CHAPTER IV
THE RESULTS OF STUDY ON SUBSTANTIAL COMPOSITION OF SAMPLES

IV.1. STUDY SAMPLES

IV.1.1. Study samples

The study samples were taken as planned by the Viet-Lao Joint Stock Company. There are two different samples: 01 ore sample taken from ore body TQ.III and other 01 ore sample taken from ore body TQ.II. Both two samples were taken from exploration and exploitation engineering of the mine. Ore sample of ore body TQ.II was preliminarily processed at the mine.

The weight of the ore sample of ore body TQ.III is 200kg with a biggest piece of 100mm in size. Ore sample of the ore body TQ.II was crushed to < 1.0 mm in dimension and then was divided into 4 parts, two parts of opposite angle of 80 kg in weight were taken for analysis. These samples were subjected to test study at the Vietnam (Minerals) Dressing Association – Vietnam National Center of Science and Technology .

IV.1.2. Processing samples

In order to prepare samples for analysis of substantial composition and test (pilot) dressing, the samples were briefly processed following the processing scheme as in fig. IV.1 - 1. Through the process of dimension decreasing, regular mixing, briefing, some represent samples taken from the ore sample of ore body TQ s.III for various analyses such as grain size, total chemical, ICP – MS, test samples and stored ones.

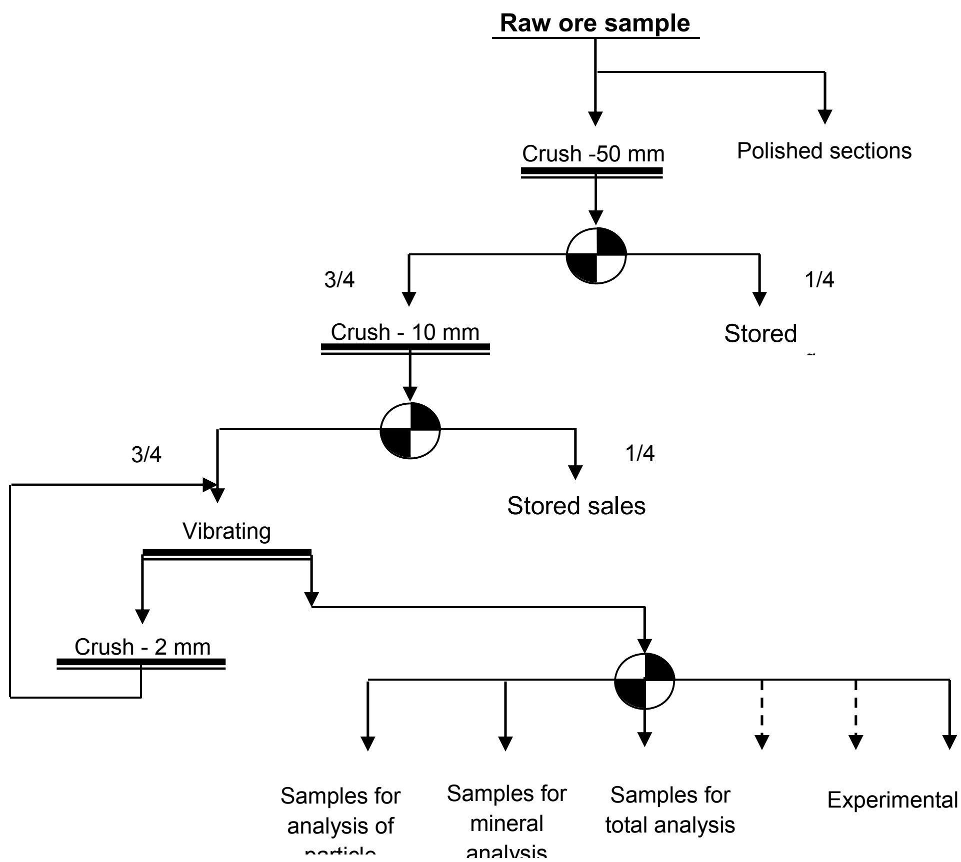


Fig. IV.1 – 1 : Processing scheme of

IV.2. STUDY ON SUBSTANTIAL COMPOSITION

IV.2.1. Study methods

In order to determine characteristics and substantial composition of the study samples, it is carried out a series of analysis such as multi-element, grain size, heavy minerals, mineragraphical, petrographical, ICP-MS, etc. It is applied appraisal method by using stereoscope microscope MBC-9. Thin and polished samples are analyzed under polarizing microscope AXIOLAB.

For determining gold content and other chemical components, it is used ICP-OES method on equipment IRIS-INTERPID.

In order to adequately study the feasibility of each ore type, the two main ore types, ie quartz-sulfide ore of the ore body TQ.III and quartz poor-in-sulfide ore of the ore body TQ.II are subjected to experiment.

IV.2.2. The results of study

IV.2.2.1. Multi-element analysis

The total composition is analyzed by ICP – MS method, in which, Au has been analyzed by AAS method. The results are demonstrated in table IV.2.2.1

Table IV.2.2 - 1. Total chemical composition of study samples

No	Element	Content			
		Unit	Concentrate sample .III	Concentrate sample II	Remarks
1	Au	g/t	14.18	9.39	AAS
2	Al_2O_3	%	1.71	12.75	ICP – MS analysis
3	CaO		0.08	0.17	
4	Fe_2O_3		4.94	14.61	
5	K_2O		0.78	3.73	
6	MgO		0.02	1.63	
7	MnO		0.09	0.16	
8	P_2O_5		0.13	0.05	
9	TiO_2		0.20	0.64	
11	As	ppm	1353.0	177.2	
10	Ag		< 2	< 2	
12	B		345.9	1360.0	
13	Ba		41.3	545.1	
14	Be		< 5	6.9	
15	Bi		371.4	< 10	
16	Cd		15.0	3.7	
17	Ce		76.7	171.6	
18	Co		21.1	20.4	
19	Cr		180.5	123.7	
20	Cu		525.4	179.8	
21	Ga		< 10	< 10	
22	Ge		< 20	< 20	
23	La		< 5	< 5	
24	Li		< 5	< 5	
25	Mo		5.4	< 5	
26	Nb		< 5	12.6	
27	Ni		69.7	107.6	
28	Pb		136.8	33.1	
29	Sb		< 10	< 10	
30	Sc		< 5	20.3	
31	Sn		< 10	< 10	
32	Sr		17.4	23.9	

IV.2.2.2. The results of grain size analysis

Ore sample of the ore body TQ.III, after crushing to a size of -2 mm, was subjected to wet sieving through a set of standard sieves: 1; 0.5; 0.25; 0.125; 0.074 and 0.04 mm. After getting 7 grain sizes respectively, they were dried, weighed and then sent to analysis of gold content of these grain sizes.

The results of study are expressed in table IV.2.2 – 2. A curve showing characteristics of grain sizes after crushing to a size of -2 mm of the ore sample taken from ore body TQ.III was drawn on the basis of these results (fig. IV.2.2 - 2).

Table IV.2.2 – 2. Grain size of the study samples

TT	Grain size, mm	Rate, %		Au content, g/t		Au distribution, %	
		γ	∑γ	β	∑β	ε	∑ε
1	- 2.0 + 1.0	25.04	25.04	12.62	12.62	22.29	22.29
2	- 1,0 + 0,5	22,85	47,89	12,21	12,42	19,68	41,97
3	- 0,5 + 0,25	12,91	60,80	12,48	12,43	11,36	53,33
4	- 0,25 + 0,125	12,76	73,56	11,93	12,34	10,74	64,04
5	- 0,125 + 0, 074	6,19	79,75	10,87	12,23	4,74	68,81
6	- 0,074 + 0,040	6,78	86,53	29,81	13,6	14,25	83,06
7	- 0,040	13,47	100,00	17,83	14,18	16,94	100,00
	Total	100.00	-	14.18	-	100.00	-

The results of the study show that when a sample crushed to a size of - 2mm then a raw grain size of + 0,25 mm occupies 60,8%, while the fine grain size of - 0,074 mm occupies more than 20% and a grain size of -0,04 mm occupies 13,47 %. Gold content in grain sizes of the sample is relatively the same, so far, gold content in the fine grain sizes is a little higher than average content of the sample. Because of that, the amount of raw grain sizes is greater than that of fine ones, so gold distributed in raw grain sizes is higher that that in fine grain sizes.

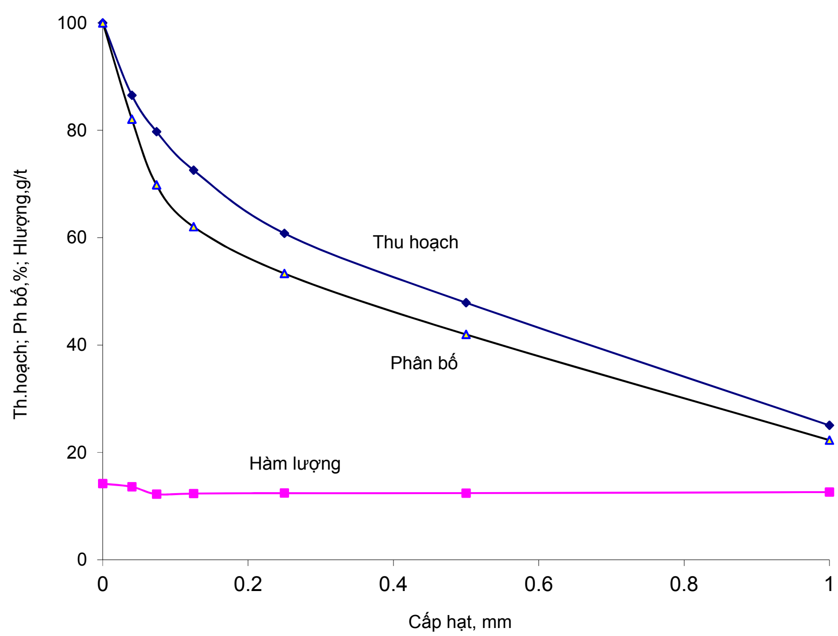


Fig. IV.2-1 : Curve showing characters of grain size of raw

IV.2.2.3.The results of mineral analysis

The results of study and analysis show that the gangue mineral components are predominant in the sample including quartz, hematite, limonite. Sulfide minerals are rare including mostly pyrite which is almost altered into limonite, goethite.

The results of refractive X-ray analysis of two above-mentioned samples on the equipment D8 - Advance are shown in the table IV.2.2 - 3, their scoundrel is expressed in appendix part.

Table IV.2.2 - 3. Results of X-ray analysis

No	Sample	Mineral composition and their contents, %							
		Gơ+Le	He.	T.anh	Felspat	Ilit	K.+C	Talc	Other
1	Ore body.III	18-20	11-13	47-49	4-6	5-7	6-8	A few	Am.FeO
2	Ore body.II	7-9	4-6	30-32	4-6	22-24	10-12	13-15	Fe_3O_4,Dia.

Notes: Gơ - Goethite, Lep - Lepidochrocite, K - Kaolinite, C - Chlorite, Am - Amphibol, Dia - Diaspor

Mineralographical analysis of cohesive polished sections has been carried out. From initial 800g of grain size -2 mm of ore sample from ore body TQ.III, after washing to eliminate light portion, a weight left is76.47g. Processing of heavy portion to get 4.26g, electro-magnetic portion to get 61g.

Preliminary analysis under microscope show that the heavy portion mainly composes of pyrite while electromagnetic portion: limonite.

All of heavy portion was cemented and then was polished. Mineral composition in the polished section is mainly of pyrite. Pyrite is idiomorphic or irregular allotriomorphic with dimension mostly of from 0.1 to1.5mm. Marginal part of pyrite was limonitized of it was completely replaced by limonite. However, limonite here is magnetic.

There have been found 6 gold nuggets (grains), grain size of which is small. The smallest nugget is 0.01 in size, isometric, lying in limonite. The rest are of 0.05-0.15mm in size, irregular, allotriomorphic or elongated. It is a cemented polished section, so the whole surface of it still was not completely polished. Some gold nuggets inlaid in pyrite are also of very small size (< 0,01 mm), somewhere they create a chain in pyrite.

The results of study show that gold seen in the sample is in the form of small size, irregular, allotriomorphic. Some nuggets disseminate in pyrite and limonite. These limonitic grains might be derived from pyrite or might be crystallized from colloidal solution.

The results of analyzing 2 cohesive sections are shown in the table IV.2.2 - 4

Table IV.2.2 - 4 Analytical results of cohesive polished samples

TT	Analyzed samples	Mineral composition and their content, %			
		Pyrite	Limonite	Gold	Other minerals
1	Sample 1	96	2	Some grains	2
2	Sample 2	95	1	Some grains	4

Hereunder are pictures of fine-grained gold inlaid in accompanying minerals such as pyrite, limonite. Before creating cohesive polished samples for analysis, samples have been processed by washing, that why the existence type of very fine-grained gold in quartz basement could not be expressed. After study on ore dressing technology, it is suggested that there is this existence type of gold. This fact indicates that the enrichment by traditional methods as floating and gravity separation result in not high effectiveness.

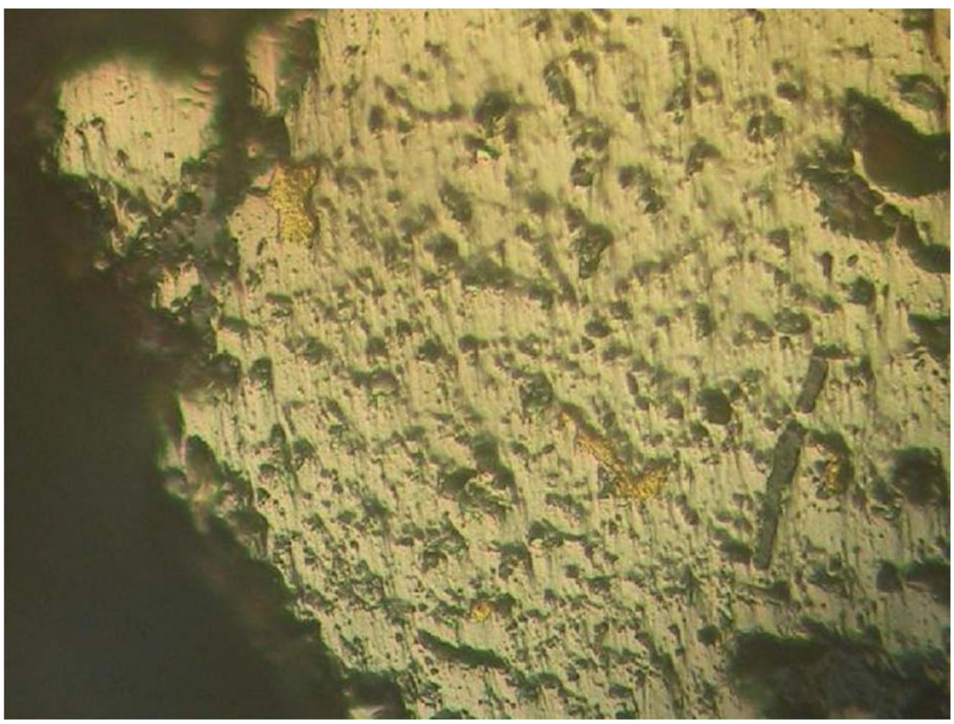


Photo 1. Gold in pyrite of ore body (TQ) III, Zoom : 500 times

Photo 2. Gold in limonitized pyrite of ore body (TQ) III. Exaggeration: 500 times

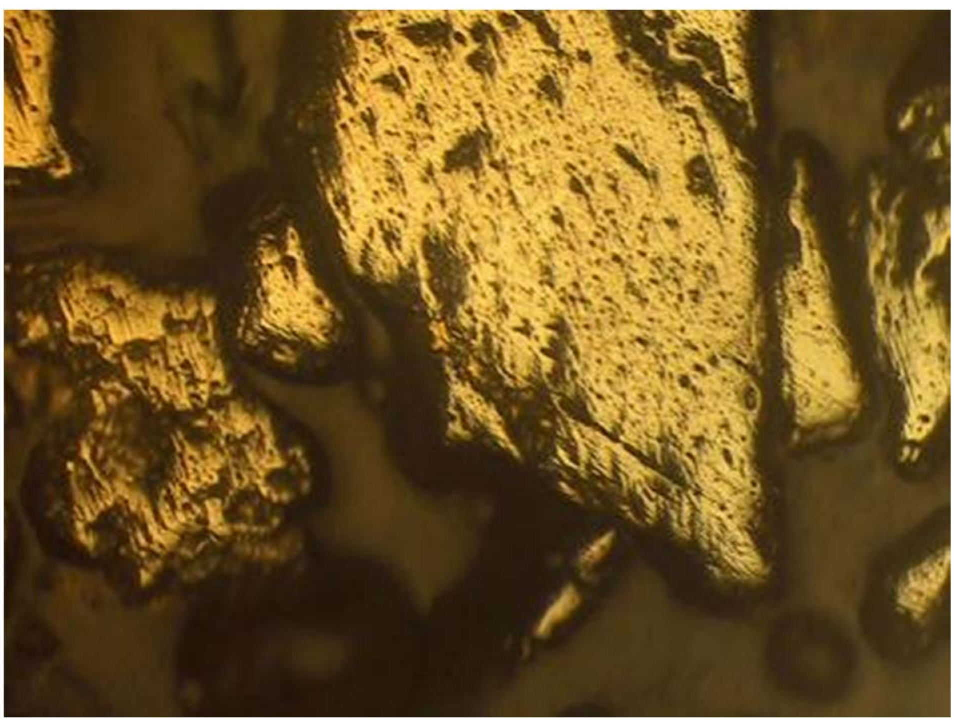


Photo 3. Gold in pyrite of ore body (TQ) III. Exaggeration: 500 times

Photo 4. Gold in quartz geode and in limonite. Exaggeration: 500 times

IV.2.2.3. Some remarks on the results of study on substantial composition of samples

The gold content in different size portions is relatively regular. However, the gold content in fin-grained portions of – 0,074 mm is 1.5-3 times higher that that in grain size of + 0,074 mm. Due to that, the coarse-grained portions are predominate over the fine-grained ones, so the amount of gold in coarse-grained portions is higher.

The results of study on characteristics of mineral composition of ore show that gold in samples is in the form of fine- to very fine-grained type, disseminated in pyrite, limonite derived from pyrite or formed from colloidal solution. It is not excluded that very fine-grained gold is also contaminated in quartz.

The results of study also indicates that there is a little difference between gold in ore body TQ.III and gold in ore body TQ.II. In the ore of the ore body TQ.III, the content of iron oxides is 3-4 times higher than that in ore body TQ.II, in contrary, the content of aluminum oxides in ore body TQ.II is 4.5-7.5 times higher than that in ore body TQ.III.

IV.3. THE RESULTS OF STUDY ON TECHNOLOGICAL SAMPLES

IV.3.1. The aim of the study

The aim of the study is to determine technological procedures of rational dressing by physical dressing methods (gravity separation and floating) for recovery of gold ore concentrates, serving for exploration work of Vang Tat Gold Mine.

IV.3.2. Study on technology of recovery by gravity separation method

The gravity separation is an effective dressing method for relatively coarse-grained gold. Nevertheless, for fine-grained gold, especially for primary gold with fine contamination, this method is lesser effective. Equipments using in this field are defecation pan (accumulator), panning table, hand pan.

For primary gold in Attapu, because of relatively fine contamination of gold and sulfides, it is necessary to study on optimal crushing-washing regime. Other working regimes of table pan will be chosen depending on what kind of gold samples to be dressed:

- Shaking amplitude of the table:10 mm
- Shaking frequency : 300 times/minute
- Water consumption: 6 l/minute
- Slop of table surface: 3^0

The experiment is done on the panning table TQ 1000 x 450. Other experiments for determining optimal regimes are carried out following a scheme shown in fig. IV.3.1

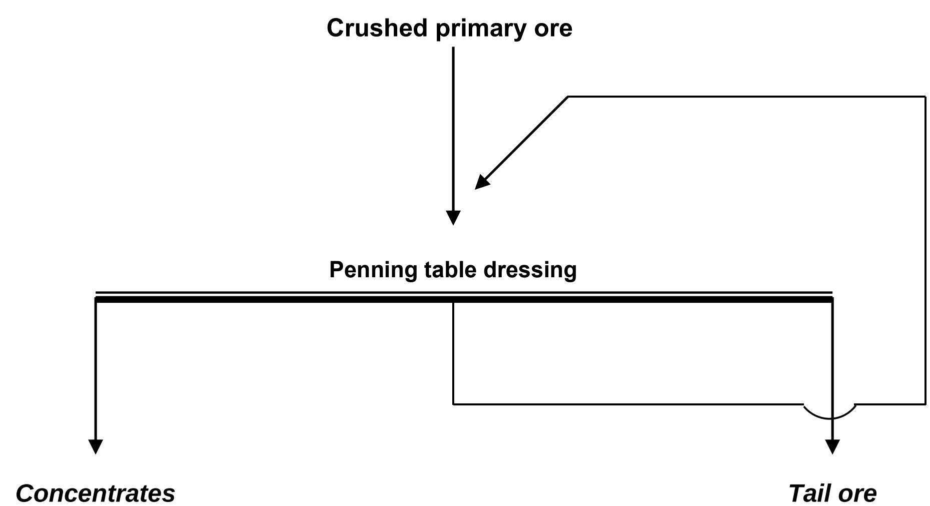


Fig. IV.3 - 1 Scheme showing test penning table dressing

IV.3.2.1 Time of ore crushing

Experiments determining the time of ore crushing are carried out in iron ball crusher with capacity of 8 litres manufactured by Russia. The ratio ball/ore/water is 12:1:1. The initial grain size of ore putting in the crusher is -2mm. Crushing time varies from 5 to 35 minutes.

The results of determining crushing time are presented in the table IV.3.2.1

Table IV.3.2.1 Determination of fineness under crushing time

No	Crushing time	Fineness, % Grain size - 0,074 mm
1	5	43,14
2	10	58,29
3	15	73,57
4	20	82,14
5	30	90,00
6	35	95,00

IV. 3.2.2. The experimental results of determining optimal crushing-washing grain size

The experiment is carried out according to the scheme shown in the fig. IV.3 -1, The experimental results of determining optimal crushing-washing grain size are presented in the table IV.3.2.2.

Under the increase of the fineness of crushing from 25% to 82% grain size: - 0,074 mm, dressing on panning table with the fineness of crushing 58% has got the best results. However, the effectiveness of the dressing is not met as desired. Obtained concentrate has a little increasing gold content in comparison with that of initial sample, while the real gold recovery norm in concentrate is too low. This is indicated that the forming features and contamination of gold in accompanying minerals have limited gold extraction leading to the low effectiveness of gravity separation on the panning table. These results have leading to the conclusion that it is impossible to use panning table to enrich this type of ore in order to get concentrate of high quality and acceptable recovery. The observation on the relationship between recovery of concentrate and content and real recovery of gold in concentrate under gravity separation on the panning table (table IV.3.2.3) show that even under increasing of concentrate recovery from 7.29% up to 26.25%, the real recovery is only increased from 17.30% to 37.8% while the content of gold in concentrate is decreased from 33.65% down to 21.23%.

Table IV.3.2.2. Experimental results of determining optimal crushing-washing grain size

Crushing fineness , % size - 0,074	Product	Recovery, %	Au content, g/t	Real Au recovery , %
25	Concentrates	8.73	20.27	12.48
	Tails	91,27	13,60	87,52
	Raw ore	100,00	14,18	100,00

33	Concentrates	8,63	20,50	12,81
	Tails	91,37	13,58	87,19
	Raw ore	100,00	14,18	100,00
43	Concentrates	8,57	22,85	13,81
	Tails	91,43	13,37	86,19
	Raw ore	100,00	14,18	100,00
58	Concentrates	7,29	33,65	17,30
	Tails	92,87	12,65	82,70
	Raw ore	100,00	14,18	100,00
73	Concentrates	7,13	34,10	17,15
	Tails	92,87	12,65	82,85
	Raw ore	100,00	14,18	100,00
82	Concentrates	6,90	35,20	17,13
	Tails	93,10	12,62	82,87
	Raw ore	100.00	14.18	100.00

Table IV.3.2.3 Relation between recovery, content and real recovery of gold

No	product	Recovery,%	Au content,%	Real recovery Au,%
I	Concentrates	7.29	33,65	17,30
	Tails	92,71	12,65	82,70
	Total	100,00	14,18	100,00
II	Concentrates	15,50	26,07	28,50
	Tails	84,50	12,00	71,50
	Total	100,00	14,18	100,00
III	Concentrates	21,12	22,59	33,65
	Tails	78,88	11,92	66,35
	Total	100,00	14,18	100,00
IV	Concentrates	26,25	21,23	37,80
	Tails	73,75	11,79	62,20
	Total	100,00	14,18	100,00

IV.3.3. The study on gold recovery by floating method

IV.3.3.1. The results of study on conditions of floating

There are numerous conditions effecting to the effectiveness of floating such as fineness under crushing, cost of regulation factors and chemicals (pH, compressed sink, agitation), integration chemicals, foam-forming chemicals, chemical content and its contact time, floating time, etc. However, in the framework of the study on technological samples for test floating of gold ore of Vang Tat Gold Mine, only main conditions are mentioned, while other conditions are chosen from literature, published research works. The study experiments for determining conditions of floating were carried out following the scheme shown in fig. IV.3.3 -1.

The main equipments using in experiments for determining conditions of floating are wet ball crusher with capacity of 8 litres manufactured by Russia and floating machine Denver with capacity of 2.5 l manufactured by UK.

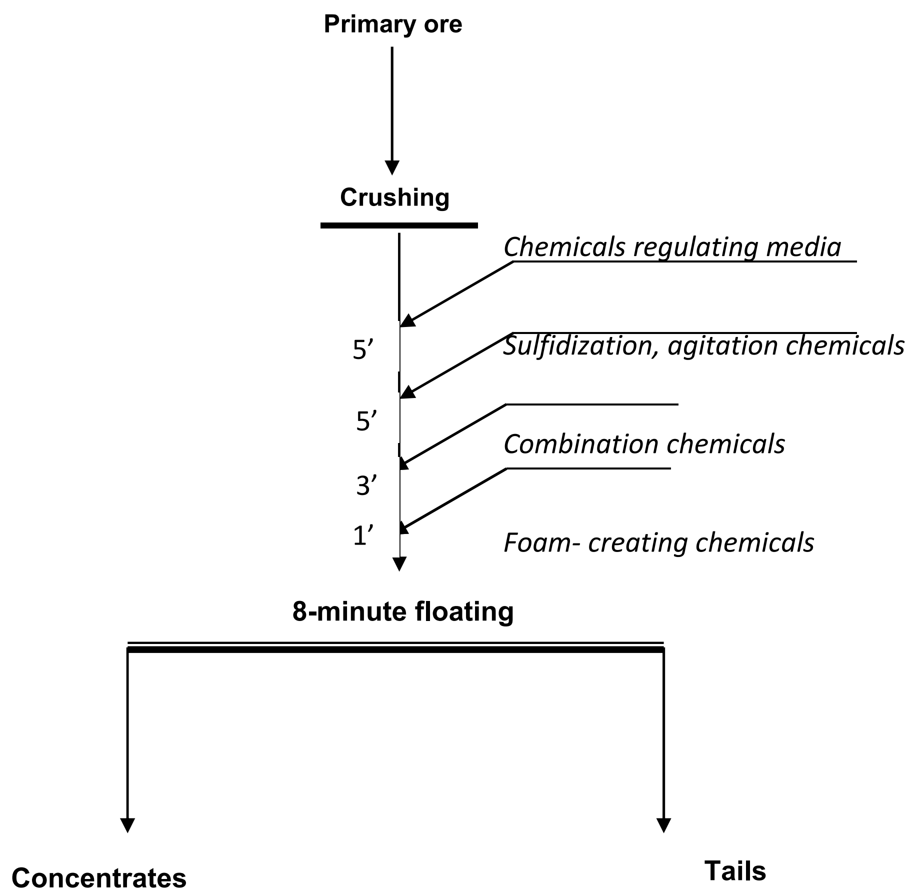


Fig. IV.3.3 -1. Scheme showing floating conditions

Floating chemicals used in experiments:

- Chemical regulating pH media is soda.
- Sulfide chemical is Na_2S.
- Concentrating chemical is Xanthate, non-pole chemical is oil.
- Foam-forming chemical is pine oil.

Besides, there are used other chemicals such as $CuSO_4$, coconut oil, cation Armax T concentrating chemical, etc.

IV.3.3.1.1. The results of study on determination of optimal crushing fineness

The experiment has been carried out following the scheme shown in fig. IV.3.3 - 1

Variable condition is the fineness of ore crushing: 70; 80; 90; 95% size - 0.074 mm.

Experimental conditions:

- Soda: pH = 8.
- Na_2S = 200 g/t
- Xanthate = 150 g/t
- Pine oil = 100 g/t

The experinental results are shown in table IV.3.3.1 ; fig. IV.3.3 -2.

Under increasing crushing fineness from 70% up to 95% size : -0.074 mm, the recovery of concentrates increases from 3.06% to 4.07%, and the content of concentrate varies : 184.27 ; 211.56 ; 210.50 ; 186.20 g/t, corresponding to real recovery: 39.76 ; 56.84 ; 60 ;27; 53.44% respectively. The results suggests that chosen optimal crushing fineness of ore subjected to floating is 90% size : -0.074 mm. With this fineness, the recovery of concentrate is 4.06%, content : 210 g/t, corresponding to real gold recovery of 60.27%.

Table IV.3.3.1.1. Study results of determining optimal crushing fineness

Fineness under Crushing,%	Products	Recovery,%	Content,%	Real recovery,%
70	Concentrates	3,06	184,27	39,76
	Tails	96,94	8,81	60,24
	Total	100,00	14,18	100,00
80	Concentrates	3,81	211,56	56,84
	Tails	96,19	6,36	43,16
	Total	100,00	14,18	100,00
90	Concentrates	4,06	210,50	60,27
	Tails	95,94	5,87	39,73
	Total	100,00	14,18	100,00
95	Concentrates	4,07	186,20	53,44
	Tails	95,93	6,88	46,56
	Total	100,00	14,18	100,00

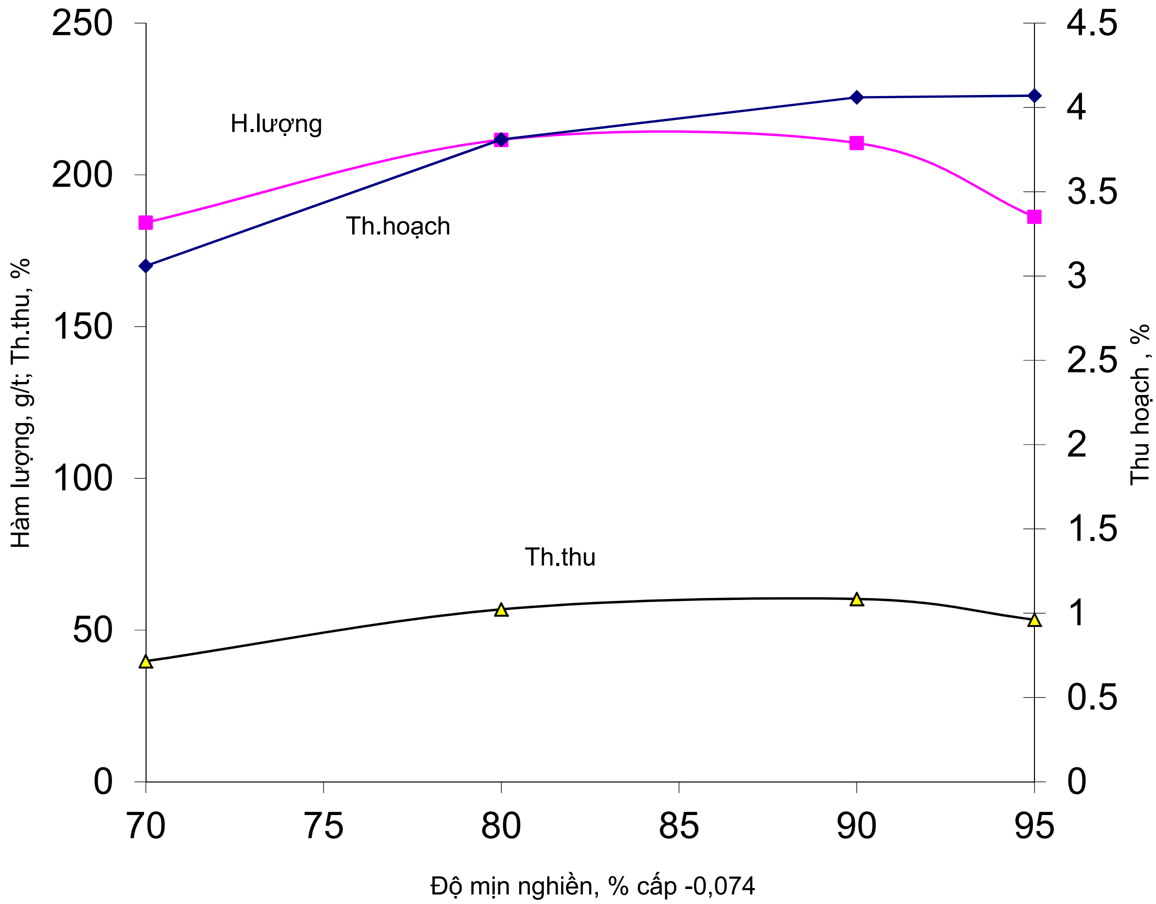


Fig IV.3.3.1.2. Effect of crushing fineness to floating norms

IV. 3.3.1.2. The study results on determining optimal pH of the media

The experiment is carried out following the scheme 4

Condition changes pH of ore mud by changing consumption for chemicals regulating the experimental conditions:

- Crushing fineness 90%, size: -0,074 mm
- Na_2S = 200 g/t
- Xanthate = 150 g/t
- Pine oil = 100 g/t

The results are shown in the table IV.3.3.1 - 2 and fig. IV.3.3.1 – 2.

Table IV.3.3.1.2 Experimental results of determining optimal pH.

pH	Products	Recovery,%	Content,%	Real recovery,%
4	Concentrates	3.29	173.19	40.18
	Tails	96,71	8,77	59,82
	Total	100,00	14,18	100,00
6	Concentrates	4,71	143,81	47,77
	Tails	95,29	7,77	52,23
	Total	100,00	14,18	100,00
7	Concentrates	3,14	225,15	49,86
	Tails	96,86	7,34	50,14
	Total	100,00	14,18	100,00
7.5	Concentrates	3,29	234,50	54,41
	Tails	96,71	6,68	45,59
	Total	100,00	14,18	100,00
8	Concentrates	3,79	230,0	61,47
	Tails	96,21	5,68	38,53
	Total	100,00	14,18	100,00
9	Concentrates	3,29	231,44	53,70
	Tails	96,71	6,79	46,30
	Total	100.00	14.18	100.00

The results of experiment with pH of different media from weak acidic to weak alkaline (from 4 to 9) show that gold can be floated in this pH interval. Indeed, the weak alkaline medium offers better results. The value of pH for the best results of floatation is 8. Recovery of concentrate is 3.79%, content 230 g/t, with real recovery of 61.47%

IV.3.3.1.3 The results of study on determining consumption of Na_2S

The experiment is carried out following the scheme 4

Changing condition: Na_2S consumption

- Crushing fineness 90%, size: -0.074 mm

- pH = 8

- Xanthate = 150 g/t

- Pine oil = 100 g/t

The results are shown in the table IV.3.3.1 - 1 and fig. IV.3.3.1 – 1.

Na_2S consumption, g/t	Products	Recovery,%	Content,%	Real recovery,%
50	Concentrates	4.51	188.65	60.60
	Tails	95,49	5,85	39,40
	Total	100,00	14,18	100,00
100	Concentrates	3,91	226,10	62,34
	Tails	96,09	5,56	37,66
	Total	100,00	14,18	100,00
200	Concentrates	3,79	230,00	61,47
	Tails	96,21	5,68	38,53
	Total	100,00	14,18	100,00
300	Concentrates	3,65	231,15	59,50
	Tails	96,35	5,96	40,50
	Total	100.00	14.18	100.00

Table IV.3.3.1 – 1 Test results of determining optimal Na_2S consumption.

Under changing Na_2S consumption from 50 g/t up to 400 g/t, the obtained results are approximate. However, under high Na_2S consumption, gold begins to be compressingly sunk. The optimal Na_2S consumption is 100 g/t.

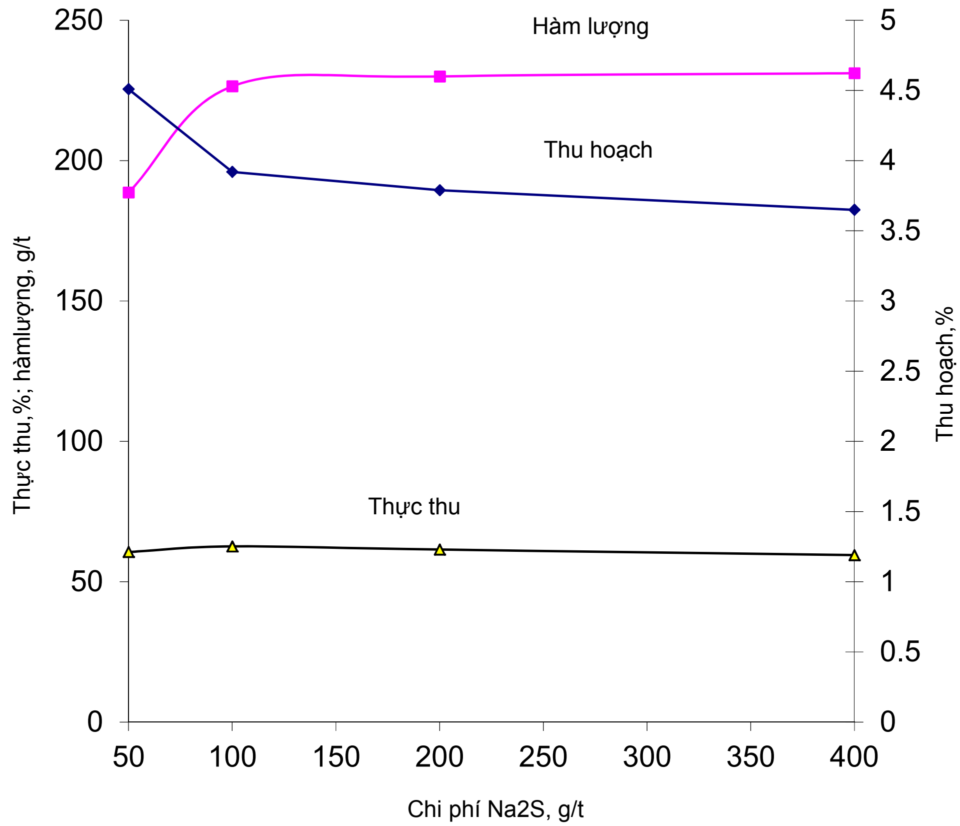


Fig. IV.3.3.1 - 1. Effect of Na_2S to floating norms

IV.3.3.1.4. The results of study on determination of Xanthate consumption

The experiment is carried out following the scheme IV.3.3.14

Changing condition is consumption of xanthate

Experimental conditions :

- Crushing fineness 90%, size: -0,074 mm
- pH = 8
- Na_2S = 100 g/t
- Pine oil = 100 g/t

The results are shown in the table IV.3.3.1 - 2 and fig. IV.3.3.1 – 2.

Table IV.3.3.1 - 2. Test results of determining comsumption of xanthate

Comsumption of xanthate, g/t	products	Recovery,%	Content,%	Real recovery,%
100	Concentrates	3.79	225.06	60.15
	Tails	96,21	5,87	39,85
	Total	100,00	14,18	100,00
200	Concentrates	3,92	226,66	62,66
	Tails	96,08	5,51	37,34
	Total	100,00	14,18	100,00
300	Concentrates	4,57	195,17	62,9
	Tails	95,43	5,51	37,10
	Total	100,00	14,18	100,00
400	Concentrates	4,86	184,11	63,10
	Tails	95,14	5,50	36,90
	Total	100.00	14.18	100.00

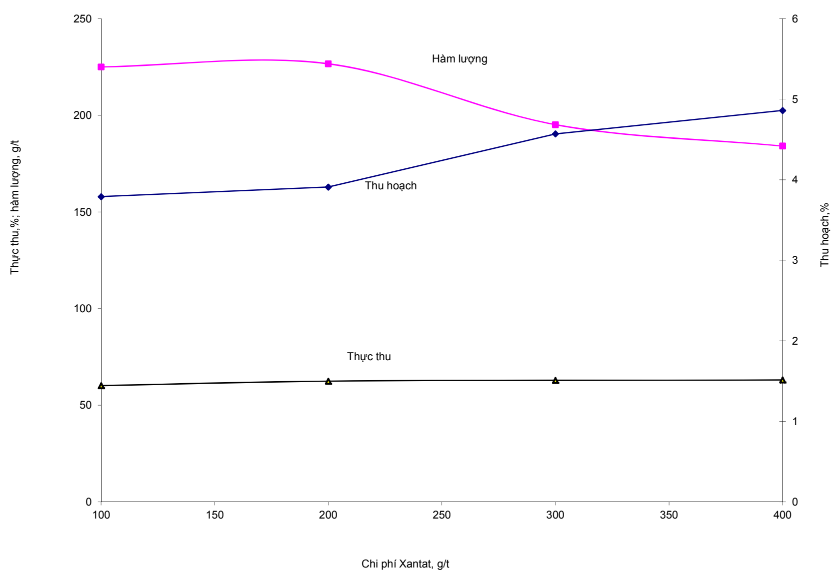


Fig. IV.3.3.1 - 2. Effect of Xanthate comsumption to floating norms

When [illegible])0 g/t, then the recovery of concentrate is also increased from 3.79% to 4.86%, at the same time, the real recovery is also increased from 60.15% to 63.10 too, but the content is gradually decreased from 225.06% to 184.11%. From the comsumption of 200 g/t the real recovery is a little increased, so the xanthate comsumption of 200/t is determined to be chosen.

The results of study on optimization of some floating conditions has led to some remarks such as the study sample is an object which is difficult to be enriched by common mechanical methods. The content of concentrate is high enough for continuous processing of following parts and it is necessary to increase real recovery of gold in concentrate. Some measures have been considered in order to increase real recovery of gold.

IV.3.3.2. The study on raising real gold recovery

In order to find measures for raising real gold recovery, the analysis of sieving floated tails, the results of which are presented in the table IV.3.3.2 - 1.

The results show that the floated tails are mainly of grain size -0,04 mm (72.3%), a gold content in two grain sizes does not much differed each from other, the distribution of gold in fine-grained portion is higher than that in coarse-grained one even its content is low. The reason of low real recovery is not caused by unenough crushing fineness, but may be the structure and gold contamination in accompanying minerals.

Table IV.3.3.2 - 1. Analytical results of sieving floated tails

No	Grain size, mm	Recovery, %	Content, g/t	Distribution,
1	+ 0.04	27.70	7.75	38.96 %
2	- 0.04	72.30	4.65	61.04%
	Floated tails	100.00	5.51	100.00%

Nevertheless, it has been put under consideration some technological measures in order to raise real gold recovery.

IV.3.3.2.1. Prolonging the time of floating

In the table IV.3.3.2 – 2, there present the results of 8-minute and 12-minute floating. Even the time of floating is prolongated more 4 minutes, the real recovery is not much increased, that may prove that the reason may not be a low floatation of gold.

Table IV.3.3.2 - 2. Comparison between different floating times

Floating time	Products	Recovery,%	Content,g/t	Real recovery, %
8 minutes	Concentrates	3.91	226.66	62.50
	Tails	96,09	5,53	37,50
	Total	100,00	14,18	100,00
12 minutes	Concentrates	4,43	204,83	63,99
	Tails	95,57	5,32	36,01
	Total	100.00	14.18	100.00

IV.3.3.2.2.Washing by acid before floating

Before floating, oxidized or dust surfaces of ore mineral particles were cleaned by soaking and stiring ore, after crushing, in acid sulphuric with pH=3 and then wash them many times by water until pH=7, then adjust pH by soda to pH=8 and then floatation is carried out normally as shown on scheme. Comparative results are presented in the Comparisontable IV.3.3.2 – 3.

Table IV.3.3.2 – 3. Results of floating with washing by sulphuric acid

Floating conditions	Products	Recovery,%	Content, g/t	Real recovery, %
Washing not by acid	Concentrates	3.91	226.66	62.50
	Tails	96,09	5,53	37,50
	Total	100,00	14,18	100,00
Washing by acid	Concentrates	5,00	185,76	65,50
	Tails	95,00	5,15	34,50
	Total	100.00	14.18	100.00

The comparison on the results of two floating methods indicates that the method with washing by acid allows to get concentrate with higher real recovery than that of conventional floating method, however, the content of concentrate is lower. Besides, in comparison with the conventional method, the technological scheme of the method with washing by acid is more complicated and it is necessary to have measures for processing of a considerable amount of acid sulphuric before its disposal to the environment.

IV.3.3.2.3. Combination of xanthate with non-pole chemical (oil)

It was carried out experiment on using combination of xanthate with oil with the purpose of increasing the cohesion of gold on air bubbles and at the same time to make bubbles to be more durable. The additional consumption of oil is following the ratio: xanthate/oil = 2/1. The results are shown on the table IV.3.3.2 – 4.

The comparison on the results of two methods shows that under using combination with oil, the results are better, the real recovery of gold is increased from 62.50% to 64.23%, while the content of concentrate is a little decreased (from 226.66% down to 212.81%).

Table IV.3.3.2 – 4. Results of floating using combination of xanthate and oil

Floating conditions	Products	Recovery,%	Content, g/t	Real recovery, %

Only xanthate in use	Concentrates	3.91	226.66	62.50
	Tails	96,09	5,53	37,50
	Total	100,00	14,18	100,00
Combination of xanthate and oil = 2:1	Concentrates	4,28	212,81	64,23
	Tails	95,72	5,30	35,77
	Total	100.00	14.18	100.00

IV.3.3.2.4. Replacement of Na_2S by $CuSO_4$

Na_2S or $CuSO_4$ can be used for the sulfidization of surface and to incite gold. When will be used with big amount, these two chemicals appears to act as a factor, sinking gold. In order to compare the effectiveness of these chemicals, experimental floating has been carried out under the replacement of Na_2S by $CuSO_4$. The results of this experiment are presented in the table IV.3.3.2 – 5.

Table IV.3.3.2 – 5. Results of using $CuSO_4$ instead of Na_2S

Floating conditions	Products	Recovery,%	Content, g/t	Real recovery, %
100 g/t of Na_2S and 200 g/t of Xanthate	Concentrates	4.43	204.83	63.99
	Tails	95,57	5,32	36,01
	Total	100,00	14,18	100,00
100 g/t of $CuSO_4$ and 300 g/t of Xanthate	Concentrates	6,92	131,78	64,31
	Tails	93,08	5,43	65,69
	Total	**100.00**	**14.18**	**100.00**

Under using $CuSO_4$, the real recovery of gold is a little increased, but the content is considerably decreased.

IV. 3.3.2.5. Coordination use of xanthate in the main floatation, combining chemicals in the dredge floatation

Coordination use of cations-combining chemicals in the dredge floatation after having used xanthate-combining chemical to recover gold nuggets and gold-bearing sulfidic grains in the main floatation in order to continuously recover the rest gold-bearing oxidic grains. Cations-combining chemicals were used are coconut oil and Armax T. The results are expressed in the table IV.3.3.2 – 6.

The use of cations-combining chemicals in the dredge floatation has increased real recovery in comparison with the dredge floatation 1 in which only used xanthate of about 1 to 3.5 %. If it is added a more dredge floatation 2, so all of these three projects have approximate results. However under using cations-combining chemicals, the content of concentrate may be lower that that when using xanthate, the recovery of concentrate is high in dredge floatation because of the cations-combining chemicals are well foam-forming.

The results of study on optimizing some conditions of the floatation and considering some measures of increasing real gold recovery have led to some following remarks:

The best conditions for the floatation of gold ore samples at Atttapu are:

- The crushing fineness of the floatation is 90%, grain size: - 0,074 mm.
- pH of medium in the main floatation = 8, the regulation chemical used is soda.
- Consumption of Na_2S is 100 g/t.
- Consumption of xanthate is 200 g/t

Furthermore, it can be increased the time of main floatation from 10 to 12 minutes, using conbination between xanthate and emulsified oil with a ratio santhate / oil = 2 / 1, it needs 1 to 2 dredge floatations in the floatation scheme.

Table IV.3.3.2 – 6. Results of using cation-combining chemicals in dredge floatation

Floating conditions	Products	Recovery,%	Content, g/t	Real recovery, %
One main floating line and two dredge floating lines using only xanthates	Concentrates	3.91	226.66	62.50
	Dredged concentrates 1	2,18	21,84	3,36
	Dredged concentrates 2	2,11	17,79	2,64
	Tails	91,80	4,87	31,50
	Total	100,00	14,18	100,00
Main floating uses xanthates, dredge floating uses 80 g/t of coconut oil	Concentrates	3,91	226,66	62,50
	Dredged concentrates 1	6,43	15,32	6,95
	Tails	89,66	4,83	30,55
	Total	100,00	14,18	100,00
Main floating uses xanthates, dredge floating uses 50 g/t of ArmaxT	Concentrates	3,91	226,66	62,50
	Dredged concentrates 1	5,31	10,94	4,10
	Tails	90,78	5,22	33,40
	Total	100.00	14.18	100.00

IV.3.3.3.The results of experimental floatation following the scheme

IV.3.3.3.1.The results of experimental floatation following the open scheme.

The experiment with open scheme has been carried out before experiment with close scheme in order to determine floatation norms obtained before returning of intermediate products and at the same time to determine a turning point of intermediate products in close circling floatation. It was carried out experiment with 2 open schemes as shown in fig. IV.3.3.3 - 1 and fig. IV.3.3.3 – 2. The results of floatation following open scheme are demonstrated in table IV.3.3.3 - 1

The study results show that the floatation following 2 schemes, the floating following the scheme 2 gives a real recovery higher than that of scheme 1 about 2%, however the gold content is lower. The results of analyzing the content of intermediate products presented in the table allow to determine a truning point of these products in the floatation following the close scheme to ensure the 2 norms, ie gold content and its real recovery from the concentrate.

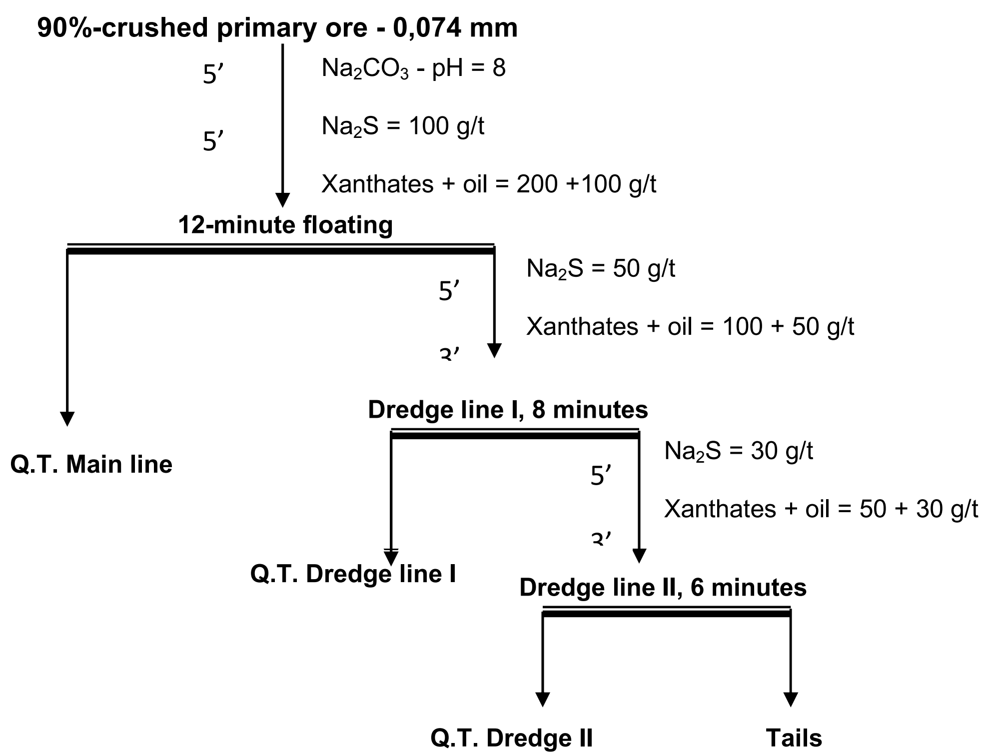


Fig. IV.3.3.3 - 1. Scheme showing experimental floatation

Table IV.3.3.3 - 1 Results of floating following the open scheme

Scheme	Products	Recovery,%	Content, g/t	Real recovery, %
Scheme No1	Concentrates	4.43	204.83	63.97
	Dredged concentrates 1	2,18	25,30	3,89
	Dredged concentrates 2	2,11	11,88	1,77
	Tails	91,28	4,72	30,37
	Total	100,00	14,18	100,00
Scheme No 2	Concentrates 1	4,50	200,95	63,77
	Concentrates 2	1,02	30,17	2,17
	S.P. intermediate	3,00	12,75	2,70
	Dredged concentrates 2	2,62	12,88	2,37
	Tails	88,87	4,63	28,99
	Total	100.00	14.18	100.00

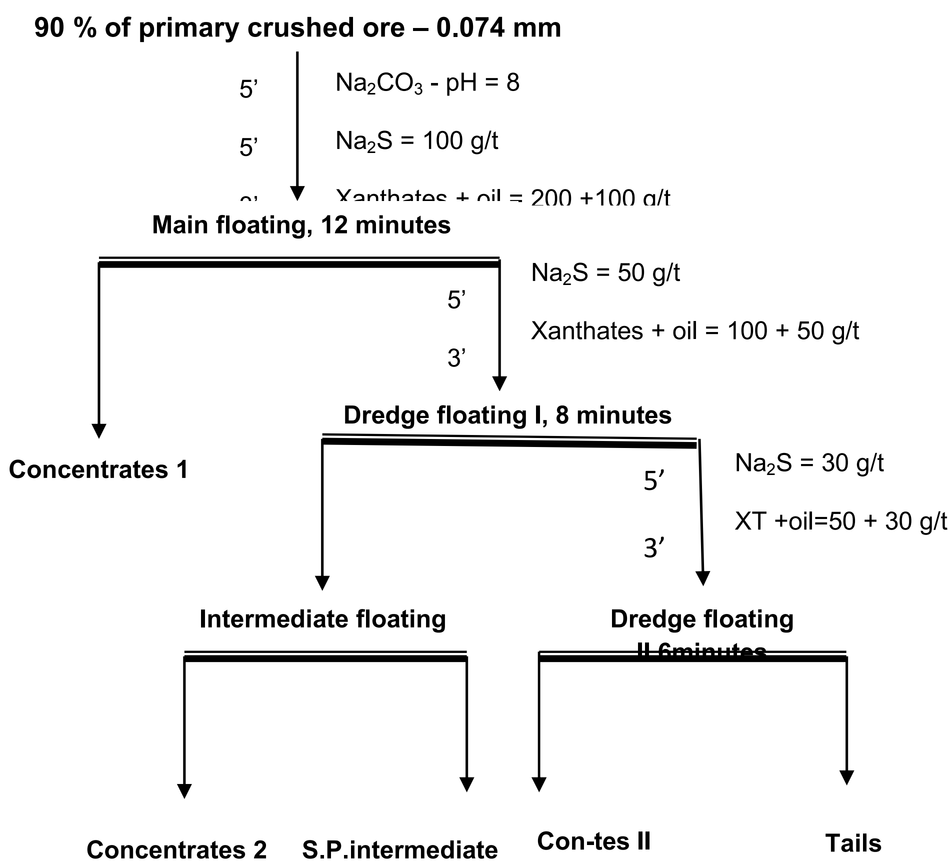


Fig. IV.3.3.3 - 2. Scheme showing experimental floatation

IV.3.3.3.2. The results of experimental floatation following the close scheme

The experimental floatation following the close scheme is carried out based on the results of the experimental floatation following the open scheme.

The first scheme as shown in fig. IV.3.3.3 -2 includes a main floatation and 2 dredge floatations. The products of the dredge floatation I are turned up to supply with initial ore. Foam of derdge floatation II is supplied for the dredge floatation I.

The second scheme as shown in fig. IV.3.3.3 -3 includes a main floatation and 2 dredge floatations and a concentrate floatation for foam products of the the dredge floatation I (intermediate floatation). The products of machine carnine (ngăn máy?) of the intermediate floatation together with foam products of the derdge floatation II are turned to supply with initial ore.

The results of the experimental floatation following the close scheme is expressed in table IV.3.3.3 -2

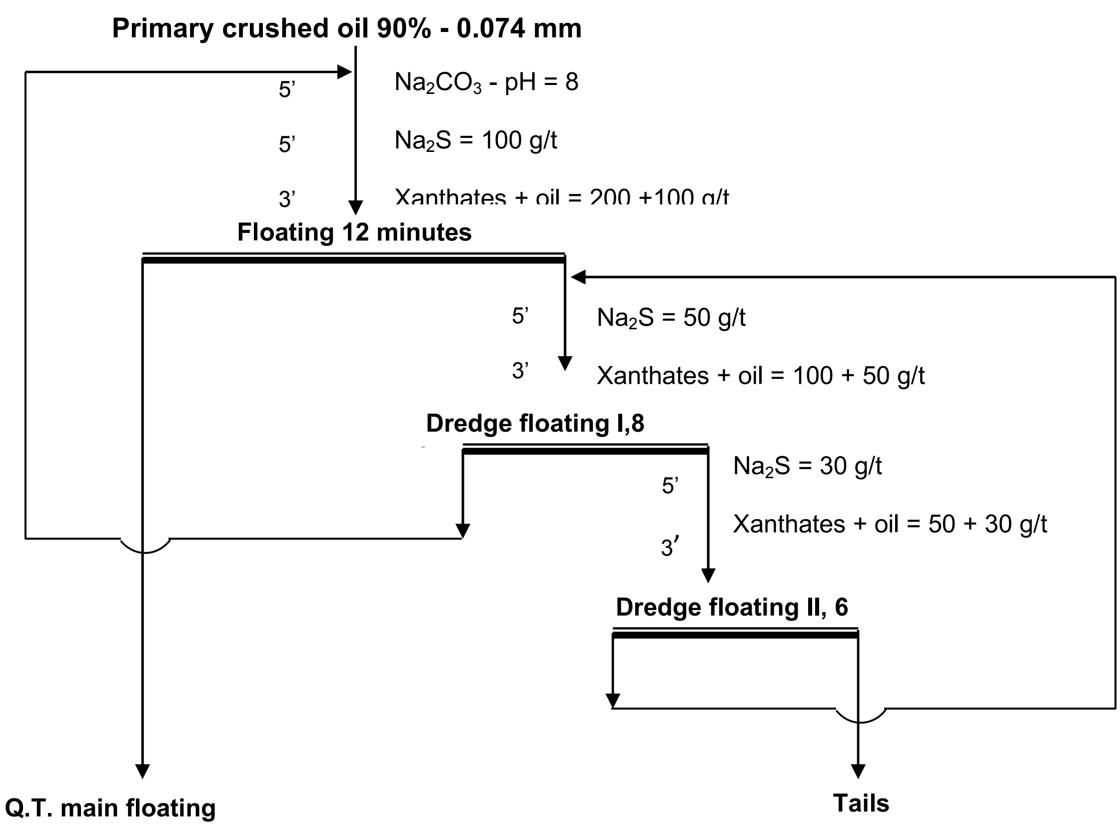


Fig. IV.3.3.3 -2 Scheme showing test closed floating No 1

Table. IV.3.3.3 -2 Results of floatation following the closed scheme

Scheme	Products	Recovery,%	Content, g/t	Real recovery, %
Scheme 1	Concentrates	6.47	145,71	66,52
	Tails	93,53	5,08	33,48
	Total	100,00	14,18	100,00
	S.p. foam dredge floating 1	3,63	26,67	6,83
	S.p. foam dredge floating 2	2,51	10,68	1,89
Scheme 2	Concentrates 1	6,13	153,50	66,36
	Concentrates 2	1,12	28,49	2,25
	Concentrates 1+2	7,25	134,19	68,61
	Tails	92,75	4,80	31,39
	Total	100,00	14,18	100,00
	S.p floating compartment TG	3,36	12,68	3.00
	S.p. foam dredge floating 2	3.61	12.01	3.06

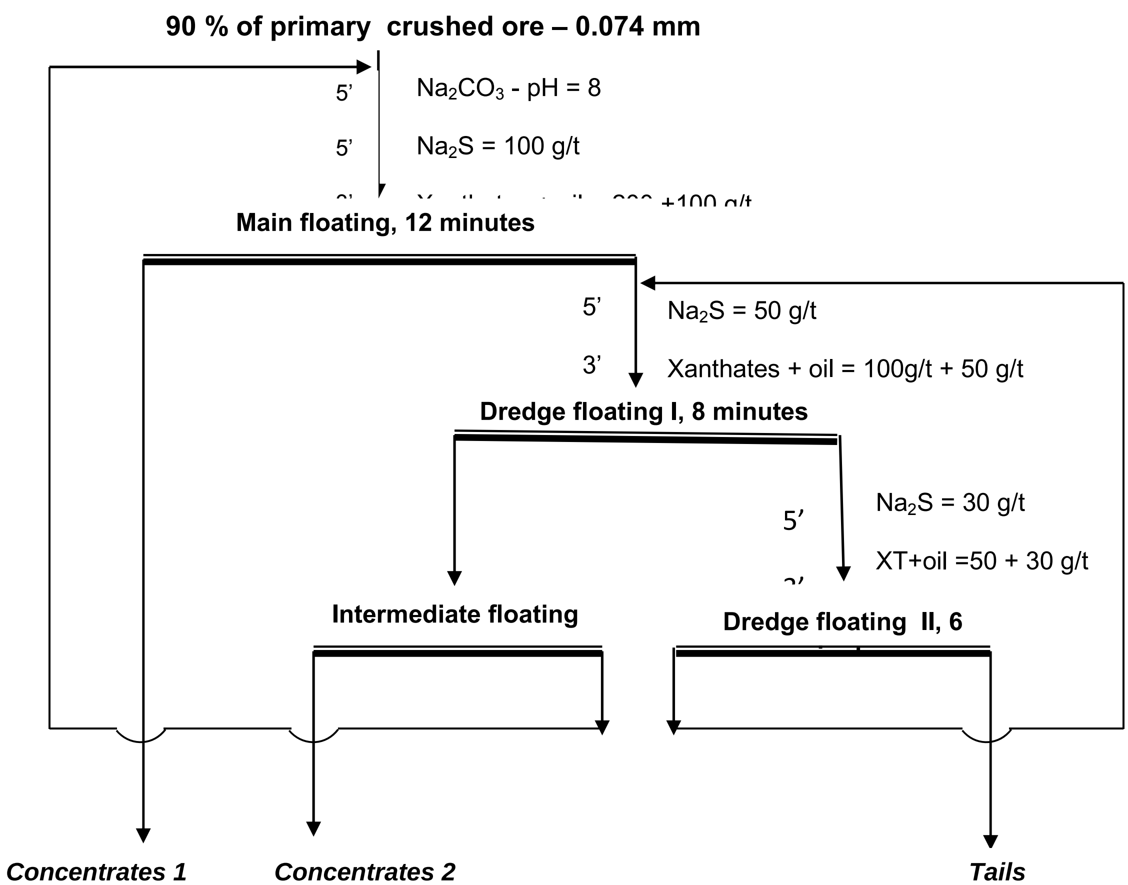


Fig. IV.3.3.3 -3. Scheme showing closed floating No 2

Table IV.3.3.3 -3. Results of multi-element analysis of floated concentrates

No	Element	Content	
		Unit	Value
1	Au	g/t	134.19
2	Al_2O_3	%	2,49
3	CaO		0,79
4	Fe_2O_3		56,06
5	K_2O		1,06
6	MgO		0,12
7	MnO		0,11
8	P_2O_5		<0,005
9	TiO_2		0,36
11	As	ppm	1641,0
10	Ag		<2
12	B		433,1
13	Ba		105,1
14	Be		<5
15	Bi		337,3
16	Cd		14,9
17	Ce		77,0
18	Co		70,1
19	Cr		319,5
20	Cu		1305,2
21	Ga		<10
22	Ge		<20
23	La		15,9
24	Li		<5
25	Mo	ppm	16,0
26	Nb		6,0
27	Ni		189,4
28	Pb		241,2
29	Sb		174,4
30	Sc		6,6
31	Sn		<10
32	Sr		33.8

The comparison on the results of experimental floatations following the two close schemes show that following the scheme 2 the experiment floatation has got a real recovery 2% higher that that of scheme 1. The content of concentrate of scheme 1 is 145.71 g/t, while the total content of concentrate of scheme 2 is 134.19 g/t. The scheme 2 is chosen for by-product recovery. The results of multi-element analysis of concentrate products are shown in table IV.3.3.3 -3

IV.3.3.3.3. Experiment floatation in combination with panning

There is added a panning link at the end of the scheme 2 for floatation, this means that the floated tails are put through panning table in order to continuously ricover unfloated gold nuggets at floating links. The results are presented in table IV.3.3.3 -4.

Table IV.3.3.3 -4. Penning results of floated tails

No	Products	Recovery, %		Content,g/t	Real recovery, %	
		Part	Whole		Part	Whole
1	Panned concentrates	4.50	4.17	15.31	14.09	4.42
2	Tails	95.50	88.58	4.40	85.91	26.97
3	Floated tails	100.00	92.75	4.89	100.00	31.39

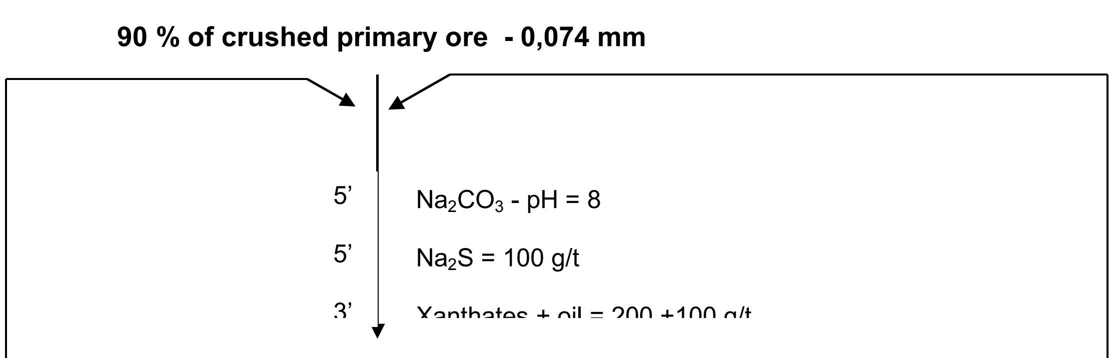
The results of tails floatation on the panning table are not met as desired. The content is only 3 times increased, while recovery is increased 4.5%, the real recovery of floatation link is only 14,09%. The content of floated concentrate is only corresponding to the content of initial ore, which can not be used to add to the concentrate for floatation. Thus, it is confirmed one again that the panning table can not be used for recovery of gold from ore sample like the study sample including by-producy gold recovery from floated tails.

IV.3.3.3.4. Proposed scheme and prevised norms

The technological scheme proposed to be applied is similar to experimental scheme of close circle 2 aspresented on fig. IV.3.3.3 – 5. The technological norms prevised to be given as shown in table IV.3.3.3 - 5.

Table IV.3.3.3 - 5. Prevised technological norms

No	Products	Recovery, %	Content, %	Real recovery, %
1	Concentrates	7	136	67.5
2	Tails	93	4.9	32.5
	Total	100.00	14.18	100.00



IV. 4. ORE SAMPLES OF THE ORE BODY II

The ore samples of the ore body TQ.II bears gold content: Au = 9,39 g/t. The sanMẫu đples were briefly processed with a grain size of < 1 m. The table IV.4 - 1 shows the results of analyzing grain size portions of the experiment samples.

Table IV.4 – 1. Results of analyzing grain size of ore samples from ore body TQ.II.

Sample	Grain size, mm	Recovery,%		Au content, g/t		Au distribution, %	
		γ	∑γ	β	∑β	ε	∑ε
TQ.II	-2+0.25	43.60	43.60	8.87	8.87	41.20	41.20
	-0,25+0,074	33,29	76,89	9,92	9,33	35,17	76,37
	- 0,074 + 0,040	5,22	82,11	11,93	9,49	6,63	83,00
	- 0,040	17,89	100,00	8,93	9,39	17,00	100,00
	Total	100.00	-	9.39	-	100.00	-

Similar to samples of the ore body TQ.III, the gold content in different grain size portions of these samples is relatively equal, only gold content in a grain size of -0,074 +0,04 mm is higher than average gold content. Equal gold content indicates that what portion has a bigger recovery, a gold is distributed in it. The results presented in the table IV.4 - 1 allows to draw a curve showing specification of grain size of the sample as shown in fig. IV.4 - 1.

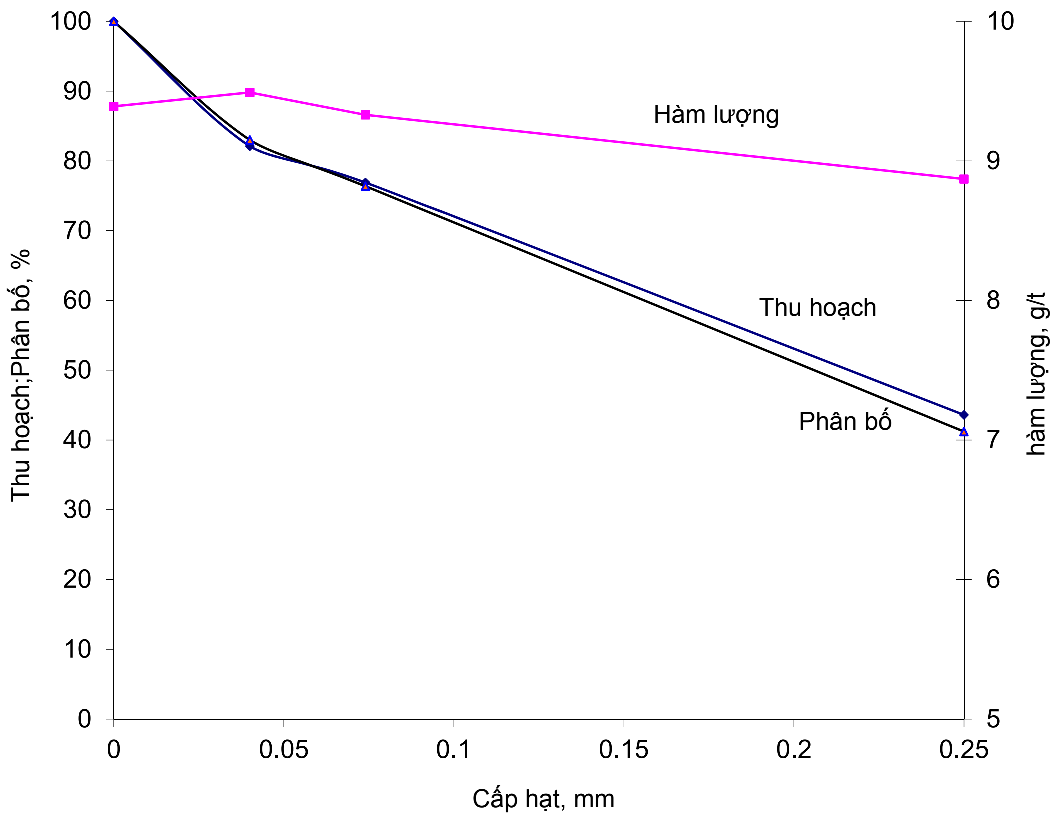


Fig. IV.4 - 1 Curve showing grain size characteristics

IV.4.2 Control floatation for the samples of ore body

The purpose of the study on floatation with samples of ore body TQ.II is to determine the possibility of floatation with poor-in-sulfides ore in the Vang Tat mine and to evaluate possibility floatation to ricover gold from these products by fixed technological scheme for floatation with ore from ore body TQ.III. Thus, floatation experiments are only carried out following the scheme and conditions fixed for the ore body TQ.III.

Firstly, the control experiment with open scheme carried out following the scheme in fig. số IV.4 - 2, The results are shown in table IV.4 - 2.

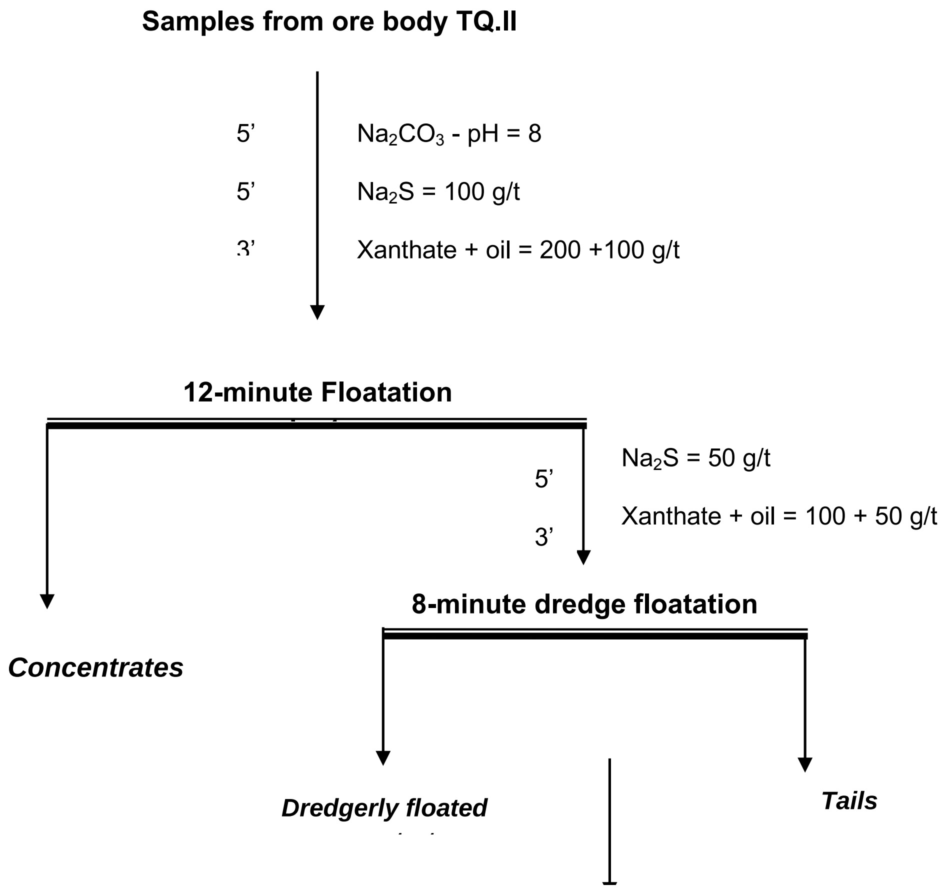


Fig. IV.4 - 2. Scheme showing test control floatation of TQ.II

Table IV.4 - 2. Results of control floatation of two tails samples

Test samples	Products	Recovery, %	Content, g/t	Real recovery, %
90 % of crushed samples from ore body TQ II -0,074 mm	Concentrate of main floating	5.53	114.09	67.27
	Concentrate of dredge floating	3.13	6.16	2.06
	Tails	91.34	3.45	30.67
	Total	100.00	9.38	100.00

The grain size of the sample of ore body TQ.II mainly is <1 m.m with himidity of 4%. Before floating, the sample was crushed to a fineness of 90% grain size : - 0,074 mm.

The results of control floatation of sample from ore body TQ.II are similar to that obtained from floatation of sample from ore body TQ.III.

IV.4.3. Close circle control floatation for sample from ore body TQ.II.

After floating following the open scheme with sample from ore body TQ.II, the close circle control floatation has been carried out like scheme shown in fig. IV.4 - 1. Comparison between the open scheme and the close one, there is additional dredge floatation 2 in the close scheme in order to increase a real recovery of concentrate. The results of close circle floatation are presented in the table IV.4 - 3.

Table IV.4 - 3 Results of close circle floation of 2 tails samples.

Test samples	Products	Recovery, %	Content, g/t	Real recovery, %
Ore body TQ.II	Concentrates	7.10	91.03	68.83
	Tails	92.90	3.15	31.17
	Total	100.00	9.39	100.00
	Concentrates of dredge floating I	2.56	14.72	4.01
	Concentrates of dredge floating II	2.35	7.58	1.90

The results of close circle floatation show that the real recovery rate is the same as that of sample from ore TQ.III. The real recovery of sample from ore body TQ.II is 68.83, while the content is not high. The recovery of sample from ore body TQ.II is 91.03 g/t. So far, for this technological scheme, it is necessary to additionally arrange a concentrate floatation link.

IV.4.4. Proposed technological scheme and prevised norms

Before putting to floatation, ore samples of the ore body TQ.II were crushed, 90% of which were crushed to a grain size of 0.074 mm. In the proposed scheme, there is additionally arranged a concentrate floatation link in order to get concentrates of desired quality serving as material for further processing. The proposed technological scheme is as shown in fig. IV.4 - 4. The prevised norms are expressed in table IV.4 - 4 with processing ore of average content of 7 g/t.

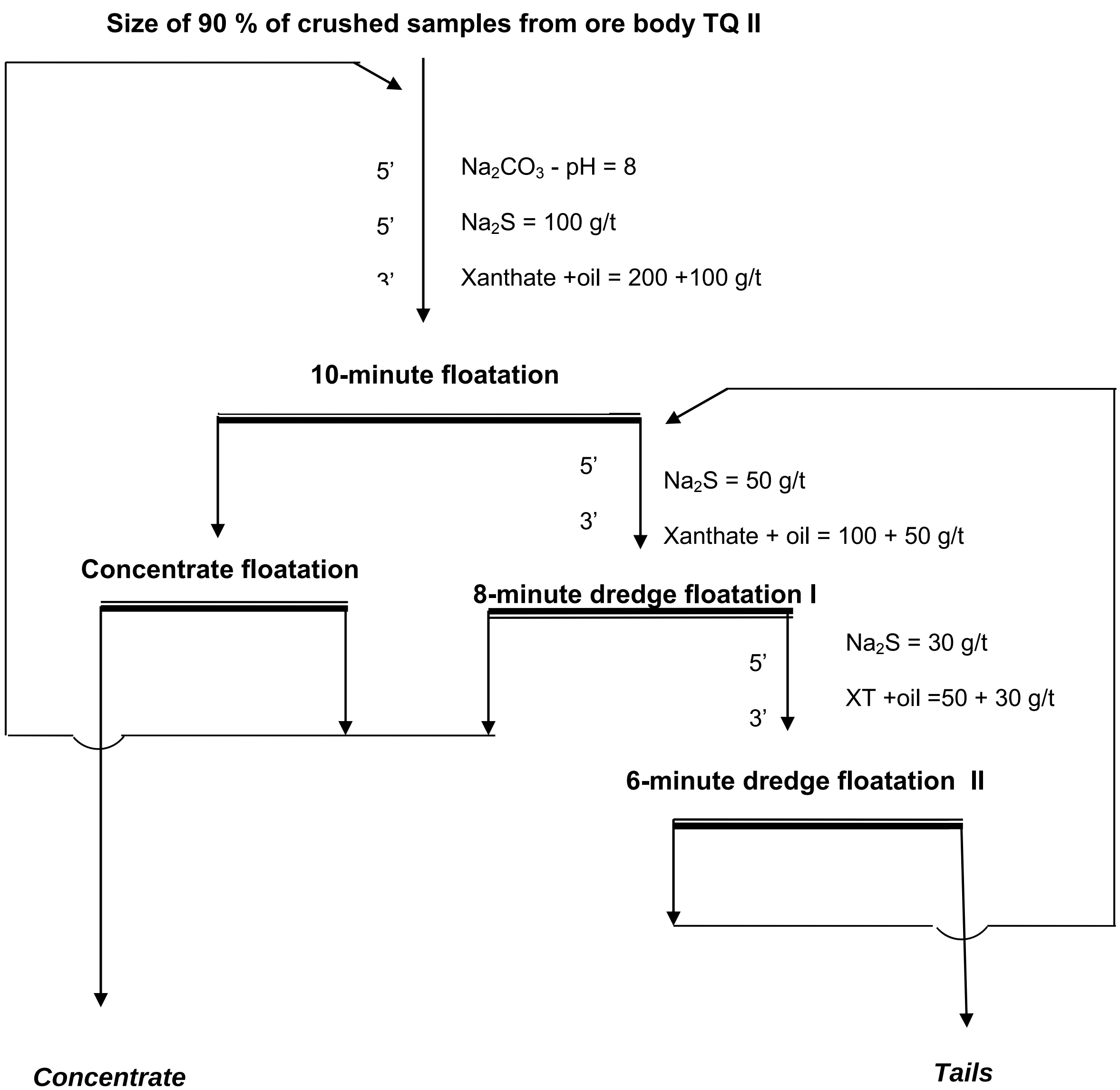


Fig. IV.4 - 4. Scheme showing prevised floatation technology for

Table IV.4 - 4. Prevised technological norms for floatation of 2 tails samples

No	Products	Recovery, %	Content, g/t	Real recovery, %
1	Concentrate	4.07	110	64
2	Tails	95.93	2.63	36
	Total	100.00	7.0	100.00

In short, the results of study on the floatation of gold ore samples from Attapu mine have led to the following remarks:

- The study samples include ore samples from ore body TQ.III with gold content of 14.18 g/T, that are representative for strongly limonitized rich-in-sulfides ore, a little of pyrite is remained in the ore, and the experimental content of ore from ore body TQ.II is 9,38 g/t, which is characterized for poor-in-sulfides ore. Gold content of ore samples from the ore body TQ.III is relatively equal in coarse grain size portions and it is lower than that in fine grain size portion. At the grain size of - 2mm, the recovery of coarse grain size is higher than that of fine grain size.

- The study on floatation on the panning table has been carried out after crushing ore to different grain sizes. The results indicate that the penning table and equipments for conventional gravity separation can not be used for gold recovery, even when 90% of sample was crushed to grain size - 0,074 mm as well as under combination with floatation.

- The recovery of gold by common mechanic methods such as gravity separation and floatation is of low effectiveness in comparison with other gold objects and is facing many difficulties. Those problems are caused by the factors of that gold here is accompanying with pyrite and pyrite was limonitized with very fine grain size, in addition, gold of very fine grain size is contaminated in quartz.

- The study on optimization of floatation conditions shows that the optimal crushing fineness is 90 % of grain size - 0,074 mm, floatation at pH = 8 regulation by soda, consumption of Na_2S is 100 g/t; comsumption of xanthate + oil is 200 g/t +100 g/t ; pine oil: 100 g/t, all of these give the best floatation results.

- The real recovery of gold from concentrate is still not high even after optimization of floatation conditions. In order to increase the real recovery of gold, the following measures have been studied on such as floatation time, washing by acid before floating, combination of xanthate with cation chemicals, combination of xanthate with non-pole floating chemicals, addition of dredge floatation links and other measures, etc.

- On the basis of optimized conditions and some measures for increasing real recovery, the experimental floatation following open scheme and close circle. The scheme 1 includes a main floatation link, 2 dredge floatation links, concentrate from dredge floatation link I turns back to main floatation link, concentrate from dredge floatation link II turns back to dredge floatation link I. The scheme 2 includes 1 link of main floatation, 2 links of dredge floatation.

Concentrate from dredge floatation link I come to dredge floatation link II, machine compartment products and foam products of dredge floatation link II turn back to main floating ratio link. Both 2 schemes have got approximate concentrate (> 130 g/t), Scheme 2 has real recovery of gold of 2% higher in comparison with that of scheme 1 (68.61 % and 66.52 %) . The concentrate obtained from floating by combination of scheme 2 with repeated tails floating has not high content and low real recovery.

- Control of samples from ore body TQ.II has been carried out with optimal conditions which were studied for sample of ore body TQ.III. The obtained results are impressive. In the floatation with open scheme, only through the main floatation link the real recovery is 67.27 % for sample from th ore body TQ.II. The concentrate of experimental floatation of sample from ore body TQ.II by close circle with real recovery of 68,83 %. However, in order to get concentrate of high content and to increase the real recovery, it is necessary to arrange one more concentrate floatation link for main concentrate floatation and one to two dredge floatation links.

- On the basis of the study results, there have been realized technological scheme and suggested norms for the ore samples of the ore bodies TQ.III and TQ.II.