OCCASION

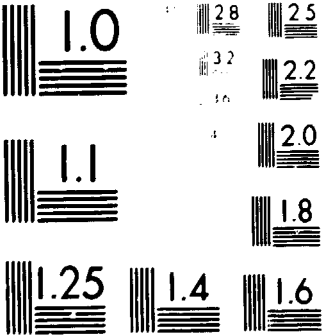
This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

11516

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.370/9
28 April 1982

ENGLISH

Workshop on Research, Utilization and Processing of Non-Metallic Minerals with Special Focus on Building Materials for the Construction Industry*

Belgrade (Yugoslavia), 10-16 May 1982

ORE DRESSING OF SOME NON-METALLIC MINERAL RAW MATERIALS**

by

Siniša Milošević, Dušica Pupezin,
Dragan Prodanović and Predrag Martinović***

* Organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Government of the Socialist Republic of Yugoslavia.

** The views expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

*** Institute for the Technology of Nuclear and Other Mineral Raw Materials, Belgrade.

V.82-25178

Nonmetallic minerals, in general, find very wide application in industry: glass-making, founding, ferrous and non-ferrous metallurgy, the chemical and building materials industries, etc. In industrially advanced countries, the degree of exploitation and primary processing of nonmetallic raw materials and the resulting economic effects by far exceed those in developing countries The growth of processing industries in developing countries is faster than the expansion of capacities for the exploitation and primary processing of nonmetallic raw materials.

As a consequence of this disparity, processing industries are increasingly dependent on imports of high-grade nonmetallic raw materials. In Yugoslavia until a few years ago there was a marked disparity between processing industries and industries extracting nonmetallic raw materials. The gap has been narrowed in the meantime but it still exists. For instance, in recent years the output of nonmetals and building materials have almost invariably taken a share of 28 and 1.5 per cent respectively in the gross domestic product.

Economic problems facing Yugoslavia have compelled all its scientific research and other institutions to engage in intensive work on:

- substituting domestic for imported nonmetallic raw materials,
- stepping up exports of non-metallic raw materials.

To achieve this it is necessary to increase capacities and the range of non-metals obtained. This is being brought about by:

- intensifying geological and technological prospecting of inadequately explored and newly discovered occurrences of non-metallic industrial materials.
- developing new technological solutions for the valorisation of nonmetals from lower grade ores.

Table 1 lists mineral deposits which are mined (continuously and occasionally) and being prepared for exploitation; and mineral deposits which are not mined (inadequately explored occurrences and possible deposits). The list of raw materials being prepared for exploitation (immediately or in the near future) has been supplemented in recent years by: phosphates, fluorite, zeolite and wollastonite. The possibility of processing natural pigments is under consideration. More interesting is that intensive technological research has made possible complex valorisation of valuable nonmetals obtained from almost uneconomical raw materials (low-grade quartz sands and sandstones, "kaolinised granites", "white granites", gravel-sand detritus, etc.). This will enable Yugoslavia to eliminate altogether or reduce imports of phosphates, fluorites, quartz sand, mica, garnet, kaoline, asbestos. Moreover it may become in important exporter of some nonmetals: feldspars, mica quartz sand, garnet and others.

This Paper in summary form sets out technological experiences of the Institute for the Technology of Nuclear and Other Mineral Raw Materials, and of some other institutions in problems of extracting:

- high grade: quartz sand, feldspar, mica and kaoline from low-grade run--of-mine quartz sands (and sandstones), "kaolinised granites" and "white granites".
- various particle sizes of high-grade gravel, garnet and associated metalliferous minerals from run-of-mine (raw materials contained in gravel-sand sediments,
- zeolite (from tufas)
- fluorite
- asbestos fibres from low-grade ores
- magnesite from low-grade ores

a) Technological experiences of extracting high-grade: quartz sands, feldspars, micas and kaolines

Quartz sand has been obtained exclusively from high-grade sedimentary deposits (Rgotina, Valjevo, Pakrac, Pula, etc.). Run-of-mine sand from these deposits contained 97 to 98 percent SiO_2 and two to three percent other constituents (Al_2O_3, Fe_2O_3) Cr_2O_3, K_2O, Na_2O, etc.). For use in

SURVEY OF NONMETALLIC RAW MATERIALS IN YUGOSLAVIA:

Table 1

I Raw materials mined (permanently, occasional & prepared for exploitation)	II Raw materials not utilized a) inadequately explored occurrences	b) possible raw materials
1. barite	1. alunite	1. amphibole, asbestos
2. bentonite clay	2. al-silicates	2. apatite
3. white bauxite	3. bromine	3. boric raw materials
4. cement marl	4. precious, semi-precious and ornamental stones	4. diamond
5. diatomite	5. iodine	5. phlogipite
6. dolomite	6. piezoptic quartz	6. potassium and magnesium salts
7. feldspars (pegmatites)	7. natural pigments	7. optical fluorites
8. phosphates (phosphorites)	8. rocks for glass and ceramics	8. optical calcite
9. gypsum and anhydrite	9. volcanic scoria	9. pumice
10. gratite		10. natige sulphur
11. chrysotil - asbestos		11. strontium raw materials
12. kaolin clays		12. vermiculite
13. ceramic clay		13. volcanic as (pozzolan)
14. limestones		
15. chalk		
16. roofing slate		
17. table salt		
18. quarts raw materials		
19. quartz sand		
20. micas (muscovite)		
21. magnesite		
22. brick clay		
23. perlite		
24. pyrotilite		
25. puzzolan additives		
26. silex		
27.		
28. rocks for stone cutting		

29. gravel and sand
30. talc and talc stone
31. engineering stone
32. ornamental stone
33. refractory ceramic clay
34. wollastonite
35. zeolite
36. fluorite
37. garnets

---

the glass-making, casting, ceramics and other industries it was enough for their refinement to apply wet-mechanical separation (washing and classification) to obtain products of specified particle size. Products separated in this way possessed the necessary chemical composition for application in the mentioned industries.

Feldspars (potassium and sodium) were extracted exclusively from high-grade pegmatite ores (Prokuplje, Bujanovac, Prilep, Strumica). The primary processing of these raw materials to obtain products of the quality required for application in the glass-making, ceramics and other industries consisted in the use of techniques of crushing and classification to the required particle size.

The production of mica was insignificant (hand sorting and crude classification). It was extracted from muscovite deposits which were always genetically and by site associated with pegmatites in metamorphic rocks. Primary processing involved hand-picking, crushing and, in exceptional cases, micronisation.

Kaolin (a raw material in very short supply) was obrained in low-grade form existing deposits resulting from hydrothermal alteration of acid magnetic rocks (Bratunac, Novo Brdo, Bujanovac), of the sedimentary type (Svabinci, Vrbica, Rudovci, Metriš) of autochthonous origin formed by the subaquatic alteration of acid magma (Motajica, Karačevo, Pehčevo) of illite glays (Črna). Primary processing of low-grade run-of-mine raw materials from these deposits consisted in crude disintegration and classification. Most often even this kind of processing was not embarked upon and for this reason raw materials were used in their low-grade form. The worst consequence of this practice was the belief that Yugoslavia did not possess high-grade kaolin and that it was necessary to import this material.

The construction of large capacities for the glassmaking, ceramics and paper industries, founding and other branches of industry created a great demand for high-grade quartz sands, feldspars, micas and kaolins. The demand could not be matched by existing primary processing capacities for the simple reason that these capacities were limited as were reserves of high--grade raw materials. This is why scientific research institute concentrated their efforts on developing technological solutions for the valorisation of the mentioned nonmetallic raw materials obtained from low-grade deposits: quartz sand and quartz sandstone, "kaolinised granites" and "white granites".

Valorisation of valuable components in lower-grade quartzs

Studies of the possibilities of complex valorisation of valuable components in low-grade run-of-mine quartz sands and sandstones were undertaken with raw materials at a number of sites. Experience set out in this Paper concerns only those raw materials for which industrial capacities for primary processing have already been built (or preparations for construction are under way).

Listed among the physical-chemical characteristics of run-of-mine raw materials are: size distribution (Table 2), chemical composition (Table 3) and mineralogical composition (Table 4).

Size distribution

Table 1

Granular size (mm)	"OBLACI"	"BELA REKA"	Content % "LIPIK"	"VRSAC"
+ 5,0	-	-	-	-
- 5,0 + 2,0	3,10		1,35	4,51
- 2,0 + 1,0	4,22		8,10	3,59
- 1,0 + 0,6	5,57	13,96	5,05	3,27
- 0,6 + 0,1	66,89	68,44	75,00	58,63
- 0,1 + 0,0	20,22	17,60	10,50	30,00
	100,00	100,00		

Chemical composition

Table 3

Element or compound	"OBLACI"	"BELA REKA"	Content % "LIPIK"	"VRSAC"
SiO_2	93,58	93,70	92,16-93,17	80,69
Al_2O_3	2,57	3,05	4,09- 3,95	10,86
Fe_2O_3	0,53	0,38	0,52- 0,48	1,37
TiO_2	0,10	0,06	0,15	0,20
Cr_2O_3	0,02	0,01	-	-
CaO	0,46	0,27	0,40	0,51
MgO	0,10	0,11	0,20	0,18
K_2O	1,46	1,25	[illegible] 37	2,75
Na_2O	0,08	0,15	0,56	0,60
S	0,23	-	-	-
g.ž.	0,74	0,65	0,48	2,36

Mineral composition

Table 4

Component	"OBLACI"	"BELA REKA"	Content % (approx.) "LIPIK"	"VRSAC"
- quartz (free)	87.94	85.87	84.02	57.48
- cal.feldspar	6.25	8.00	9.87	19.24
- sodium feldspar	2.12	-	-	-

- kaolinite	2,42	3,0-4,0	5.05	-
- kaolinite montomorillonite	-	-	-	17,63
- muscovite	-	-	-	1,23
- other impurities (Fe_2O_3, Fe_3O_4)	1,26	1,0-2,0	1,06	4.42

Technological schemes of complex valorisation of the mentioned valuable components (Table 4) were established by detailed laboratory, semi-industiral and industrial research. Figure 1 shows the technological scheme of complex valorisation of quartz sands or sandstones (sandy soil) which in their paragenesis contain economically interesting quantities of free quartz, feldspars and kaolinites, etc.("Oblaci", "Bela Reka", "Lipik"). Figure 2 shows the technological scheme of complex valorisation of run-of--mine raw materials which apart from the earlier mentioned constituents contains economically interesting quantities of mica, metalliferous components (ilmenite) etc. ("Vrašac").

Both technological schemes, generally, use:

- disintegration technique (multi-stage for sandy soil),
- technique of wet-mechanical separation (hydraulic separators are fitted out),
- technique of mechanical attrition washing (to remove from quartz grains impurities such as mineral Fe_2O_3 and clay-mud ingredients.
- technique of concentration by flotation (selective and collective) to remove impurities, feldspar and mica,
- technique of dewatering all products: thickening and filtration,
- technique of drying,
- technique of purifying waste waters together with the valorisation of kaolinites and free quartz of granular size - 0.1 + 0.0 mm.

Research and practical experiences have shown that the application of the mentioned methods makes possible: maximal utilisation of valuable constituents and extraction of good quality products. For lack of space, this

Paper does not go into details oftechnological processes and lists only some basic conditions for the application of concentration by flotation:

Selective flotation:

- flotation of "metalliferous" impurities:

conditioning:

Solid: Solution = 1:0.67

pH = 3.2 - 3.5 (H_2SO_4)

Collectors: anion-sulphanate or mixture of thallium oil and mineral oil

Time: variable (5 - 10 min.)

- Flotation of feldspars:

conditioning:

Solid: Solution = 1:0.67

pH = 2.1 - 2.2 (NaF)

Collectors: cation-type

Time: variable (5 - 10 min.)

Flotation:

pH = 2.1 -

Time: variable (2 - 5 min.)

Bulk flotation of impurities:

Conditioning:

Solid: Solution = 1:0.67

Ph = 5 - 6

Collectors: anion + cation collectors

Characteristics (chemical composition and yield by weight) of the products obtained are presented in Table 5. Chemical composition of products obtained from quartz sands.

Table 5

Elements or compounds	Content %				
	Quartz sands (-0.6 + 0.1) mm	Feldspar concentrate	Mica concen.	Kaolin concen.	Ilmenite concentrate
SiO_2	98,34-99,60	oko 70,00	oko 50,00	oko 68,00	3,46
Al_2O_3	0,48- 0,16	oko 16,50	oko 33,25	oko 25,00	3,57
Fe_2O_3	0,075- 0,02	oko 0,09	oko 1,80	oko 0,58	41,20
TiO_2	0,04-0,015	-	oko 0,20	-	50,00
Cr_2O_3	oko 0,0004	-	-	-	-
Cao	oko 0,23	oko 0,54	oko 0,27	-	0,46
MgO	0,10-0,04	oko 0,32	oko 1,15	-	0,30
K_2O	0,20-0,04	10,0-11,0	oko 6,30	oko 2,03	0,12
Na_2O	0,05-0,01	2,35-2,40	oko 0,80	oko 0,11	0,01
S	-	-	-	-	-
g.ž.	0,20-0,05	oko 0,40	oko 6,50	oko 7,57	0,36
Yield by weight T%	58,00-65,00	6,0-8,0	oko 8,14	1,5-5,0	0,74

Characteristics of products listed in Table 5 and of other products and of other products obrained by complex valorisation of run-of-mine quartz sands and sandstones (granular size: - 5.0 + 2.0 mm, - 2,0 + 1.0 mm, - 1.0 + 0.6 mm, - 0.1 + 0.04 mm, etc.) in keeping with the standards of technological processes maintained by industries that use these materials. This was proved by detailed semi-industrial and industrial attestation.

- Valorisation of valuable constituent in "kaolinised granites"

Studies of the possibilities for complex valorisation of valuable constituents of "kaolinised granites" (disintegrated granites) were made with raw materials at a number of sites ("Karačevo", "Bare", "Motajica"). Industrial plant for complex valorisation (primary processing) of these raw materials are soon to be constructed.

Tables 6, 7, and 8 show: size distribution and chemical and mineral composition of the relevant run-of-mine "kaolinised granites".

Size distribution

Table 6

Granular size (mm)	Content, T %		
	"KARAČEVO"	"BARE"	"MOTAJICA"
+ 0,30	32,71	41,47	46,65
- 0,30 + 0,10	23,95	18,08	19,77
- 0,10 + 0,06	7,19	7,53	10,98
- 0,06 + 0,04	1,05	1,40	0,54
- 0,04 + 0,03	3,57	3,37	3,37
- 0,03 + 0,02	3,76	3,12	4,24
- 0,02 + 0,01	6,25	5,50	6,33
- 0,01 + 0,00	21,52	16,53	8,12
	100,00	100,00	100,00

Chemical composition

Table 7

Elements of compounds (mm)	Content, T %		
	"KARAČEVO"	"BARE"	"MOTAJICA"
SiO_2	72,65	72,03	71,55
Al_2O_3	17,00	16,26	17,16
Fe_2O_3	0,85	1,71	0,83
TiO_2	0,25	-	0,12
CaO	0,58	0,98	0,70
MgO	0,27	0,20	0,40
K_2O	1,12	4,00	4,80
Na_2O	4,03	1,10	3,02
g.ž.	3,18	4,12	2,50

Mineral composition

Table 8

Component	Content, % "KARAČEVC"	"BARE"	"MOTAJICA"
- Na-feldspar	approx. 35,20		26,22
- K-feldspar	approx. 6,85	27,91	29,12
- Kaolinite	approx. 20,61	24,74-30,00	13,36
- Quartz (free)	approx. 35,25	46,28	29,27
- Impurities	approx. 2,10		2,11

Technological schemes of complex valorisation of valuable components in "kaolinised" granites have been established by laboratory and semi-industrial testing. A general technological scheme applicable to all the mentioned "kaolinised granites" is shown in Figure 3.

The technological scheme uses:

- technique of disintegration
- technique of wet-mechanical separation (in hydraulic separators, hydrocyclons and centrifuges)
- technique of selective flotation (mica, feldspar and quartz)
- technique of magnetic separation (kaolin and, where necessary, feldspars and micas) in high-intensity magnetic separators,
- technique of dewatering: thickening and filtration,
- technique of drying.

Selective flotation of micas and feldspars from disintegrated run-of-mine raw material of granular size - 0.3 + 0.06 mm, is carried out under the following conditions:

- Flotation of mica:

  Conditioning:
  Solid: Solution = 1:0.67
  pH = 3.5 (H_2SO_4)

Collector: cation collector
Time: variable (about 5 min.)

- Flotation:

    Solid: Solution = 1:2.33
    pH = 3.2
    Collector: cation-type
    Time: variable (about 5 min.)

- Flotation of feldspars:

    Conditioning:
    Solid: Solution = 1:0.67
    pH = 2.8 (NaF)
    Modifying agent (activating agent) NaF
    Collector: cation collector
    Time: variable (about 5 min.)

Average chemical composition of products obtained according to the technological scheme in Figure 3 from all the mentioned "kaolinised granites" and yield by weight are shown in Table 9.

Chemical composition and yield by weight of products obtained from "kaolinised granites":

Table 9

Element or compound	Content, %				
	Mica concentrate	Feldspar concentrate	Quartz sand	Product -0.063-0.01	Kaolin -0.01-0.00 mm
SiO_2	- 61,05	66,33-70,20	88,30	68,00	46,20 - 55,95
Al_2O_3	- 24,05	18,80-18,27	7,50	19,49	36,45 - 28,26
Fe_2O_3	3,57 - 1,89	0,05- 0,20	0,25	1,14	2,09 - 1,12
TiO_2	- 0,20	- 0,20	0,31	0,31	0,10 - 0,62
Cao	- 0,20	- 0,20	0,50	0,40	0,30 - 0,75
MgO	- 0,20	0,66- 0,20	0,40	0,60	0,08 - 0,41
K_2O	7,44 - 5,35	11,06- 8,00	0,36	1,12	1,15 - 2,85
Na_2O	1,08 - 2,86	2,42- 4,00	2,09	5,96	0,60 - 1,41
G.Z.	- 4,50	0,50- 1,25	0,15	0,15	13,03 [illegible]
Yield by weight T%	- 1,15	28,00-22,90	33,50	18,80	14,00 - 21,80

Products obtained by complex valorisation of "kaolinised granites" have physical and chemical characteristics which come up to the standards of industries making use of them.

- Valorisation of valuable components of "white granites"

Raw materials from the "Samoljica" - Bujanovac site were used to study possibilities of complex valorisation of "white granites". Industrial plants for complex valorisation of valuable components contained in these raw materials are under construction.

Table 10 shows size distribution, and chemical and mineral composition of crude raw materials.

Table 10

Size distribution		Chemical composition		Mineral composition	
Granular size (mm)	T %	Element or compound	Content %	Component	Content %
+0,100	10,30	SiO_2	74,53	- plagioclase	about 34
-0,100+0,050	12,50	Al_2O_3	14,25	- microcline	about 21
-0,050+0,030	15,10	Fe_2O_3	0,53	- gree quartz	about 21
-0,030+0,020	16,60	TiO_2	0,04	- kaolin-fraction	about 4
-0,010+0,006	11,10	MgO	0,34	- muscovite	about 7
-0,006+0,003	6,50	K_2O	3,58	- others	about 2
-0,003+0,001	2,85	Na_2O	3,51		
-0,001	4,30	g.ž.	0,20		
	100,00				

The technological scheme (Figure 4) of complex valorisation of valuable components of "white granites" has been established on the basis of laboratory and semi-industrial strudies. The technological scheme makes use of all the techniques mentioned when considering valorisation of "kaolinised granites". Conditions of work are also simular except for certain differences in the values of technological parameters.

Average chemical composition and yield by weight of products obtained according to the technological scheme shown on Figure 4 can be found in Table 11.

Chemical composition and yield by weight of products obtained from "white granites"

Table 11

Element or compound	Content, %				
	Mica concentrate	Feldspar concentr.	Quartz sand concentrate	Granular size	
				-0.1+0.04	-0.04
SiO_2	56,60	69,00	98,20	76,30	66,10
Al_2O_3	26,50	18,50	0,68	14,45	21,20
Fe_2O_3	2,07	0,09	0,04	0,25	1,21
TiO_2	0,30	0,06	0,03	-	-
CaO	0,55	0,54	0,36	0,58	0,68
MgO	0,70	0,25	0,32	0,22	0,53
MnO	0,03	-	-	-	-
K_2O	7,50	4,70	0,09	3,00	4,50
Na_2O	2,85	6,53	0,10	4,18	4,35
g.ž.	2,70	2,80	0,09	0,33	0,60
Yield by weight T %	about 8.00	about 52.00	about 20.00	about 20.00	

The physical and chemical characteristics of products obtained by complex valorisation of "white" granites fully correspond to the standards of industries which use them.

b) Technological experiences of valorisation of raw materials obtained from gravel-sand sediments.

These raw materials have been regarded as typical building materials. Production of gravel of varying size, in accordance with the requirements of the construction industry, has been great up to the present day.

Geological prospecting in recent years has shown that Yugoslavia has huge reserves of high-grade gravel and sand which contain economically very interesting quantities of garnet, magnetite, titanomagnetite, ilmenite and so on. Table 12 shows the average mineral composition of gravel and sand from sediments.

Characteristics of crude raw materials from gravel-sand sediments.

Table 12

Characteristics	Content, %	
	I-type	II-type
- grain size of gravel		
+ 31,5 mm	about 7.96	about 10.00
- 31,5 + 16,0	15,87	8,00
- 16,0 + 8,0	11,84	14,00
- 8,0 + 4,0	9,09	14,50
- 4,0 + 0,0	55,24	53,50
- garnet	15 kg/m^3	-
- magnetite	0,48 kg/m^3	-
- titanomagnetite	-	28,00 kg/m^3
- ilmenite	0,60 kg/m^3	20,00 kg/m^3
- gold	0,032 gr/m^3	0,025 gr/m^3
		in cl -4,0 + 0,0 mm
- vanadium		0,040 %
- gallium		0,003 %

Technological schemes of complex valorisation of valuable components have been established by laboratory and semi-industrial studies. Figure 5 shows a technological scheme (under "a") of the valorisation of raw materials from I-type sediments and a scheme (under "b") from II-type sediments.

Both mentioned types of sediments, according to technological schemes in Figure 5 produce high-grade granular sizes of gravel used in all types of concrete (they have been attested in detail).

Tables 13 and 14 show the chemical composition of other products obtained from raw materials in gravel-sand sediments:

Chemical composition of products obtained from I-type deposits

Table 13

Element or compound	Content, %			
	Garnet		Concentrate magnetite	Concentrate titanium
	-4.0-0.86	-86.0-0.0		
SiO_2	34,00	35,00	4,05	14,70
Fe	27,00	27,00	63,02	-
Fe^{++}	-	-	19,56	19,63
Fe^{+++}	-	-	43,46	16,07
TiO_2	1,01	1,00	4,33	35,16
Al_2O_3	20,50	21,00	2,17	4,62
CaO	3,00	2,80	0,85	1,38
MgO	2,20	2,10	0,28	0,33
MnO	1,05	1,20	0,36	0,69
Cr_2O_3	-	-	0,18	-
P_2O_5	-	-	-	-
S	-	-	-	-
As	-	-	-	-

Chemical composition of products obtained from II-type deposits

Table 14

Element or compound	Content, %	
	Concentr. of titanomagnetite	Concentr. of titanium
Fe	38,80	32,26
Fe_2O_3	55,50	46,27
TiO_2	18,75	50,00
SiO_2	11,50	3,60
Al_2O_3	4,68	1,20
CaO	3,57	0,15

MgO	2,73	0,60
MnO	-	2,10
K_2O	-	0,06
NaO	0,41	-
Na_2O	-	0,07
Cr_2O_3	-	0,03
Cr_2O_4	0,04	-

NOTE: Vanadium and gallium are concentrated in the concentrate of titanomagnetite from which they are separated by metallurgical methods.

Products obtained by valorisation of gravel-sand sediments are of good quality and find very wide application. The problem that remains is the metallurgical valorisation of the concentrate of titanomagnetite. Studies of the problem are under way.

c) Technological experiences of the valorisation of zeolite

Zeolites, a raw material with great possibilities of application (for dumping radioactive waste, purification of waste waters and waste gases, cleaning of spilled oil, gasification of coals, production of fertiliser, animal feed, etc.) were not produced in Yugoslavia until recently. Newly proven deposits in the vicinity of Vranjska Banja spa have made possible construction of plants for the classification, crushing, drying and packing of zeolites. The chemical composition of crude zeolites is shown in Table 15.

Chemical composition of zeolites

Table 15

Element or compound	Content, %
SiO_2	61,96 - 67,17
TiO_2	0,15 - 0,23
Al_2O_3	12,46 - 15,20
Fe_2O_3	0,98 - 2,05
MnO	0,05
MgO	1,30 - 1,96
CaO	3,03 - 4,35
K_2O	0,78 - 1,32
Na_2O	0,70 - 1,11
H_2O at 100°C	0,05 - 4,74
H_2O at 1000°C	7,56 - 9,56

Absorption capacity of zeolite (its important characteristic) is as follows:

Time (h)	Water steam	Benzole vapour
1	4,615	7,645
2	8,745	9,330
3	10,760	9,460
4	11,105	9,515
17	13,445	9,540

The technological scheme of the valorisation of zeolite consists in selection, dry classification, crushing, grinding and drying. Products obtained (granular size): - 2.0 + 0.7 mm, - 0.7 + 0.3 mm and - 0.3 + 0.0 mm. Product - 0.3 + 0.0 mm can be further fragmented (by grinding) for use as a filler.

The basic characteristics of the obtained products (grains) of zeolite are shown in Table 16.

Table 16.

Characteristics	Value
- specific volume	2.4 gr/cm^3
- whiteness in relation to $BaSO_4$	55%
- Absorption capacity of particle:	
water	20 - 21 %
alcohol	20 - 22 %
xylolite	20 %
kerosene	20 - 21 %
linseed oil	18 - 20 %
- wearing of grain	up to 2 %
- pH value	6.6 - 7.0 %
- surface active acidity (pKa)	1.0 - 2.5 %
- hygroscopicity after 10 days	7.0 %

Positive characteristics have been attested and products obtained find wide application. Research is under way to establish possibilities of wider application of zeolite (granular size - 0.3 mm).

d) Technological experiences in the valorisation of fluorite

Fluorite, a raw material with wide application (in metallurgy as smelting flux, in the chemical industry to obtain fluor acid and salt, in the cement industry, to obtain enamel, Cryolite, opalescent glass, etc.) has been in very short supply in Yugoslavia. The Yugoslav industry used to meet its requirements by importing this raw material.

However, the explored "Ravnaja" deposit offers possibilities for obtaining the required quantities within the country. Characteristics of crude fluorite (granular sizes are given for ores ggk - 85 mm fragmented to 100 % - 15 mm) are shown in Table 17.

Characteristics of crude fluorite

Table 17

Size distribution		Chemical composition	
Granular size (mm)	T %	Element or coumpound	Content, %
+ 15	2,70	SiO_2	oko 29,22
- 15 + 10	3,58	Fe_2O_3	4,82
- 10 + 8	2,65	Al_2O_3	2,78
- 8 + 5	6,20	TiO_2	0,10
- 5 + 3	5,67	MnO	0,02
- 3 + 2	6,88	$CaCO_3$	12,60
- 2 + 1	9,89	CaF_2	45,50
- 1 + 0,5	10,83	$MgCO_3$	1,50
- 0,5 + 0,3	7,99	Na_2O	0,08
- 0,3 + 0,1	14,78	K_2O	0,08
- 0,1 + 0,06	6,18	S	2,07
- 0,6 + 0,00	21,65	Pb	0,06
	100,00	others	

Technological tests were carried out by applying gravity concentration of particles of large and small size and direct concentration by flotation. Gravity concentration does not produce good results in contrast to direct selective concentration by flotation, which is recommended as the method for the valorisation of fluorite.

In the first phase, whit the particles about 75 % - 0.074 mm in size, sulphides are floated, and in the second phase - fluorites. The basic concentrate of fluorite obtained undergoes multi-stage purification. The purified concentrate of fluorite contains about 98 % CaF_2, and the yield of CaF_2 is about 48 per cent.

The achieved grade of the concentrate of fluorite fully satisfies the requirements of all industries using this material so that its application is extensive.

e) Technological experiences of the valorisation of asbestos fibre obtained from low-grade raw materials

Thanks to its fibrous structure and other physical and chemical characteristics, asbestos has many applications. It is employed as thermal insulation material, in the automobile industry (for brake linings), in the cement asbestos, chemical and electro-chemical industries and elsewhere.

Without going into details of the technology of primary processing of asbesto, which is well known, the Paper sets out only technological experiences gained from research into possibilities of concentrating asbestos fibre from low-grade ore (Korlaće).

Low-grade asbestos ore Korlaće appears in several types which differ in their physical-chemical characteristics: when "ore is semi-compact, with asbestos fibre strongly embedded in the matrix"; when ore is "soft, crumbling, with asbestos fibre loosely embedded in the matrix" and when there is a very strong connection between asbestos fibre and the matrix". The content of asbestos fibre in the ore ranges from 1 to 2.3 %. Good results have been achieved with the mentioned low-grade ore by applying the technological scheme for the fragmentation of ore and a four-stage separation of fibre (4 "Fiber Lines"). For instance, 38 % of the final product belongs to Class 4 (according to Canadian standards: 16 and 19 % 4-R whereas 3 % transforms into Class 3-3-Z), and 62 % belongs to Class 5 (according to Canadian standards, 55 % is 5-X and 7 % is 5-R). Fibre is completely free from dust and can be spread to between 2,000 and 14,000 cm^2 per gramme. Analyses of the characteristics of the obtained products of asbestos (specific surface area, the share of magnetic fraction, analysis for RO-TAP and others) and tests carried out (in the cement and other industries) have shown that these are of good quality and therefore widely applicable.

f) Technological experiences gained from the valorisation of magnesite

"Because of the diversity of type, size and quality of raw materials in deposits, Yugoslavia ranks among those European countries which have a solid basis for the production of top-grade refractory magnesite products."

By their origin, magnesite deposits can be divided into the following types: hydrothermal-metasomatic deposits and filtration deposites in serpentines (a. vein magnesite and b. magnesite of the web type), sedimentary deposits and the Adriatic Sea. As processing capacities have grown so have capacities for extraction from deposits. This has led to the fast depletion of reserves of high-grade magnesite, particularly from hydrothermal-sedimentary deposits. As low-grade magnesite from these deposits and the vein- and web-type magnesite began to be worked, great problems arose in their valorisation (preparation and concentration).

Industrial plants for the preparation and concentration of magnesite from rich ores (which will not be the subject of detailed discussion) made use of the following technological methods:

- hand-sorting
- washing
- gravity concentration (heavy medium)

As ores have become progressively less productive and the content of main impurities such as silicates, calcium-carbonate and dolomite increased, existing and newly built industrial capacities have been equipped or will be equipped with new supplementary technological processes for their removal.

- decarbonisation and hydration,
- concentration by flotation,
- electronic-optical separation

These new technological techniques have made possible valorisation of magnesite from waste material of existing industrial capacities employing gravity concentration - preconcentration.

- <u>Decarbonisation and hydration</u>

Processes for the concentration of low-grade ores in heavy medium are not sufficiently efficacious because "silicates possess great density so that the separation of carbonates is unsatisfactory since the density of silicates approximate the density of magnesites, with magnesite ores being porous at that".

To overcome these difficulties, technological processes for the gravity concentration of magnesite in heavy medium have been extended according to the patent of Professor Radoslav Ignjatović. The extension involves preconcentration for the purpose of removing impurities of small density. The preconcentration is then heated at temperatures of between 970 to 1370^{0}K in order to transoi carbonate into oxide. Decarbonisation is selective, depending on the temperature. Calcinated products are then subjected to hydration controlled by means of specified surface-active reagents and then washed up to undergo concentration in heavy medium where the concentrate of caustic is obtained in floating fraction. To following diagram presents the results in industrial plants of the processes of preconcentration, decarbonisation and hydration:

Crude ore
-15-1 mm
SiO_2 = 12.52%, Cc=1.42%

Concentration-I
(preconcentration)
- cutoff density 2650 kg/m^3
- preconcentration:
T% = 62.18 %
SiO_2= 3.30 %
CaO = 1.22 %

Decarbonisation (1370^{0}K)

water + reactive — Hydration — slurry -0.8 mm

Concentration II
- cutoff density 2200 kg/m^3
- concentrate:
T% = 13.45 %
SiO_2= 1.51 %
CaO = 1.41 %
R_2O_3=96.15 %
MgO =96.15 %
L. by H. = 0

- Concentration by flotation

Intensive work has been going on a semi-industrial and industrial basis to resolve the problem of applying the method of concentration by flotation to achieve valorisation of magnesite from wastes of existing TS separations and directly from low-grade ores of all geological types (after preconcentration).

The results achieved point to great possibilities of concentration by flotation in removing associated mineral SiO_2 but also to its inadequacy in eliminating other carbonates, dolomites etc.

Final semi-industrial - industrial testing is under way in "Magnohrom" to establish optimal possibilities of using concentration by flotation for low-grade magnesite ores of the Sumadija zone. The tests should provide a technological and techno-economic basis for the construction of industrial flotation capacities.

- Electronic-optical separation

The method of the electronic-optical concentration of magnesite ores has been used for a long time. Basic conditions for the application of electronic-optical concentration are as follows:

- that there is a distinct difference in colour between magnesite and the mineral containing impurities,
- that the size distribution of magnesite ore is suitable for tretment by this method,
- that magnesite is freed from the ore.

Industrial application of electronic-optical separation ("Goleš-Magura") and extensive studies of recent date have shown that this method can be used not only as a substitute for hand-sorting or in the phase of preconcentration but also for the purpose of obtaining specific concentrates.

CONCLUSION

The above brief survey of technological experiences in Yugoslavia in the valorisation of: quartz sand, feldspar, mica, kaolin, garnet, zeoline, fluorite, asbestos, magnesite, gravel of varying size etc. From low-grade ores eloquently speaks of the efforts scientific research institutions and all experts employed in them are making to obtain high-grade nonmetallic raw materials and building materials from until recently non-commercial ores. These efforts are regarded as justified and very fruitful as demonstrated by concrete techno-economic effects on investment programmes for the construction of plants in the immediate future.

Technicl bibliography:

- Siniša Milošević, M.Eng., Miroljub Marinko, Radoslav Ivković and others; 1979: "The Main Technological Project "Oblaci-Rgotina", ITNMS Belgrade
- Siniša Milošević, M.Eng., Miroljub Marinko, Radoslav Ivković, 1982: "The Main Technological Project "Donja Bela Reka BOR", ITNMS Belgrade
- Radoslav Ivković, Nenad Djaković, Miroljub Marinko and others, 1981: "Draft Investment Project Vršac", ITNMS Belgrade
- Miroljub Marinko, Radoslav Ivković, Nenad Djaković and others, 198?: "Draft Investment Project Lipik" ITNMS Belgrade
- Siniša Milošević, M.Eng, Radomir Vuković and others, 1979: "Technological Exploration of rare and heavy Minerals and ements from Gravel-sand Sediments at Bela Crkva" ITNMS Belgrade
- Radomir Vuković, Siniša Milošević, M.Eng., Miroljub Marinko, Nenad Djaković and others, 1981: "Technological Exploration of Gold and Heavy Minerals from Gravel-sand Sediments at Knjaževac", ITNMS Belgrade
- Dr. Magdalena Tomašević, Nenad Djaković, Miodrag Gajić, Miloš Maksimović and others, 1980, 1981, 1982: "Technological Testing of Kaolinised Granites: Karačevo, Bare, Motajica", ITNMS Belgrade,
- Dragoljub Milić, Bogoljub Petrović and others, 1982: "The Main Project Samoljica - Bujanovac", ITNMS Belgrade.

- Miloš Maksimović and others, 1982: "The Main Project Zlatokop - Vranjska Banja", ITNMS Belgrade

- Dr Branimir Vakanjac, 1979: "The Raw Material Base of Nonmetal Mineral Raw Materials in Yugoslavia", the Second Consultation on Nonmetal Mineral Raw Materials in Yugoslavia, Opatija

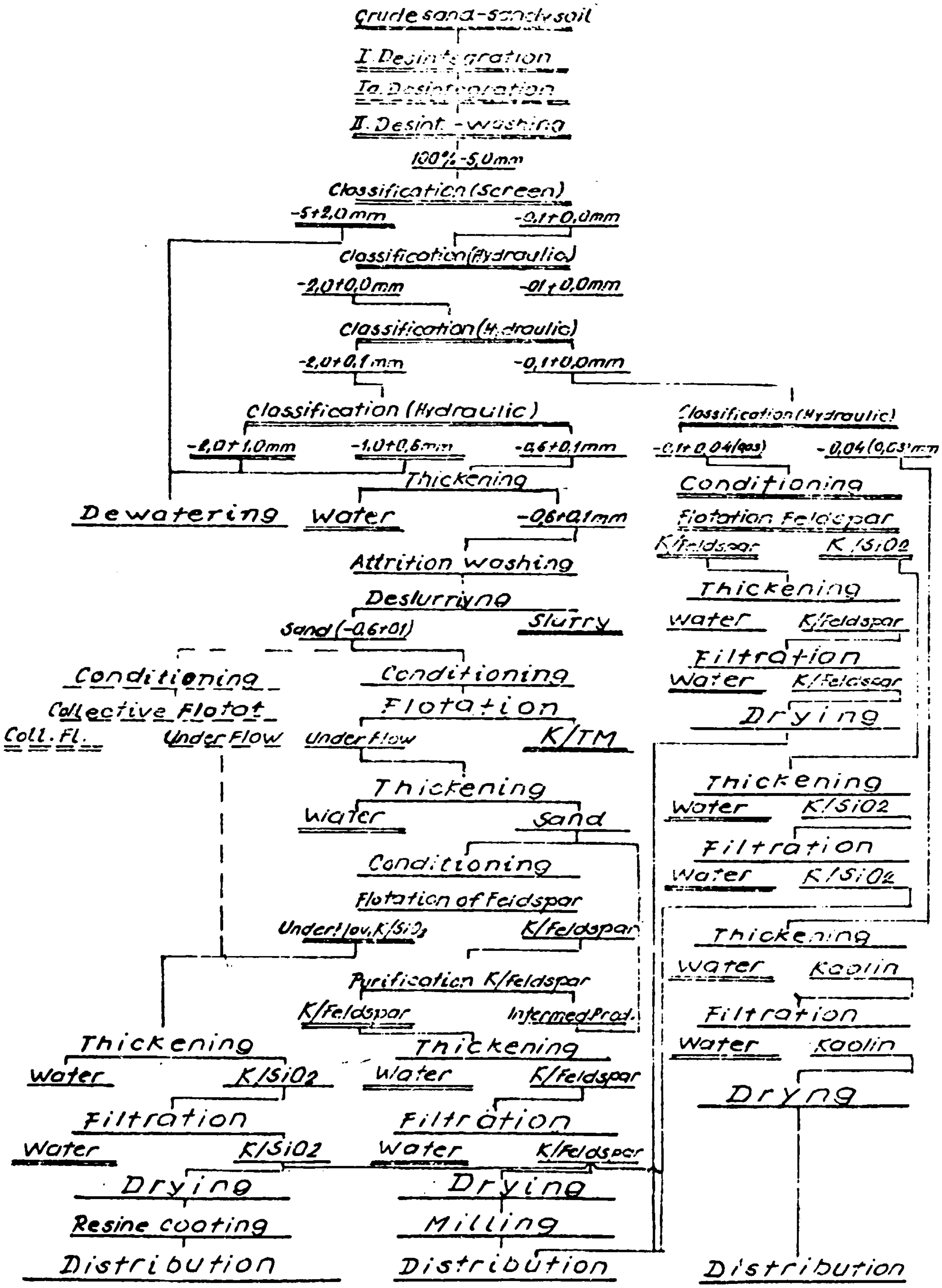
- Mirko Ceh and others, 1979: "Fluorites from the Ravnaja Deposits - Potential Raw Material for the Chemical Industry and Metallurgy" - The Second Consultation on Nonmetal Mineral Raw Materials in Yugoslavia - Opatija

- Dr Dragoljub Ivanković and others, 1979: "Technological Studies of the Possibilities of Concentrating Asbestos Fibre from Low-Grade Ores", Draft Project RI Zemun

- A group of authors, 1979: "The Raw Material Base of Nonmetal/Mineral Materials in SR Serbia", the Second Consultation on Nonmetallic Mineral Materials in Yugoslavia - Opatija

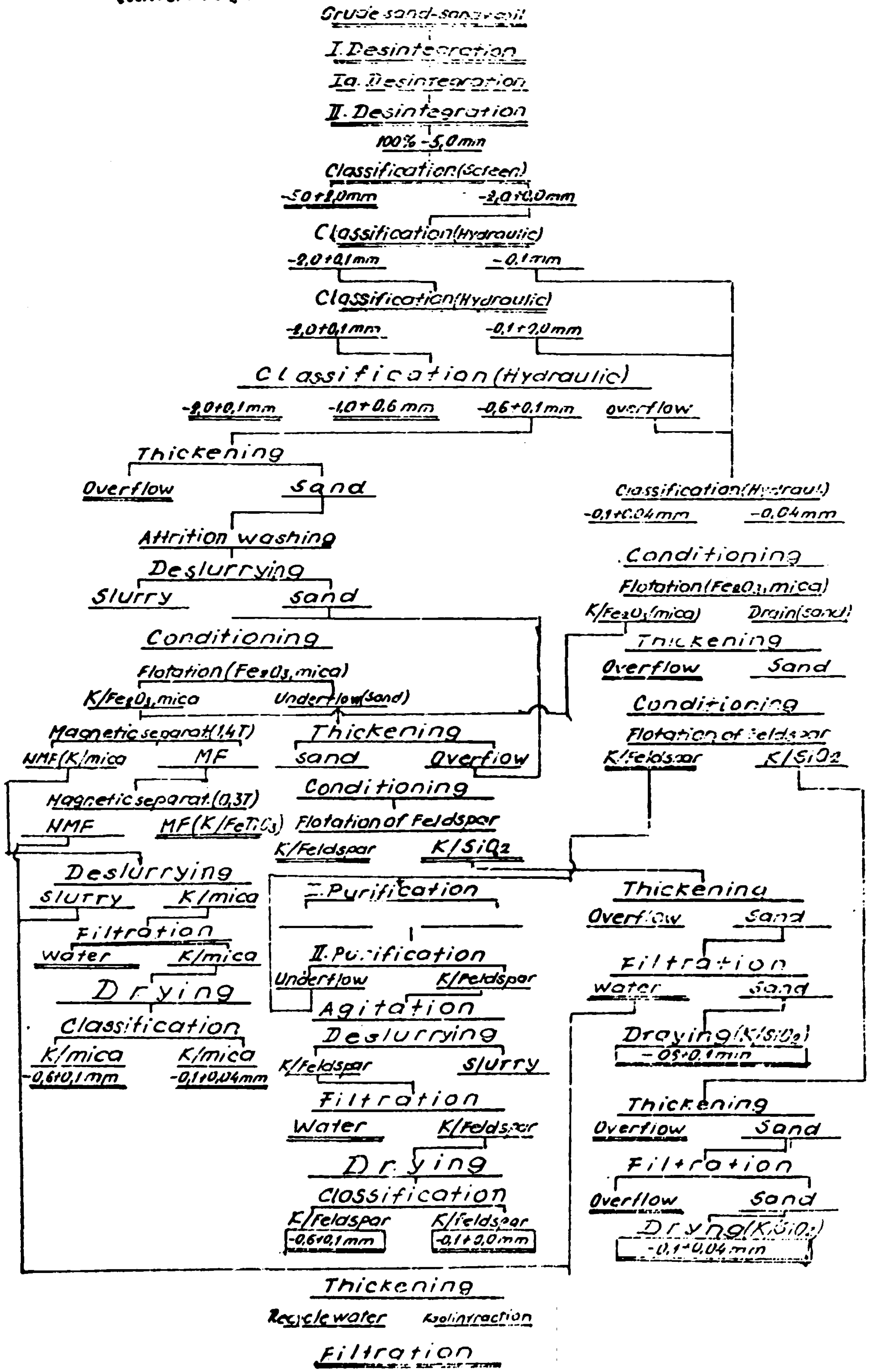
- Dr Dragoslav Ignjatović, Dragoslav Stefanović, Rajko Aćić, Nedeljko Magdalinović, M.Eng., 1979: "Industrial Application of the process for the Concentration of Magnesite Ore Following Decarbonisation", Collection of Papers from the Seventh Yugoslav Symposium - Žabljak

- Dušan Vučković, 1981: "The Electronic-optical Sorter-type Separator and its Application to Magnesite Concentrates", Collection of Papers from the Eight Yugoslav Symposium on The Application of Mineral Raw Materials. Vrnjačka Banja.

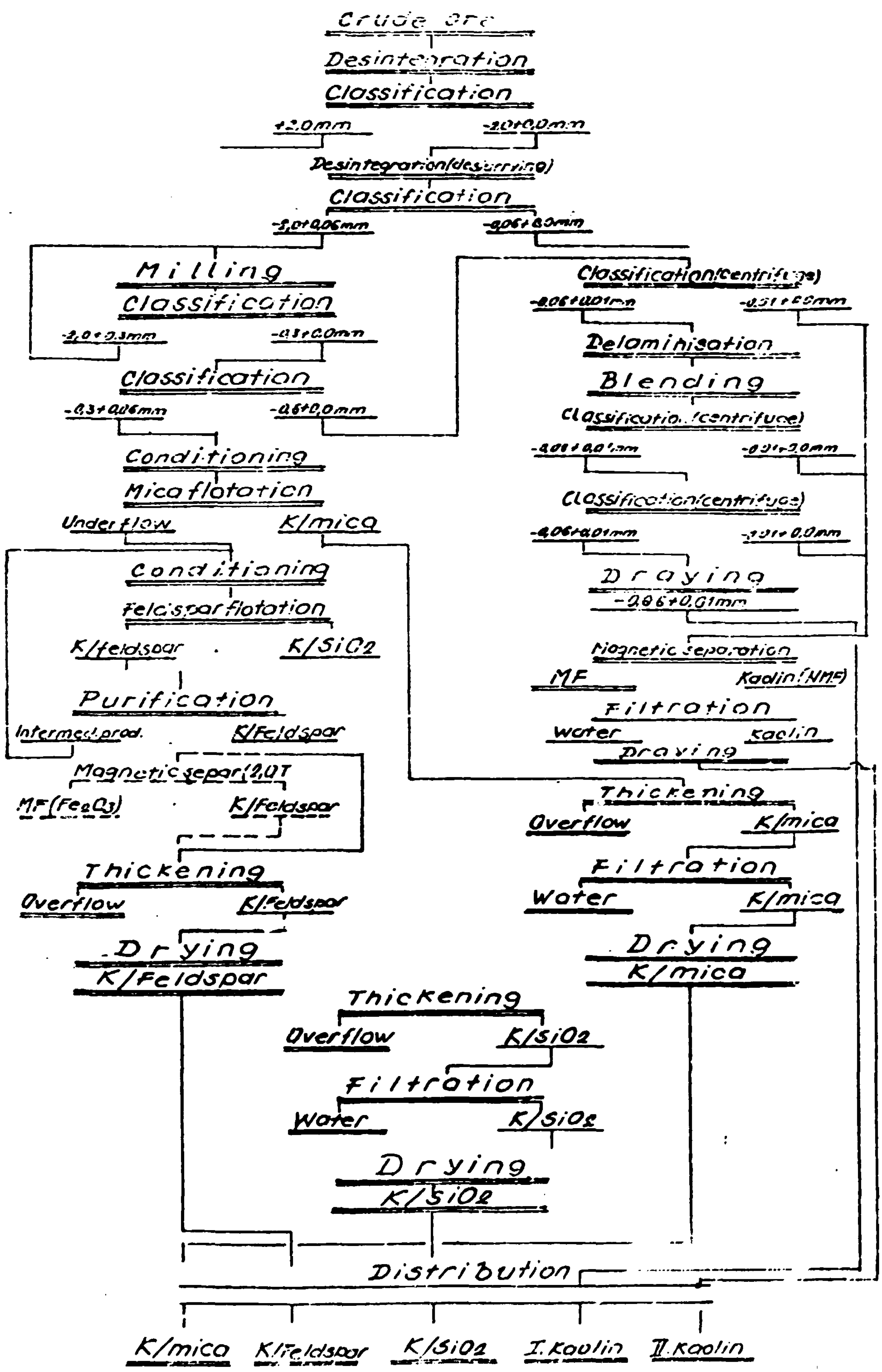


Sl. 1. - Technological scheme of complex valorisation of crude quartz sands - sandy soil containing quartz, feldspar, kaolin

FIG.2.-Technological scheme of complex valorisation of the muscovite sands containing quartz, feldspar, mica, ilmenite, kaolin"



Sl.3-Technological scheme of complex valorization of kaolinised granite



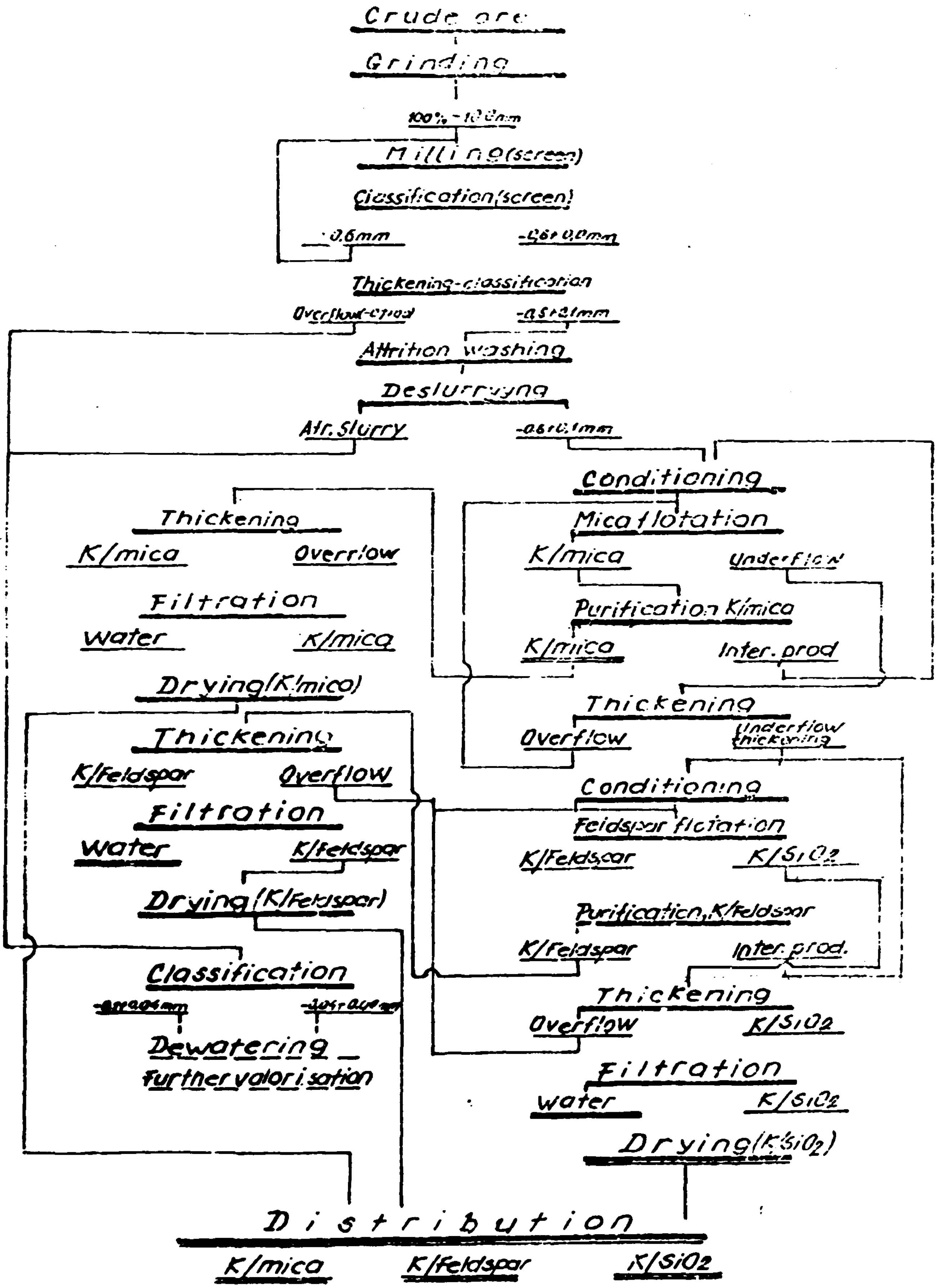
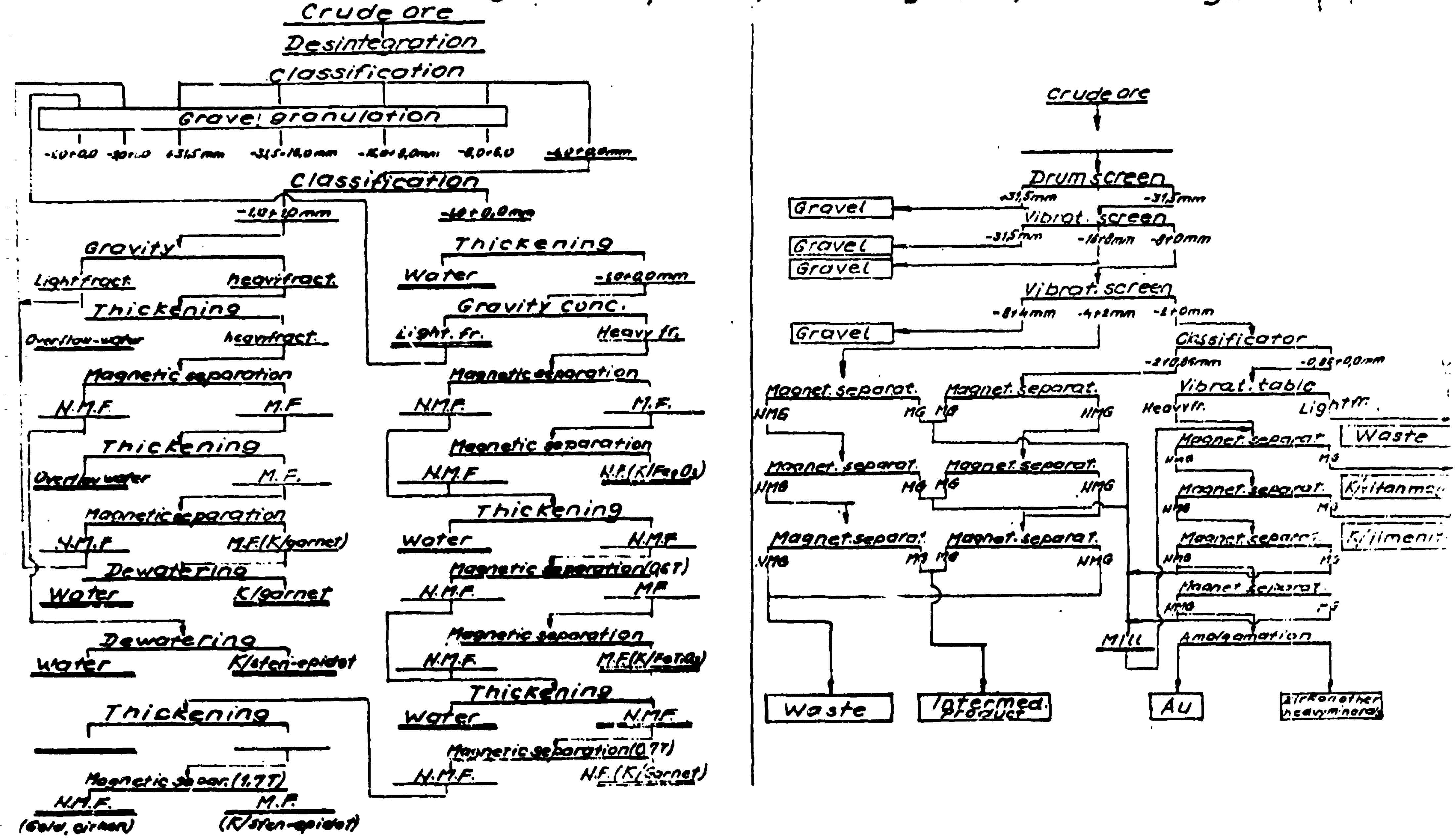


Fig. 4.- Technological scheme of complex valorisation of biotite granite

Fig. 5.- Technological scheme of valorisation of raw materials from sand-gravel deposits; a.- with garnet; b.- withou garnet



II

PROCESSING OF NON-METALIC ROW MATERIALS IN YUGOSLAVIA

Having in mind that processing of numerous non-metalic row materials which are available in local and righ natural resources is a very complex matter, as well as due to the time limit for more detail presentation, we had to concentrate only to a global presentation of more important capacities in this field.
Since this presentation is the integral part of the paper "Preparation and Concentration of Some Non-Metalic Row Materials", the industry of ceramic products, glass products as well as industry of fire resistant products are presented here for this occasion.

INDUSTRY OF CERAMIC PRODUCTS

The ceramic industry in Yugoslavia recorded special successes during 1981 both in the field of production and in the area of economic indexes. Increased production was the result of new production facilities but most of all it stemmed from the special efforts exerted by our work organisations to increase output and to make use of capacity reserves.

According to official statistics, production of all kinds of ceramic products, including electroporcelain registered such lighs in the period of

January - December last year, that its growth dynamics was much greater than that of the production of nonmetal raw materials. Thus, the index of growth of the physical volume of production with relation to the previous year was as follows:

- Industry and mining	104.2
- Production of nonmetal raw materials	103.0
- Processing of nonmetal minerals-production in branch 0112	115.0

It can be seen that production in branch 0112 had a 3.5 times greater growth rate than industrial production in the SFR Yugoslavia.

The following ceramic products registered significant production results in this period:

- Production of all kinds of ceramics, including electroporcelain	127.2
- Production of technical ceramics and porcelain	128.9

Within the framework of technical ceramics and porcelain the following growth rates were achieved in the production groups:

- Ceramics for home use	198
- Ceramics for sewer pipes	84
- Total ceramic tiles	135
- Sanitary ware	104
- Other ceramics for the building industry	84

Exports of consumer nonmetal products, in other branches, with relation to the previous year, recorded significant increases, giving us the following figures

- Exports	118

while imports of these products maintained a somewhat lower rate

- Imports	113

Production and inventory of finished products in 1981 within the framework of the production of technical ceramics and porcelain as per groups of technical ceramics and porcelain as per groups of products, showed an unfavourable tendency which resulted from the market situation, so that except for wall tiles and other ceramic tiles, the figures for the other products maintained last year's levels:

	Sales Index:	Stock
- Ceramics for household use	100	285
- Ceramics for sewer pipes	80	239
- Wall ceramic tiles	118	364
- Floor ceramic tiles	98	171
- Other ceramic tiles	1521	831
- Sanitary ceramics	100	172

The production of electroceramics in Yugoslavia in 1981, except for apparatus ceramics, showed a slight fall in production but on the basis of the existing stock of these products satisfactory results were achieved

Index:	Product	Sale	Stock
- Apparatus ceramics for low and high tension	104	100	154
- Insulators and other electro-porcelain materials	92	100	77
- Insulators of steatite and other electroceramics	93	97	141

The growth tendency of the ceramic products industry was reflected in better supplies in the domestic market, reduced imports and higher exports.

<u>Production trends</u>

The production of ceramic sewer pipes and other ceramics for the construction industry with relation to the previous year was 16% less. The fall in production was registered also for insulators of electroporcelain and steatite and other electroceramics, by 8% and 7% respectively. Other ceramic products recorded increases of from 4-35 index points.

Survey of production in tons in 1980 and 1981.

	1980	1981	Index
Household ceramics	16,471	17,782	108
Sewer pipe ceramics	15,734	21,567	84
Wall ceramic tiles	152,633	202,036	132
Floor ceramic tiles	135,082	152,977	113
Other ceramic tiles (mosaic and others)	2,969	38,549	1298
Ceramics for the constraction industry	1,583	1,323	84
Sanitary ceramics	12,348	12,783	104
Apparatus ceramics for low and high tension	8,505	8,827	104
Insulators and other electroporcelains	8,523	7,812	92
Insulators of steatite and other electroceramics	2,775	2,590	93

Increased production was partially the result of new capacities, mainly those for wall ceramic tiles, the new plant at Slavonska Orehovica, and in greater part due to better use of existing capacities and reduction of waste as well as the reconstruction and expansion of capacities. Of significance was also better supplies of required raw materials both from domestic and foreign sources. Greater demand in the domestic market and exports had a favourable effect on the growth of the physical volume of production.

Problems of realization

The increase in results optainedin 1981 with relation to the previous year was 14%. Reduced results were recorded for ceramic sewer pipes by 20%, for other ceramics for the construction industry 26%, for floor ceramics 2%, for insulators of steatite and other electroceramics by 3%. A more important reduction in the realisation of ceramic sewer pipes and other ceramics for the building industry resulted from the needs of the market, the presence of these products made of other materi als, and also the low production possibilities of existing capacities.

Ceramics for household uses, sanitary ceramics, apparatus ceramics for low and high tension, insulators and other materials of electroporcelain, maintained results at last year's level, while for the total ceramic tiles, the growth of 18.5 index points was recorded.

Parallel survey of realisation by types of products:

	1980	1981	Index
Household ceramics	16,287	16,328	100
Ceramic sewer pipes	24,430	19,414	80
Wall ceramic tiles	155,498	184,210	118
Floor ceramic tiles	149,540	147,015	98
Other ceramic tiles	2,146	32,645	1521
Other ceramics for the building industry	1,660	1,225	74
Sanitary ceramics	12,586	12,551	100
Apparatus ceramics for low and high tension	8,841	8,518	100
Insulators and other materials of electroporcelain	7,980	7,978	100
Insulators of steatite and other electroceramics	2,658	2,591	97

By putting into operation new capacities for the production of mosaic, 15 times more results were achieved in relation to the previous year.

Imports and exports

Depending on the type of ceramic product, imports with relation to the previous year varied. Their structure was the following:

	1980 tons	1981 tons	Indes
Ceramics for households	3,994	4,288	107
Ceramic sewer pipes	3,763	768	20
Sanitary ceramics	202	457	226
Other construction ceramics	940	971	104
Ceramic tiles	9,637	6,999	73
of which:			
Ceramic tiles for walls and floors-unglazed	4,083	1,010	25
Ceramic tiles for walls and floors - glazed	4,843	5,493	113
Other ceramic tiles for walls and floors - glazed	712	496	70

The pysical volume of imports with relation to the previous year for all groups of ceramic products was 27% lower while for the other products imports were increased. During the past year white and unicoloured wall tiles were imported to the amount of circa 400,000 m^2 or 4000 tons as well as tiles and accessories for pools and basins which are not produced in our country. These imports came mostly from Czechoslovakia, Italy, West Germany and Sweden. The imports of porcelain ware came mostly from the People's Republic of China, Poland and Hungary. The imports of sanitary ceramics and ceramic sewer pipes was mostly from Czechoslovakia. A total of 452 million foreign currency dinars or 18% more than in the previous year was expended on imports during 1981.

The imports of insulators without metal parts fell, while consumer goods showed varied results:

	1980 tons	1981 tons	Index
Ceramic insulators without metal parts	133	105	79
Household articles	144	311	216
Porcelain ware	2384	2 143	90
Household porcelain articles	1212	1660	137
Faience household articles	43	83	193
Art objects, jewelry, figurines	160	48	30
Porcelain jewelry and art objects	50	43	86

About 276,000 foreign exchange dinars were spent on the imports of the above-mentioned consumer products.

During the past few years domestic products have been more present in foreign makets so that exports were increased by 111%.

The following physical volume was achieved in the given groups of products:

	1980 tons	1981 tons	Indes
Household ceramics	2,503	3,762	150
Sewer pipe ceramics	7	29	414
Sanitary ceramics	445	528	119
Ceramic tiles	13,316	30,007	225
Total:	16,271	34,326	211

The structure of exports has varyous results according to the type of product and survey of consumer articles.

	1980 tons	1981 tons	Index
PROCESSING			
Ceramic tiles for walis and floors-unglazed	480	1,146	239
Ceramic tiles for walls and floors - glazed	10,635	26,466	249
Other ceramic tiles for walls and floors - glazed	2,200	2,395	109
Insulators without metal parts (electroporcelain)	3,984	4,864	122
Consumer Goods			
Ceramic household goods	38	-	
Porcelain ware	311	354	114
Household porcelain ware	1,724	1,978	115
Ceramic wares	185	250	135
Household faience wares	226	295	131
Jewelry and art objects of porcelain	11	1	11

Tnere were significant increases in both processed ceramic products and in consumer goods.

Total exports of products of nonmetal raw materials	000 din	000 din	
Processed goods	2,994,381	3,265,697	109
Consumer goods	1,140,262	1,694,034	149
Nonmetals in other branches	360,6[illegible]	351,485	97
Total:	4,495,281	5,311,216	118

The higgest exports of ceramic tiles was to the markets of the USSR, Hungary and the developing countries Lybia, Iraq and others. Kuwait was an important buyer of ceramic tiles.

Porcelain ware and other utensils for households were predominantly exported to the USSR, Holland and Greece, and of sanitary ceramics to the USSR, Austria and Iraq.

The amount obtained in the total exports of nonmetal raw materials products through the marketing of ceramic goods 452 million foreign exchange dinars or 98% more than in 1980. In 1981 exports continued to rise. The structure of the assortment of products changes with changes in the market favouring the developing countries. However, all in all, the biggest markets for ceramic products were in the East European countries.

Development of Technology

The development of technology in the ceramic industry directly affects the production and financial results obtained. The state of the technology in the ceramic industry generally depends on investments. Favourable market conditions created tendencies for the expansion of capacities and opening up of new processing plant.

As concerns technology, it is estimated that it is at a satisfactory level, although there are production capacities with obsolete technology and organisation of work.

The machine equipment and automation in the ceramic industry has been mostly obtained from abroad which causes certain maintenance difficulties. The trend for a maximum effort to be made with domestic possibilities brought about the fact that kilns and drying premises had to be built by domestic manufacturers. and materials.

The dependence of the ceramic industry on the possibilities of obtaining imported raw materials such as kaolin and others,directly depends on the development of domestic potential deposits of such raw materials. The ceramic industry has at its disposal a domestic raw material basis in ceramic clay, sand and feldspar.

The domestic capacities of the ceramic industry and that of porcelain and electroceramics have been constructed according to the designs of large European houses (in Italy, West Germany, Czechoslovakia) with the most up-to-date equipment and automation from abroad.

The group of producers of ceramics and porcelain for household use is characterized by many years of experience, contemporary technology, and a large choice of forms and decor. A large assortment of decor is available in various colours and widths. We cite the most important manufacturers:

- Porcelain factory - Zaječar
- "Boris Kidrič" - Titov Veles
- "Jugokeramika" - Zaprešić
- Keramička industrija "KIL", Liboje-Celje
- "Kaolin", Bratunac

The group of manufacturers of technical ceramics, wall and floor tiles, sanitary ceramics, ceramic pipes and other ceramic materials for the building industry, is characterized by the application of contemporary technological procedures and techniques which enables it to offer a broad assortment of products and designs. We list some of these manufacturers:

- "Boris Kidrič", Titov Veles
- "Toza Marković", Kikinda
- "Jugokeramika", Zaprešić
- "Jugokeramika", Vojnić

"Labinprogres", Podpičan

- "Polet", Novi Bečej
- "Kaolin", Bratunac, factory of wall tiles under construction
- "Keramika", OOUR Pločice, Mladenovac
- "Gorenje", OOUR Construction Elements, Titovo Velenje
- "Zorka", OOUR Ceramic Tiles, Šabac
- EKK, OOUR Floor and Wall Mosaic Tiles, "Selena", Prijedor

- "Sanakeram", Sanski Most
- "Karačevo", Kosovska Kamenica
- "Ljubečna", TOZD Ceramics, Celje
- "Kil", Liboje - Celje
- "Keramika", OOUR Sanitation, Mladenovac
- "Jugokeramika", Sanitary Ceramics, Zaprešić
- "Keramika", OOUR Pipes, Mladenovac

The group of manifacturers of electroceramics produces a large assortment of products characterized by good microstructure, mechanical properties, electrophysical and other features. Also produced are "soft" and "hard" porcelain as well as a special type of electrotechnical porcelain for high and low tension. Products made of steatite are also produced.

We list some of these manufacturers:

- Industry of Electroporcelain, Arandjelovac
- "Rade Končar", OOUR Electroporcelain Factory, Novi Sad
- "Energoinvest", Sarajevo

etc.

GLASS INDUSTRY

In 1981. the glass industry in Yugoslavia registered increases and according to statistical data the production of all kinds of glass was greater than the growth dynamics of nonmetal raw materials. The growth index of the physical volume of production, is given in these figures:

- Industry and mining	104,2
- Nonmetal raw materials production	103,0
- Processing of nonmetal minerals production in branch 0112	115,0

Increased production has been registered for the following types of glass products:

- Sheet window glass, t	105
- Sheet castglass, t	130
- Container glass, t	114
- Laboratory glass, t	103
- Consumer hollow glass, machine-made, t	101
- Consumer hollow glass-hand-made, t	106
- Other hollow glass, t	150
- Grinded-crystal products, t	122
- Other crystal and semi-crystal products	165
- Other technical glass	113
- Glass wool and fibres	110

The structure of glass imports shows that glass for processing was imported, namely:

- Broken glass mass	138
- Glass tubes	105
- Cast or rolled glass with decorated surface	189
- Bricks and tiles of cast or pressed glass	276
- Security automobile wire-strenghten glass	296
- Unframed mirror glass	158
- Glass packaging, bottles and containers	447
- Headlight glass	165, etc.

For consumer needs:

- Kitchen ware of blown or pressed glass	178
- Household crystal and grinded glass ware	77, etc.

The structure of exports as per groups of the glassware industry indicates a considerable increase in relation to 1980. Foreign exchange dinars increased considerably:

	1981/1980
- Hollow glass	134
- Sheet glass	139.9

Of these, the foreign exchange inflow in groups had the following growth index:

- Window glass	114
- Flat cut or polished glass	160
- Cast or rolled glass with surface decoration	558, etc.

Realisation and inventories of finished products in 1981 depended upon the situation in the domestic and foreign markets:

	Realisation	Inventory
- Flat window glass, t	101	216
- Flat cast glass, t	125	322
- Packing glass, t	109	120
- Cut-crystal ware	115	172, etc.

PRODUCTION TRENDS

The production of plain cut glass and safety glass fell by 4% with relation to 1980. It can be said that last year's production was maintained. Other types of products showed an increase in the range of from 1 - 65 index points.

Survey of production by types of products in 1980 and 1981:

PROCESSING	tons	1980	1981	Index
Flatt window glass		110,479	116,092	105
Flat cast glass		28,935	37.508	130

Packing glass	336,131	384,477	114
Laboratory glass	802	823	103
Hollow consumer glass-hand-made	10,440	11,078	106
Hollow consumer glass-machine--made	15,746	15,966	101
Other hollow glass	3,885	5,837	150
Cut-crystal ware	2,210	2,707	122
Other crystal and semi-crystal glassware	7,239	11,945	165
Plain cut-glass	215	206	96
Safety glass	15,256	14,689	96
Technical glass	732	825	113
Other glass products-glass wool and fibres	7,828	8,633	110

Increased production was the result of new production capacities, better use of existing ones and reconstruction of certain production lines as well as the introduction of new technology. In 1981 many work organisations set aside significant funding for expansion and improvements. Capacities for packing and hollow glass have been expanded significantly while investment undertakings are under way in the Serbian Glass Works in Paraćin, the Skopje Glass Works, the Glass and Plastics Factory Stražani Hum na Sutli, in the Glass Factory in Hrastnik and in others. Likewise, flat glass factories have earmarked considerable sums for modernization of production of production as in the Glass Works in Pančevo and in others.

Increased demand in the domestic market as well as favourable trends in exports were incentives for investments and greater output. However, a constant shortage in power that beset the whole economy, had a negative effect on fulfilment of the physical volume. The sudden price rises of fuel and electric power followed by higher costs of raw materials, made this branch of industry insufficiently accumulative.

PROBLEMS IN REALISATION

Increased results in 1981 with relation to 1980 for various types of products showed as broad span with results for other products of hollow glass and safety glass remaining at last year' level while the realisation of hollow glass for consumer consumption (machine-mde) fell by 8% and plain cut glass by 10%.

Parallel table of realisations by types of products:

tons	1980	1981	Index
Flat window glass	107,356	110,824	101
Flat cast glass	27,921	34,924	125
Packing glass	353,344	383,420	109
Laboratory glass	843	851	101
Hand-made hollow glass	10,393	11,003	106
Machine-made hollow glass	16,055	14,845	92
Other hollow glass products	4,015	3,999	100
Crystal ware	2,273	2,613	115
Other crystal and semi-crystal ware	7,180	11,950	166
Plain cut glass	238	213	90
Safety glass	14,784	14,822	100
Glass wool and fibres	6,998	7,326	105
Other technical glass	723	830	115

IMPORTS AND EXPORTS

Imports of glass for processing and consumer consumption mainly refer to the imports of those types of produicts not produced by domestic industry or produced only in small quantitites.

PROCESSING	1980		1981		Index
	ton	din.	ton	din.	
Glass mass and broken glass	317	2,810	438	3,923	140
Rod and bead glass	657	10,804	726	13,737	127
Glass pipes	3,865	134,107	4,049	135,955	115
Eyeglass glass	2	5,516	1	4,903	89

Optical glass	345	64,976	265	61,445	96
Window G glass	7,652	112,436	5,901	67,483	60
Coloured sheet glass	1,091	22,760	497	12,243	54
Drawn or blown glass	22	3,151	82	6,257	199
Flat cut or polished glass	2,338	29,218	1,311	17,560	60
Flat coloured cut glass	6,225	140,065	5,533	121,218	87
Decorated cast or rolled glass	944	12,255	1,782	21,753	178
Flat coloured rolled or cast glass	108	2,208	69	2,559	116
Flat wired glass	1,762	12,874	446	5,337	41
Bricks, tiles of cast or pressed glass	1,944	29,893	5,360	62,459	209
Safety glass for cars	680	57,401	657	63,198	110
Wired safety glass	212	53,931	627	78,488	146
Unframed mirror glass	664	37,247	1,052	55,977	150
Glass rods or pipes (mass)	46	677	174	3,169	468
Tinted cast or rolled glass	35	795	101	2,186	275
Rolled, drawn, or blown glass	3,180	65,533	3,286	90,226	138
Enamelledengraved glass	52	3,528	79	4,433	126
Insulating flat glass (multi-layered)	964	32,003	431	33,711	105
Glass for electric pipes and glass holders	2,820	34,479	2,542	34,513	100
Glass containers	4,522	35,725	20,225	125,829	352
Glass wool and fibres products	1,331	105,583	860	83,179	79
Glass for medical labs	39	21,535	56	31,001	144
Glass ampoules	1	415	6	1,089	262

Water-gauge glass	8	6,823	12	8,621	126
Industrial uses glass	329	37.465	243	29,280	78
Glass for lamps	232	29,481	186	37,605	128
Glass for signalling apparatus	78	59,339	64	40,368	68
Glass for headlights	248	17,842	409	30,136	169
Glass for prisms and lenses	7	24,452	9	55,193	226
Optical filters-polarizing	1	3,888	1	4,143	107
Consumer goods					
Glass for watches	2	322	1	199	62
Sunglasses	3	2,936	9	2,918	99
Plain glass	16	2,372	6	1,438	61
Glass parts for thermos flasks	4	226	1	102	45
Kitchenware of blown or pressed glass	361	22,915	642	37,511	164
Household cut crystal glass	87	6,430	67	4,704	73
Vases, ashtrays of plain glass	161	11,787	197	14,726	125
Crystal vases,ashtrays and similar goods	8	1,832	7	799	44
Beads and simulated gems of crystal glass	466	6,991	641	11,988	171
Yarns of glass wool (other branches)	709	47,096	491	39,897	85
Total:	1,313,222			1,481,459	113

According to the structure of exports, the following foreign exchange balance was achieved:

	1980	1981	Index
Hollow glass	1,502,834	2,014.667	134
Flat glass	83,992	117,518	139
Total:	1,586,826	2,132,185	134

As can be seen from the above, imports of glass were covered by exports.

DEVELOPMENT OF TECHNOLOGY

It is a characteristic of the Yugoslav glass industry to constantly keep abreast of the latest technical achievements in the world, as well as of assortments and technology. The use of "earth gas" instead of conventional fuels contributed to the attainment of a whole range of technical and technological and economic advantages:

- high caloric value
- permanence of composition and caloric value
- better regulatory possibilities
- maintenance of constant atmospheric content, and others.

In tub kilns, for the production of drawn glass various kinds of fire are applied (partiall use of mixtures of gas and air, diffusion) with the width of the tub in the heated part of the kiln up to 5.8 m. Air for burning is led through regenerators and at the entry into the flame are a of the kiln amounts to about 1100° C. The maximum temperature in the kiln is about 1550° C.

In the production of hollow glass various kinds of kilns are used: tub, liteks, crucible and others. Also various machines are used (IS-6, s10, IS-8, R7-6, etc.) Hollow commercial glass for consumer consumption is made either by hand or my machine depending on the quantity of the series.

In the foregoing period new capacities were put into operation and new investment works were started to expand capacities and build new ones. Thus, the construction was begun of a new capacity for the manufacture of optical glass and other types of glass.

The glass industry predominantly uses domestic raw materials, quartz, sand and soda, additions. For special needs its imports various basic raw materials.

In the group of manufacturers of hollow glass, two main trends can be signled out: packing and hollow glass for consumer consumption or commercial glass. The producers of packing glass are the following:

- Serbian Glass Works, Paraćin
- Glass and Glass Wool Works, Skopje
- Staklara, Hrastnik
- Factory of Glass and Plastic Articles, Straža, Hum na Sutli

The manufacturers of commercial glass are:

- Serbian Glass Works, Paraćin
- Glass Works, Prokuplje
- Staklara, Hrastnik
- Enterprise for the production of tinted and decorative glass, Alibunar
- Staklara, Hrpelje, Kozina

The manufacturers of flat, laboratory and special glass are:

- Glass Industry, Pančevo
- Glass Industry and Nonmetal Mines, Lipik
- "Boris Kidrič", factory of laboratory glass, Pula, etc.

The manufacturers of pure crystal products have a very large assortment. They are:

- Glass and Glass wool Factory, Skopje
- Glass and Crystal Ware Factory, Zaječar
- Kristal, Sombor
- "Boris Kidrič" Glass Works, Rogaška Slatina
- Serbian Glass Works, Paraćin

Finishing of glass objects is done by a number of work organisations,namely:

- "Zvezda" firm for glassware and mirrors, Zemun
- "Učila", Zagreb
- Staklara, Hrpelje, Kozina
- Glass Works, Prokuplje
- Enterprise for the manufacture of lighting glass, Ilirska Bistrica

Glass-cutting facilities have been set up within large work organiations producing cut-crystal ware but also among the smaller ones:

- Serbian Glass Works, Paraćin
- "Kristal", Zaiečar
- Dalmacija-Crystal, OOUR Vrgorec, Kardeljevo, etc.

REFRACTORY INDUSTRY

The long-standing tradition of the industry of refractory materials in Yugoslavia has made it possible to reach a high level of technological development in this field of the economy and to be competitive outside the borders of our country. However, due to deficiencies during the past few years in the supplies of domestic raw materials and also because of the increased physical volume of production, there has been an increase in imports and fall in exports. A brief survey is given on the following manufacturers of refractory materials in our country:

- "Šamot" - alumsilicate refractory products, Arandjelovac
- "Magnezit" - basic refractory products, "Magnohrom"- Kraljevo
- "Silika" - refractory products, "Silika" - Gostivar
- "Vatrostalna" - Zenica

"Šamot" - alumosilicate refractory products

In joined plant units, the process of obstaining alumosilicate refractory products began with the exploitation of raw refractory products began with the exploitation of raw refractory clays from two surface faces and one pit plant in which the work is mechanized. The raw materials are then processed in rotor and shaft kilns into semiproducts (clinker) which is then taken over by specialized factories in Arandjelovac and in Partizani.

The factory in Arandjelovac specilizes in the production of normal and high aluminising alumosilicate refractory materials based upon semi-dray and dray procedures. The factory at Partizani specialized in alumosilicate materials based upon plastic procedure for special purposes.

The main feature in obtaining alumosilicate refractory products in the factory is the production and technological unity of the raw materials base and processing capacity. Such a technological unity makes it possible to have large series of the following assortments:

- raw refractory clay	circa 300,000 t/year
- dry refractory clay	circa 50,000 t/year
- fired refractory clay	circa 200,000 t/year
- alumosilicate refractory bricks	circa 150,000 t/year
- refractory ramming masses	
- refractory concretes	
- refractory putty, dust and mortars and other alumosilicate products	circa 50,000 t/year

MAGNESITE - basic high refractory materials

Yugoslav magnesites are well-known in the world as excellent raw materials for the production of high refractory basic materials. "Magnohrom" in Kraljevo has founded its production on this raw material. "Magnohrom" began its development after World War II and started production of sintermagnesites and basic refractory bricks in 1952. During the past few years, with modernization and reconstruction of existing plant as well as with the operation of new plant, "Magnohrom" has joined the ranks of the most modern enterprises in the world in this industrial branch.

The technological process in "Magnohrom", takes place in the plants for the production of:

- sintermagnesites
- basic refractory bricks and
- refractory masses and bricks

The production of sintermagnesites is based on the firing of previously prepared raw magnesite in a special granulometric composition. Sintering is done in rotor kilns that are fully automated. After sintering, sintermagnesite is stored in silos as per granulations.

The production of basic refractory bricks is divided into four phases:

- preparation of the mass
- pressing and drying brick
- firing in chamber kilns
- firing in tunnel kilns

The section for preparing the mass includes the storage of chrome ore and silos for sintermagnesite, equipment for preparation (crushing and grinding), silos for components, mixers and conveyor equipment for transporting the mass to the pressing department.

The department for bricks pressing equipped exclusively with hydraulic presses.

The sintering of the bricks is done in tunnel and chamber kilns with control and regulation of the firing diagram. "Magnohrom" has its own Institute for Refractory Materials which is outfitted with the most up-to-date equipment. The Institute also disposes with complete semiindustrial installations which makes it possible to undertake scientific research work as well.

"Silika" - refractory products

"Silika" in Gostivar has based its production on the domestic raw materials base exploiting raw materials from its mines and from those in its proximity. Rich high-grade quartzite and dolomites offer broad possibilities for the production of silica and dolomite refractory materials. On the basis of ninety years of work, it can be concluded that "Silika" has grown from a simple plant producing silica brick into a modern industrial establishment for the production of all kinds of quality silica, fire clays, high aluminous, silicium-carbide, dolomite refractory materials.

The production program of OOUR "Alumosilikat" includes the production of silica, fire clay, high-grade aluminous silicium carbide products as well as all kinds of masses, mortar and concrete.

The production program of OOUR "Dolomit" encompasses the production of converter brick, dolomite blocks and various kinds of dolomite masses. The capacity of these factores is circa 60,000 t/per annum.

"Vatrostalna" - Zenica

The "Vatrostalna" plant in Zenica has in addition to the work organization for refractory construction materials and the overhauling of heating installations, also an organisation for the production of various kinds of refractory milled products in Busovača. This plant produces basic, semiacid and acid milled products in a plastic and dry state.