9	65,9	71,0	5,8	11,0	3,3
Goldhausen FRG		22,0	61,8	65,6	5,0	5,4	0,3
Lämmersbach FRG		12,6	43,5	51,6	3,4	3,8	1,3
"WI" ČSSR		18,0			5,2	10,5	0,5
"IBN" ČSSR	6,1	24,5	49,8	55,5	3,0	10,0	2,2
"NERO" ČSSR	14,9	34,5	56,1	66,6	8,0	22,0	1,4
Ball clay "EWVA" England	5,5	14,8	67,1	75,8	3,2	14,8	0,4

Table No. 8 <u>Survey of Some Well-known Stoneware Clays from Middle-European Area</u>

		Chemical analysis							
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O + Na_2O	Loss of ignition
Pfalz "HSH 4"	FRG	53,16	30,24	2,13		0,53	0,62	2,31	11,00
Steinmühl	FRG	71,79	19,90	1,15			0,34	1,09	6,36
Niesky "J III"	GDR	51,80	32,20	1,60	1,70	0,05		1,22	11,80
"DV"	ČSSR	50,00	32,55	3,30	0,80	0,71	0,15	0,50	12,00
"AGW"	ČSSR	52,80	30,70	2,50	1,00	1,00	0,20	3,20	8,60
"MIC"	ČSSR	54,40	28,30	2,50	1,40	0,80	0,50	2,00	10,80

b)

		Rational analysis +			
		Clay	Quartz	Feldspar	Melting point °C
Pfalz "HSH 4"	FRG	88,1	10,4	1,5	27/28
Steinmühl	FRG	43,3	50,2	6,5	
Niesky "W III"	GDR	78,0	14,4	7,6	
"DV"	ČSSR	88,3	3,8	7,9	30
"AGW"	ČSSR	86,5	8,1	5,4	27/28
"LTC"	ČSSR	83,7	8,5	7,8	29/30

+ Kallauner – Matějka method

V. Final Note

The ceramics based on a broad scale of natural types of raw materials has been associated with a mankind since prehistoric times. In spite of its long and rich tradition there are the physics and chemistry of the last three or four decades which have opened quite new technological possibilities and, of course, quite unprecedented application feasibilities.

Every country is rich in natural ceramic raw materials. The successful exploitation of this common great wealth depends only on a few conditions which are determined by the most actual need of ceramic products and the manner how to establish quickly an economically prosperous production. There exist many ways how to reach this aim which might be most desirable in the economy of every country, but without a good knowledge of the quality and general technological and commercial value of raw materials available there is only a small probability to be successful in whatever enterprises.

In the previous parts some important informative points of view have been shown which seem to be principal for the first orientation in this field, mainly as regards the clay raw materials. A survey of the representative properties of various types of clays should set an example to a closer acquaitance with a customary classification of clays according to their applications in production (see Table No. 4 to 8). However, it should be noted that the choice of particular clay representatives emphasizes a characteristic types only and neglects a possible variety of chemical, mineralogical, and ceramic properties which might occur, and usually occur, at particular materials in accordance with the changed geological conditions.

In the conclusion it should be mentioned that the most convenient and prosperous commercial use of any clay depends very often on the level of preceding clay dressing. It means that even the simplest ceramic production should not take place without an adequate preceding dressing of the raw materials.

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