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RESULTS OF PRELIMINARY TESTING OF THREE ALUNITE ORE SAMPLES FROM THE FANSHAN DEPOSIT (PRC)

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INTRODUCTION

The USSR is the first country in the world to have developed and commercialized the efficient technology of multi-purpose processing of alunite ores by the reduction-alkaline process to obtain alumina, potassium sulphate and sulphuric acid with extraction of pure vanadium pentoxide from recycled alkaline aluminate liquors. The mud-like wastes are used to obtain the light weight construction materials based on the cellular silicate concrete and of decorative asbestos silicate tiles for building facing using the specially elaborated processes.

The production is characterized by the relative simplicity of process sections, low specific fuel and energy consumption and assures the high quality of commercial products.

In accordance with the contract with UNIDO the VAMI Institute has undertaken the preliminary laboratory studies to determine the mineralogical composition and to carry out the technological testing of three characteristic samples weighing 3 kg each taken at the Panshan deposit in the People's Republic of China.

The results of preliminary laboratory studies revealed good technological properties of alunite ore samples and the possibility of their efficient industrial processing by the reduction-alkaline method commercialized in the USSR.

Compared with the Zaglik deposit alunite ores being processed in the USSR the Chinese alunite ore samples have elevated alunite content, higher molar ratio of potassium sulphate in alunite (up to 95% of all alkaline sulphates in alunite) and relatively high content of vanadium (up to 0,11% of V_2O_5 in the first sample).

Silicium oxide in all samples is represented by the large big grain quartzite and only the small part of silicium oxide is represented by the kaolinite which predetermines low chemical losses of aluminium oxides and alkalis with the disposed mud in the hydrochemical processing of reduced alunite.

1. MINERALOGICAL COMPOSITION OF THREE SAMPLES OF ALUNITE ORE TAKEN AT THE FANSHAN DEPOSIT

1. The mineralogical composition of alunite ore samples was determined by a number of physical and chemical methods giving reliable diagnosis of main minerals: radiography, IR spectroscopy, thermography, optical microscopy, X-ray spectrometry, flame photometry, wet chemical method. According to data obtained by said methods all three samples have similar qualitative mineral composition and differ only in the quantitative composition and structure. The main minerals are alunite and quartz, the secondary ones are gematite and kaolinite. X-ray photographs, IR-spectrograms, thermograms (fig.1.1) of the samples correspond to the reference ones for alunite-quartz ores. The chemical and mineral composition of the examined samples is given in the table 2.1.

Sample 1 is represented by the grey-violet dense ore with clearly distinguishable fine layer texture. The microscope study shows that the layer texture of the ore is created by alternation of two types of flattened layers (fig.1.2) - 1) composed of hypidiomorphic granular stream-like concordantly extinguishing alunite aggregates with small number of indented quartz grains (grain size 0,01-0,05 mm) and 2) of contrastingly built areas composed of highly irregular grain size alunite-quartz aggregate with elevated quartz content and alunite from fine-grained to coarse-grained one (grain size 0,002-0,005 to 0,05-0,1 mm). Alunite intercalations predominate in thickness over alunite-quartz which explains the very high content of alunite in the sample.

The said sample contains rather big number of scattered flattened particles of gematite and occasional coarse (up to 1-2 mm) crystalloplasts of magmatic quartz.

Table 1

Chemical and mineral composition of three samples of alunite ore collected at the Panshan deposit (in weight %)

Name of components	Sample N 1	Sample N 2	Sample N 3
SiO_2	17.2	36.0	31.3
Al_2O_3	29.2	22.7	23.7
SO_3	30.0	22.8	24.2
K_2O	8.3	6.2	6.55
Na_2O	0.4	0.32	0.36
Fe_2O_3	3.5	2.9	4.3
TiO_2	0.3	0.5	0.39
P_2O_5	0.2	0.23	0.31
V_2O_6	0.11	0.04	0.07
BaO	0.12	0.11	0.14
F	0.20	0.15	0.11
$H_2O + 480^o$	10.4	8.0	8.4
Others	0.07	0.05	0.17
Alunite	77.5	58.2	62.6
Quartz	16.7	35.0	30.7
Kaolinite	1.5	2.5	1.6
Gematite	3.6	3.0	4.4
Others	0.7	1.3	0.7

Differential thermal curves of three samples of the Fanchan deposit alunite ore

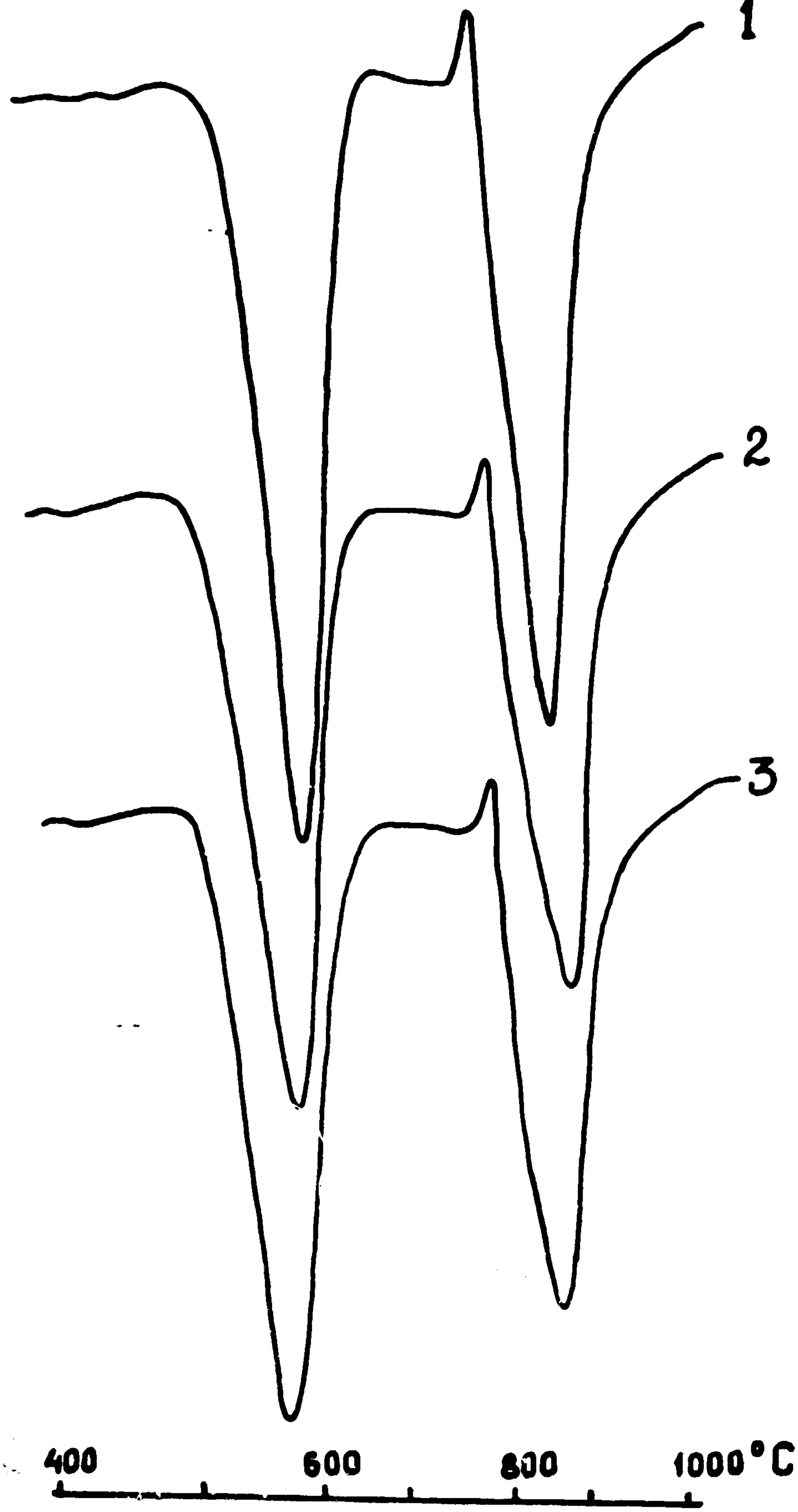
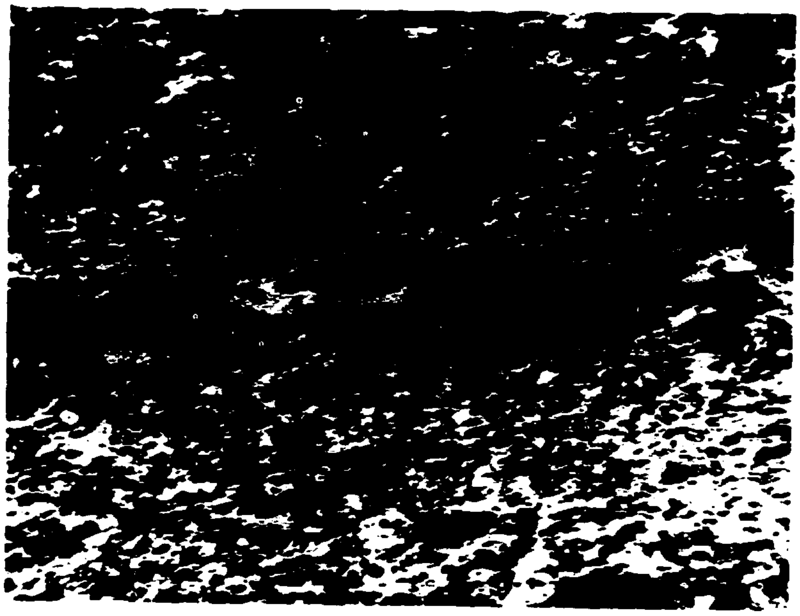


Fig. 1.1. The digits at curves correspond to the sample number

Sample N 2 macroscopically looks like dense grey rock with feebly marked disseminated stratified texture. Under microscope the stratified texture is more pronounced, though not so sharp as in the sample N 1. The ore is composed mainly of the same elements: predominantly stream-like concordantly extinguishing alunite aggregates and alunite-quartz aggregates and grained alunite aggregates, though the form of these elements and quantitative relationship are somewhat different. The alunite-quartz grained aggregates occupy the considerable part of the ore volume and have slightly flattened form close to the isometric one. They are enveloped or "streamlined" by the alunite streamlike aggregates which receive sinuous form instead of straightlined remaining substantially subparallel to each other (fig.1-3). Sometimes the consolidated alunite sections (0.05-0.08 mm) and fine-grained quartz aggregates (0,005-0,01 mm) are met in the sample N 2. Occationally crystalloplastic quartz up to 1,5 mm is found. Constant presence of fine grains of gematite is characteristic.

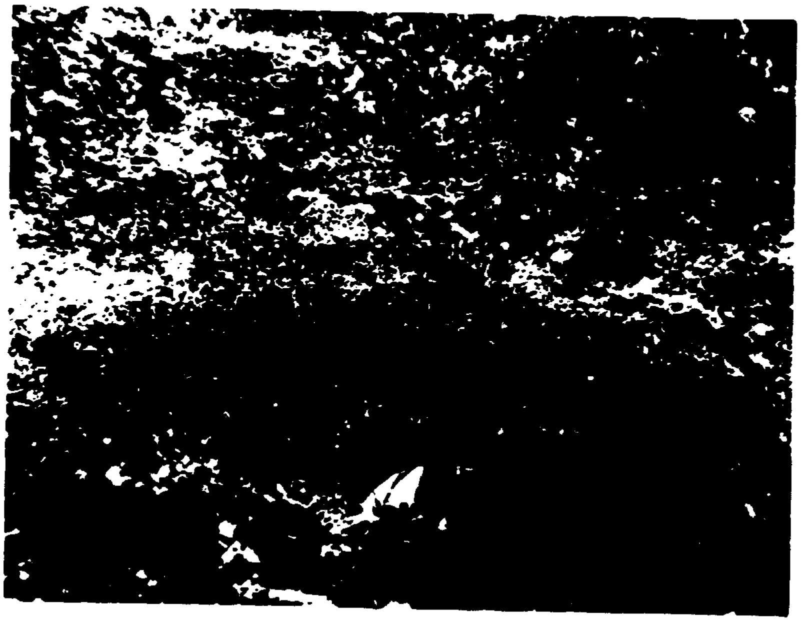
Sample N 3 is represented by rather variegated dense rock of grey colour with rose-violet shade with disseminated a large fragment texture. The microscopic study shows that the rock consists of amorphous alunite-quartz aggregates with fine-grained alunite and medium-grained quartz as well as minute lenses, bands disposed approximately in parallel between alunite-quartz aggregates which allows to determine the slightly pronounced stratified character of the rock. Except the said elements the rounded aggregates of fine-grained quartz with small amount of particular alunite as well as crystalloplastic quartz are observed in the alunite ore of this sample (fig.1.4). As in the above samples the fine gematite grains are widespread, sometimes the nests with enlarged gematite are met (fig.1.5).

Thus the examined samples of the Panshan deposit are characterized by a rather simple mineralogical composition. Samples do not contain the minerals of amorphous silica, practically all silica is in the form of medium-grained quartz. The geochemical peculiarity of examined samples is the almost completely potassium composition of the alunite.



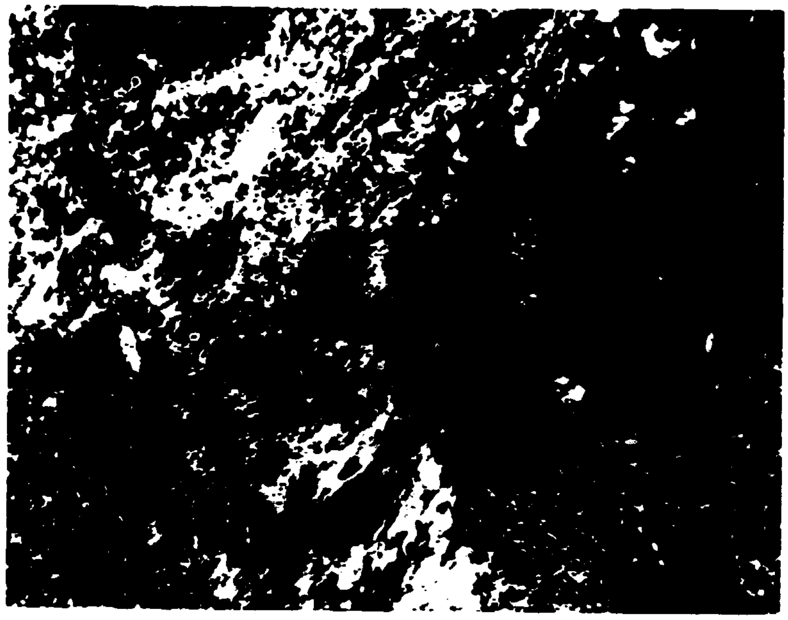
Stratified texture made by alternation of fine-grained alunite sections and medium-grained alunite-quartz sections.
Sample N 1, magnification 90^x, crossed nicols.

Fig.1.2



Combination of alunite streamlike aggregates (lights spots) and alunite-quartz aggregates with particular alunite.
Sample N 2, magnitude 40^x, crossed nicols.

Fig.1.3



Structure of alunite ore: quartz aggregate with small amount of alunite (right), streamlike alunite aggregate (light), alunite-quartz aggregate with particular alunite (shimmering grey mass). Sample N 3, magnification 80^x, crossed nicols

Fig.1.4

Nest of enlarged gematite and alunite in a quartz-alunite rock. Sample N 3, magnification 90^x, nicols at 45°

Fig.1.5

2. RESULTS OF THE PRELIMINARY TECHNOLOGICAL TESTING OF THREE ALUNITE SAMPLES FROM THE PANSHAN DEPOSIT BY THE REDUCTION-ALKALINE METHOD

All three samples of alunite ore after being ground in the ball mill till the thinness 50% of -270 mesh were subjected to the thermal decomposition in two stages on the large bench. scale installation. At the first stage the dehydratation at 520°C was carried out. The dehydrated alunite at the second stage was subjected to thermal decomposition under effect of of gaseous elementary sulphur at 560°C according to equilibrium reaction:

$$R_2SO_4 \cdot Al_2(SO_4)_3 \cdot 2Al_2O_3 + 1.5S \longrightarrow$$
$$R_2SO_4 + 3Al_2O_3 + 4{,}5\ SO_2$$

The resulting samples of reduced alunite were subjected to leeching in the standard conditions by the solution of the caustic. The received results of the laboratory studies are given in the table 2.1.

The received data show that all three sample of alunite ore decompose under the effect of the gaseous elementary sulphur at 560°C during one hour by 90-92% without passivation of the aluminium oxide in the reduced alunite.

During leeching by the caustic solution in standard conditions from the reduced alunite the solution of more that 98% of aluminium oxide, potassium sulphate and sulphur anhydride is extracted.

In order to give the technological assessment of the alunite ores quality in their hydrochemical processing by the alkaline-aluminate solution under simulated industrial conditions the samples of reduced alunite ores were subjected to the leeching by the alkaline-aluminate solution at 60 and 90oC during 1,2 and 4 hours.

The results of the studies are given in the table 2.2 where it can be seen that the received samples of reduced alunite ores have good technological characteristics.

Table 2-1

Characteristics

of thermal decomposition and leeching of reduced alunite under standard laboratory conditions

Name of sample and process area	Unit of measure	Sample N 1	Sample N 2	Sample N 3
1. Composition of reduced alunite in weight %				
Al_2O_3 *alunite*	%	38.8	26.5	27.3
Al_2O_3 *sol. in alk.*	%	38.7	26.6	27.0
K_2O	"	11.6	7.5	7.9
SO_3	"	13.0	9.0	9.2
2. Level of alunite decomposition	%	92	91	93
3. Extraction into solution during leeching of reduced alunite under standard conditions:				
Al_2O_3 *alunite*	%	99.0	101	98.5
K_2O	"	98	97	98.5

During leeching of reduced alunite ore samples under the said conditions the silicium oxide did not practically pass into the aluminate solution and the processes of secondary chemical interaction of aluminate solutions with the mud's silicium oxide with formation of alkaline hydroalumosilicate compounds, did not take place. Over 98% of aluminium oxide and potassium sulphate was extracted from the reduced alunite into solution.

Basing on the results of the preliminary technological testing of the three alunite ore samples and on the experience of industrial multi-purpose processing of the Zaglik alunite ores at the Kirovabad aluminium smelter in the USSR the expected specific consumptions of raw materials, fuel, energy and amounts of the products received by industrial multi-purpose processing of the Fanshan alunite ore through the reduction-alkaline method are determined. These data are shown in the table 2-3.

SHEMATIC FLOWSHEET FOR COMPLETE PROCESSING OF ALUNITE ORE

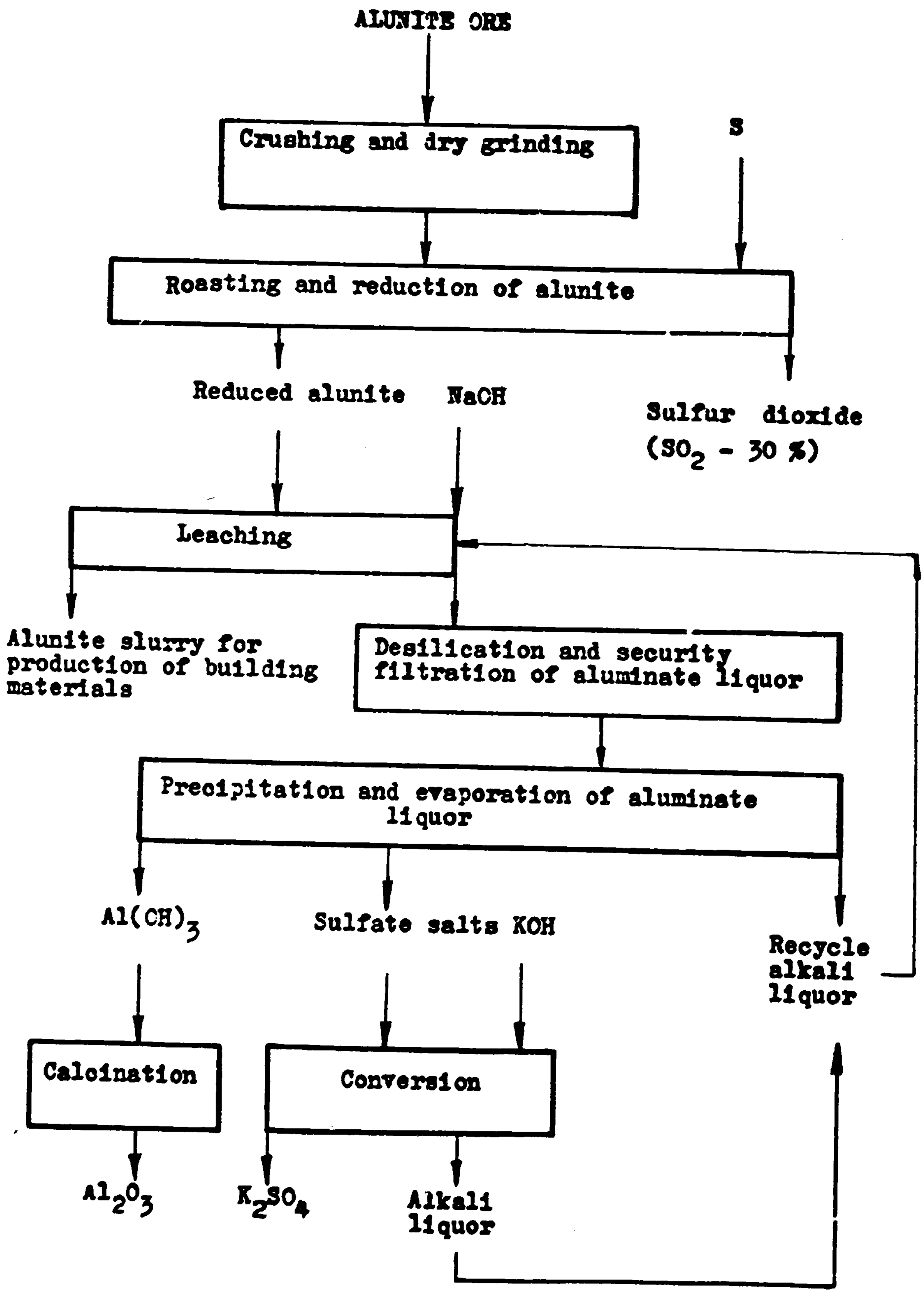


Fig.2-1

Table 2-2

R e s u l t s
of technological leeching of reduced alunite samples

	Leeching conditions		Chemical composition before and after leeching in g/l					Chemical composition of reduced alunite and muds after leeching, in %				Extraction of Al_2O_3 taking into account SiO_2 in solution
	t°C	hour.	V_{ml}	Na_2O_k	Al_2O_3	SiO_2	α_K	SiO_2	Al_2O_3	Fe_2O_3	R_2O	
Sample N 1	Initial solutions and reduced alunite		150	121.0	50.8	-	3.93	23.96	39.86	4.87		-
	60°	1	150	114.9	103.0	0.15	1.83	80.5	2.2	14.7	0.25	98.0
	"	2	150	111.9	97.9	0.16	1.88	80.7	2.0	15.2	"	98.1
	"	4	149	113.1	102.0	0.16	1.83	81.2	2.2	14.8	"	98.1
	90°	1	139	119.3	108.0	0.18	1.82	80.7	1.8	15.1	"	98.3
	"	2	147	116.1	104.4	0.18	1.83	80.5	1.7	15.1	"	98.4
	"	4	127	133.2	120.0	0.28	1.83	80.5	1.8	15.0	"	98.3
Samples N 2 & 3	Initial solutions and reduced alunite		106	121.0	50.8	-	3.93	51.0	28.8	3.4	5.44	-
	60°	1	103	114.9	100.0	0.12	1.89	89.1	0.46	5.8	0.25	98.9
		2	85	136.6	118.5	0.135	1.89	89.6	0.54	5.6	"	98.7
		4	80	139.1	123.2	0.21	1.86	89.7	0.46	5.5	"	98.8
	90°	1	91	127.0	111.0	0.17	1.88	89.4	0.48	5.8	"	98.7
		2	97	121.0	105.6	0.22	1.89	89.2	0.55	5.6	"	98.5
		4	92	127.0	110.6	0.265	1.89	89.4	0.41	5.5	"	98.8

Table 2-3

Expected specific consumptions of raw materials, materials, fuel energy and commercial products obtained through processing of the Panshan deposit alunite ore by the reduction-alkaline method

Item	Unit of measure	Expected characteristics
1. Specific consumptions of raw materials, energy, fuel		
- alunite ore	t	4.5-5.5
- sulphur	t	0.35-0.4
- KOH solution (100%)	t	0.27-0.30
- NaOH solution (100%)	t	0.02-0.03
- electric energy	kWh	1000-1100
- fuel	t conventional fuel	0.40-0.45
- vapeur	Gcal	3.2-3.4
- fresh water	m^3	18
2. Commercial production		
- alumina, 00	t	1.00
- potassium sulphate (K_2O - 51%)	t	0.95-1.00
- sulphuric acid (grade A)	t	1.85-2.00

3. CONCLUSIONS

- The assessment of possibility of efficient processing of the alunite ores from the Panshan deposit by the reduction-alkaline method developed in the USSR on the basis of results of preliminary studies and technological testing of three characteristic samples is made.

- The expected specific consumptions of raw materials, materials, fuel, energy and expected amount of commercial products received by industrial multi-purpose processing of the Panshan deposit alunite ore by the reduction-alkaline method are determined.

- In order to elaborate the FS for the industrial plant in the People's Republic of China for processing the Panshan deposit alunite ore by reduction-alkaline method it is recommended to examine the quality and reserves of alunite ore basing on the geological survey of the deposit, to elaborate the method of collecting the representative lot of alunite ore weighing 4-5 thousand tons, to carry out more detailed laboratory studies and pilot testing of the collected representative lot of alunite ore.