YU ISSN 0352—1206

УНИВЕРЗИТЕТ „КИРИЛ И МЕТОДИЈ“ — СКОПЈЕ
РУДАРСКО ГЕОЛОШКИ ФАКУЛТЕТ — ШТИП

UNIVERSITY »KIRIL AND METODIJ« — SKOPJE
FAKULTY OF MINING AND GEOLOGY — ŠTIP

GEOLOGICA MACEDONICA

T. I Fasc. 1

ŠTIP — 1984

SEGREGATIONAL ROASTING OF THE OXID - SILICATE NICKEL ORES FROM »RUDŽINCI« AND »RŽANOVO« MACEDONIA

Boris Krstev

ABSTRACT

The combined methods for enriching of the oxide-silicate nickel ores are new, through which by heating the ore with coke and calcium chloride ($CaCl_2$) at high temperatures metal nickel is formed on the present coke, or on the silicates which are component parts of the ore.

The experimental investigations of the ores from »Rudzinci« and »Rzanovo« show that further investigations are necessary during the processes of segregation, flotation, and magnetic concentration.

INTRODUCTION

The principle production of primary nickel was, until recently, based on the sulphides and high grade garnierite ores, while the importance of the oxid laterite ores have increased during the last years. However, because the quantity of known reserves of oxide ores amount to 85.2% of the total world reserves of nickel, in comparison to 14.0% reserves of sulphide ores, it is predicted that the share of oxide ores in the production of nickel will increase in the future.

The steady growth of nickel prices, it's bigger application in the industry and especially the development in the nickel technology enables more nickel to be obtained out of the oxide ores, which until recently were considered uneconomical because of the weak possibilities for obtaining concentrates. This is emphasized because Jugoslavia is rich with nickel oxid ores. The great diffusion of low grade oxide ores with nickel content under 1% attract attention for better study and for more economical methods for drawing out useful components.

The exploitation of these ores is rendered more difficuly because of the strong connection of the metal with the silicate minerals of the ores waste, which prevents mechanical processing. That is why the extraction of useful components from these ores is to be done with direct pyrometallurgy treatments if the ore contains from 0.9% to 1% nickel. The ores with a lower contribution of useful components are usually processed by hydrometallurgy conducts.

In order to solve the problem of processing the low grade nickel ores, many scientists tried with the help of segregational conduct combined with classical methods, to obtain a high extraction of the metal from the low grade ore.

The process of segregational roasting can be applied with the ores and minerals which produce easily evaporable chlorides and oxichlorides. The success of the process depends on the balance of the reactions in the process and the proper choice of influential parameters. The fundamental mechanism of the SEGREGATION is generally accepted, though there are distinctions between different metals.

With the process of segregational roasting we change the situation in the sense of further metallurgical processing, because instead of ore a concentrate would enter the process, which would enable less investments in the equipment and a lower production costs, but would attain larger profits.

The process itself can be divided into three successive operations.

— SEGREGATION
— FLOTATIONAL CONCENTRATION
— MAGNETIC CONCENTRATION.

Research is still in the experimental stage, but it is expected that this process will find full affirmation in the extraction of nickel in the near future. The level of the investigation of the ore from „RUDŽINCI" is minimal, and that is why comparison is not possible, while the ore from „RŽANOVO" is preconcentrated to obtain a hematite concentrate, but the content of the nickel is very small. The aim of segregational conduct is to obtain a high grade concentrate with a high percentage of useful components.

EXPERIMENTAL PART

The experimental investigations of the concentration of nickel ores from „Rudžinci" and „Ržanovo" are performed with the combined methods: SEGREGATION — FLOTATIONAL CONCEN-

TRATION — MAGNETIC CONCENTRATION. The chemical structure of the treated ores and the working conditions used during the investigations are given in the registers 1 and 2. The investigations are performed in the Institute for Non-ferroous Metallurgy at TMF Belgrade, and in the Chemical Laboratory at the Smeltery FENI Kavadarci.

Register 1

CHEMICAL STRUCTURE OF THE TREATED ORES

	A — Rudžinci	B — Ržanovo
Ni	1.20	1.07
Fe	14.20	32.33
Sio_2	55.40	29.10
Cr_2O_3	0.97	2.40
CaO	0.74	1.40
MgO	4.49	12.00
Al_2O_3	2.98	2.80

Register 2

WORKING CONDITIONS AND THE RELATIONS OF THE AGENTS

	largeness mesh	coal %	calcium-chloride %	ore %	time of roasting (min)
„A"	1.) — 100	0.9	7.5	91.6	60
	2.) — 100	0.9	7.5	91.6	90
	3.) — 100	0.9	7.5	91.6	120
	4.) — 100	0.9	7.5	91.6	150
„B"	5.) — 150	0.9	7.5	91.6	120
	6.) — 150	1.5	7.5	91.0	120
	7.) — 150	1.0	9.0	90.0	120

Mineralogical characteristics of the treated ores

The locality „Rudžinci" SR Serbia is a lateral — silicate deposit whose ore is represented by a clay-earth material with a high content of humidity from 25 to 30% (IVANOV T., 1974). This ore is composed of the following minerals:

— Notronit 0.5 $NiO \cdot (Al \cdot Fe)_2O_3 \cdot 3SiO_2 \cdot 3H_2O$
— Pimelit $(Ni \cdot Mg \cdot Ca \cdot Al) \cdot SiO_2 \cdot H_2O$
— Ni — montmorionit
— Fe — oxides

— and other minerals.

— Bravoit $(Ni . Fe)S_2$
— Pyrite FeS_2
— Markasit (jewstone) FeS_2
— Halkopyrite (Yellow copper ore) $CuFeS_2$

The locality „Ržanovo" SR Macedonia is a predeposited laterite deposit whose mineral structure is the following:

— Blood stone (Hematite) $Fe_2O_3 . xH_2O$
— Load stone (Magnetite) $FeO . Fe_2O_3 . yH_2O$
— Chromite $FeO . Cr_2O_3$
— Talc (Soapstone) $H_2Mg_3Si_4O_{12}$
— Oxides SiO_2, Al_2O_3, TiO_2
— Carbonates $CaCO_3$, $MgCO_3$, $GeCO_3$
— Nickel silicates $x\ (NiO . SiO_2 .)\ MgO . SiO_2)) . nH_2O$
— Serpentine (Pierolite) $Mg\ (Si_3O_{16})\ (OH)_8$
— Sulfides

Influence of time of the segregational roasting of the ore from „Rudžinci" upon the technological indexes of the combined process SEREGATION — FLOTATION — MAGNETIC — CONCENTRATION (TESTS A1 — A4)

In order to test the influence of the time of the segregational roasting, and the relation between the agents, upon the technological indexes of the combined process SEGREGATION — FLOTATION — MAGNETIC CONCENTRATION during the treatment of the ores from „Rudžinci" and „Ržanovo", a basic and principal sheme is set for testing (Fig. 1).

The grounded and dried ore (100% — 100 mesh) is roasted segregationally in a horizontal rotational oven. The reactor of the horizontal rotational oven is a pipe of fireproof material in which the ore together with the agents is placed. After the roasting the roasted material is poured into a vessel for flotational concentration where the flotation is performed.

The flotational concentration is performed in a flotational machine type „Denver". Conditioning is perfored for 30 minutes by adding chalvanthite as an activator, and chlorhydric acid as a regulator of the PH-value from 5.5 to 6 and at a rotation of 1200^0 per min. After the conditioning a collector — KAX and foamy — PINE OIL are added, the number of the rotations is increased to 1800^0 per min, some air is supplied, and then the flotation, which lasts for 14 min, begins. In this way we get concentrates and refuses, which are dried and measured, and after that a quantitative regulation of the nickel is performed.

The obtained concentrates and refuses from the flotational concentration are led to magnetic concentration where we get two products — a magnetic and a non-magnetic part. The magnetic concentration is performed with a Devis magnetic analyzator which consists of a coiled electromagnet with tappered poles and a glass pipe under angle of 45^0. The working conditions of a magnetic con-

centratioin are: 100V; 1.7A with flow of water of 0.4 liters per min.

The results of the treated tests (A1 — A4) are given in the registers that follow.

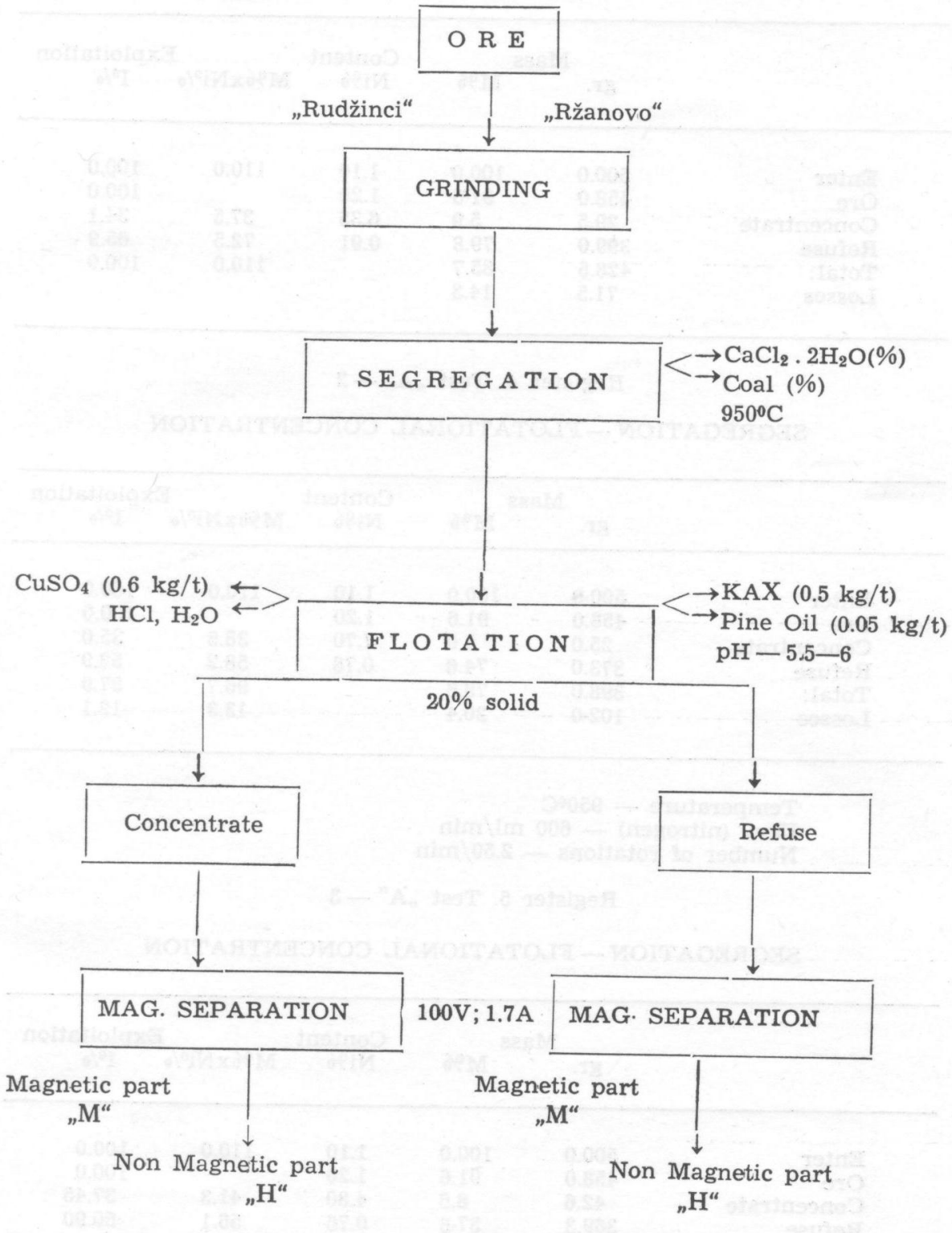

FIG. 1. Principal and basic sheme of the investigations of the ores from „Rudžinci" and „Ržanovo" with the process SEGREGATION-FLOTATION-

Register 3. Test „A" — 1

SEGREGATION — FLOTATIONAL CONCENTRATION

	Mass gr.	Mass M%	Content Ni%	M%xNi%	Exploitation I%
Enter	500.0	100.0	1.10	110.0	100.0
Ore	458.0	91·6	1.20		100.0
Concentrate	29.5	5.9	6.35	37.5	34.1
Refuse	399.0	79.8	0.91	72.5	65.9
Total:	428.5	85.7		110.0	100.0
Losses	71.5	14.3			

Register 4. Test „A" — 2

SEGREGATION — FLOTATIONAL CONCENTRATION

	Mass gr.	Mass M%	Content Ni%	M%xNi%	Exploitation I%
Enter	500·0	100.0	1.10	110.0	100.0
Ore	458.0	91.6	1.20		100.0
Concentrate	25.0	5.0	7.70	38.5	35.0
Refuse	373.0	74.6	0.78	58.2	52.9
Total:	398.0	79.6		96.7	87.9
Losses	102·0	20.4		13.3	12.1

Temperature — 950°C
Flow (nitrogen) — 600 ml/min
Number of rotations — 2.50/min

Register 5. Test „A" — 3

SEGREGATION — FLOTATIONAL CONCENTRATION

	Mass gr.	Mass M%	Content Ni%	M%xNi%	Exploitation I%
Enter	500.0	100.0	1.10	110.0	100.0
Ore	458.0	91.6	1.20		100.0
Concentrate	42.6	8.6	4.80	41.3	37.45
Refuse	369.3	37·8	0.76	56.1	50.90
Total:	411.9	82.4		97.4	88.35
Losses	88.1	17.6		13.6	11.65

Regisetr 6. Test „A" — 4

SEGREGATION — FLOTATIONAL CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Enter	500.0	100.0	1.10	110.0	100.0
Ore	458.0	91.6	1.20		100·0
Concentrate	20.2	4.0	9.90	40.0	36.4
Refuse	374.0	74.8	0.71	53.1	48.2
Total:	394.2	78.8		93.1	84.6
Losses	105.8	21·2		16.9	15.4

Temperature — 950°C
Flow (nitrogen) — 600 ml/min
Number of rotations — 2.5 o/min.

Register 7. Test „A" — 1

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	29.5	100.0	6.35	635.0	100.0
Magnetic part	1.9	6.35	65.00	412.75	65.0
Non-magnetic	27.6	93.65	2.26	212.25	35·0
Total:	29.5	100.0		635.0	100.0

Register 8. Test „A" — 1

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Refuse	399.0	100.0	0.91	91.0	100.0
Magnetic part	5.0	1·25	3.60	4.5	4.9
Non-magnetic	394.0	98.75	0.78	86.5	95.1
Total:	399.0	100.0		91.0	100.0

Register 9. Test „A" — 2

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concenrate	25.0	100.0	7.70	770.0	100.0
Magnetic part	2.3	9.3	72·00	669.6	86.2
Non-magnetic	22.7	90.7	1.10	100.4	13.8
Total:	25.0	100.0		770.0	100.0

Register 10. Test „A" — 2

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Refuse	373.0	100.0	0.78	78.0	100.0
Magnetic part	4.3	1,15	2.72	3.2	4.0
Non-magnetic	368.7	98.85	0.76	74.8	96.0
Total:	373.0	100·0		78.0	100.0

Register 11. Test „A" — 3

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	42.6	100.0	4.80	480.0	100.0
Magnetic part	2.7	6.4	47.50	303.0	63.1
Non-magnetic	39.9	93.6	1.90	177.0	36.9
Total:	42 6	100·0		480.0	100.0

Register 12. Test „A" — 3

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Refuse	369.3	100.0	0.76	76.0	100.0
Magnetic part	5.2	1.4	1.16	1.66	2.2
Non-magnetic	364.1	98.6	0.75	74.34	97.8
Total:	369.3	100.0		76.0	100·0

Register 13. Test „A" — 4

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	20.2	100.0	9.90	990.0	100.0
Magnetic part	2.6	13.1	73.0	956.3	96.6
Non-magnetic	17.6	86.9	0.39	33.7	3.4
Total:	20.2	100.0		990.0	100.0

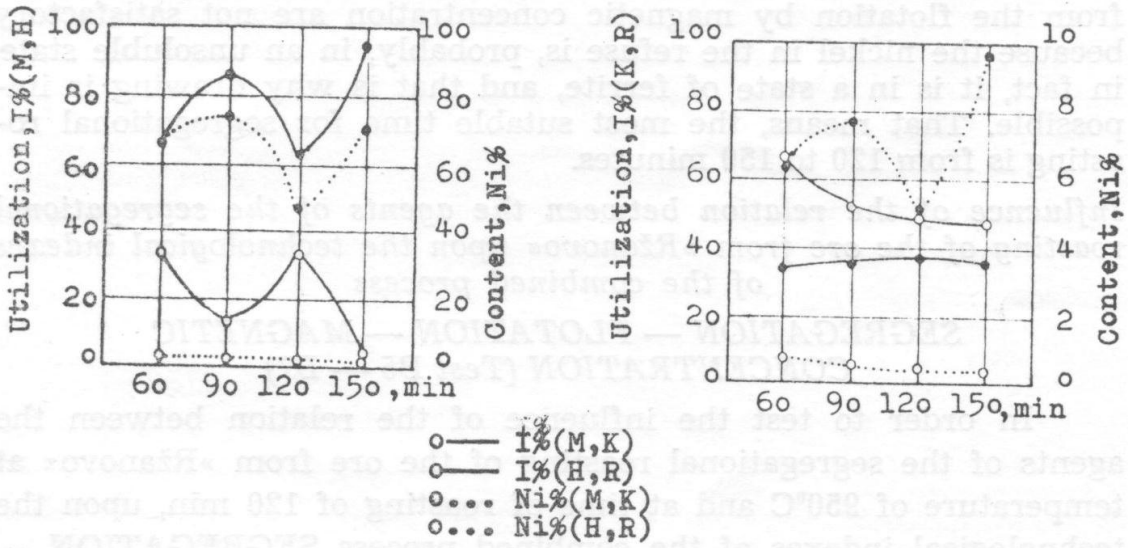

Fig. 2

Fig. 2 The influence of the time of the rosting of the ore from »Dudžinci« upon the technological indexes of the process

Register 14. Test „A" — 4

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	374.0	100.0	0.71	71.0	100.0
Magnetic part	7.0	1.85	2.59	4.8	6.75
Non-magnetic	367.0	98.15	0.67	66.2	193.25
Total:	374.0	100.0		71.0	100.0

0 — — I% vo K	0 — — I% vo M
0 — — I% vo J	0 — — I% vo H
0 . . Ni% vo K	0 . . Ni% vo M
0 . . Ni% vo J	0 . . Ni% vo H

From the performed researches of the ore from »Rudžinci« by the combined processes can be seen that the content of nickel in the flotational concentrate is satisfactory and it amounts from 4.8 to 9.9%, while the exploitation is not satisfactory and it is under 40%. With further treatment of the obtained concentrates and refuses by magnetic concentration, the following can be observed: The exploitation of nickel in the magnetic part of the concentrate amounts from 63.1 to 96.9%, while the content of nickel is from 47.5 to 73%. The results from the treatment of the refuses from the flotation by magnetic concentration are not satisfactory because the nickel in the refuse is, probably, in an unsoluble state, in fact, it is in a state of ferrite, and that is why drawing is impossible. That means, the most sutable time for segregational roasting is from 120 to 150 minutes.

Influence of the relation between the agents of the segregational roasting of the ore from »Ržanovo« upon the technological indexes of the combined process

SEGREGATION — FLOTATION — MAGNETIC CONCENTRATION (Test B5 — B7)

In order to test the influence of the relation between the agents of the segregational roasting of the ore from »Ržanovo« at temperature of 950°C and at time of roasting of 120 min, upon the technological indexes of the combined process SEGREGATION — FLOTATION — MAGNETIC CONCENTRATION. Following the basic sheme for investigation, some experiments have been performed, with results as in the following registers.

Basic parametres:

— Temperature	950°c
— Flow (nitrogen)	600 ml/min
— Time of roasting	120 min.
— Number of rotations	2.5 o/min

Register 15. Test »B« — 5

SEGREGATION — FLOTATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Enter	500.0	100.0	0.98	98.0	100.0
Ore	458.0	91.6	1.07		100.0
Concentrate	35.4	7.1	1.38	9.8	10.0
Refuse	396.0	79.2	1.02	80.8	82.4
Total:	431.4	86.3		90.6	92.4
Losses	68.6	13.7		7.4	7.6

Register 16. Test »B« — 6

SEGREGATION — FLOTATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Enter	500.0	100.0	0.97	97.0	100·0
Ore	455.0	91.0	1.07		100.0
Concentrate	47·25	9.5	2.15	20.45	21.1
Refuse	369.0	73.8	1.02	75.3	77.6
Total:	416.25	83.3		95.75	98.7
Losses	83.75	16.7		1.25	1.3

Regilter 17. Test »B« — 7

SEGREGATION — FLOTATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Enter	500.0	100.0	0.96	96.0	100.0
Ore	450.0	90.0	1.07		100.0
Concentrate	67·85	13.6	1.23	16.7	17.4
Refuse	371.20	74.2	0.99	63.4	66.0
Total:	439.05	87.8		90.1	83.4
Losses	60.95	12.2		5.9	16.6

Register 18. Test »B« — 5

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	35.4	100.0	1.38	138·0	100.0
Magnetic part	3.5	10.0	4.90	49.0	35.4
Non-magnetic	31.9	90.0	1.04	89.0	64.6
Total:	35.4	100.0		138.0	100.0

Register 19. Test »B« — 6

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	47.25	100.0	2.15	215.0	100.0
Magnetic part	7.30	15.4	2.15	33.1	15.4
Non-magnetic	39.95	84.6	2.18	181.9	84.6
Toal:	47.25	100.0		215.0	100.0

Register 20. Test »B« — 7

FLOTATION — MAGNETIC CONCENTRATION

	Mass		Content		Exploitation
	gr.	M%	Ni%	M%xNi%	I%
Concentrate	67.85	100.0	1.23	123.0	100.0
Magnetic part	5.70	8.4	1.45	12.2	10.0
Non-magnetic	62.15	91.6	1.23	110.8	90.0

From the performed investigations of the influence of the relation between the agents of the segregational roasting of the ore from »Ržanovo« upon the technological indexes, the following can be seen: From the three experiments that were performed can be concluded that this process is not suitable for treating such ore, because small exploitations of nickel have been got, in the concentrate, which means that nickel in this concentrate is in form of a unit, not in form of metal and because of that, it is impossible to draw it out by classical methods of concentration such as flotational and magnetic concentration. Further investigations are useful, because they will enable nichel to be drawn out better from the refuse mass, which will give results in the further treatment of the ore with clasical methods of concentration.

BIBLIOGRAPHY

ИВАНОВ Т., 1974: Никл и кобалт у дугорочном развоју Југославије, Међународно саветовање.

IWASAKI I., TAKAHASHI Y. and KAHATA H., 1966. Extraction of nickel from iron laterites and oxidised nickel ores by a segregation process. Trans. Soc. Min. Eng. AIME, Vol. 235, pp 308—320.

ХУДИНА И., 1980: Исследование механизма выделения металлического никела в процессе сегрегацции никлевых руд, Зборник радова — БОР, стр. 245—249.