

**University of Belgrade
Technical faculty in Bor**

**XI International Symposium on
Recycling Technologies and
Sustainable Development**

PROCEEDINGS

Editors

**Zoran M. Štirbanović
Zoran S. Marković**

**Hotel Albo, Bor
2-4 November 2016**

**University of Belgrade
Technical faculty in Bor**

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Prof. dr Nada Štrbac, Acting Dean

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Dr Zoran M. Štirbanović, Assistant Professor

Dr Zoran S. Marković, Professor

TECHNICAL EDITORS

Vladimir Nikolić, BSc

Dragana Marilović, BSc

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University of Belgrade Technical faculty in Bor
Vojske Jugoslavije 12, 19210 Bor, Srbija
Tel: +38130 424 555, 424556, Fax: +38130 421 078

UTILIZATION OF WASTE MATERIALS FROM FLOTATION PLANT "FELDSPAR" BUJANOVAC

**Dragan S. Radulović^{1#}, Milan Petrov¹, Milan Trumić²,
Grozdanka Bogdanović², Maja Trumić², Ljubiša Andrić¹.**

¹Institute for Technology of Nuclear and other Mineral Raw Materials,
Belgrade, Serbia

²University of Belgrade, Technical faculty in Bor, Serbia

ABSTRACT - This paper gives a review of results determining conditions of thickening and filtration of waste material from the flotation plant "Feldspar" – Bujanovac. This flotation plant last few years did not function as should be, and have many problems. Investigation of waste materials, should to enable recycling and re-use of flotation tailings.

Tests of possibilities of thickening and filtration of the non-magnetic fraction of waste material sample of the class -0,063 mm after magnetic separation in laboratory conditions have been carried out within this research. Based on dewatering testing, time of thickening and calculated results have been determined.

Key words: feldspar, valorization, waste material, dewatering

1. INTRODUCTION

Waste material from the flotation plant "Feldspar" Bujanovac by its chemical and mineral composition [1, 2] is very valuable raw material that in present conditions is practically underutilized. In this paper we have treated waste material from the tailing dump. Additionally, this plant has large quantities of this raw material (rough estimate is over 100 000 t) that is very valuable from the point of view of ceramic industry. Investigations of this raw material were carried out on several occasions. This paper presents the pooled data with the proposed technological scheme of valorisation of the tailings. In accordance with the request of the ceramic industry, the task was to obtain a product with the following characteristics from waste material in the flotation plant "Feldspar" Bujanovac:

- product size to be 100% - 0,063 mm
- Fe₂O₃ content to be lower than 0,2%

[#] corresponding author: d.radulovic@itnms.ac.rs

- moisture content in the finished product to be around 20% (moisture content should be such to enable the product to be loaded and transported in extra-large bags)

In the field of research and application of flotation and dewatering process [3-5] and based on previous results the following tests have been carried out:

- Possibility of sorting and grinding the waste material starting sample,
- Possibility of magnetic separation of ground and sorted product,
- Determination of conditions of thickening and filtration of waste material

sample after magnetic separation in laboratory conditions [3-6].

The work plan within laboratory testing has envisaged the following:

- Physical/chemical and mineralogical characterization
- Determination of composition according to grain sizes

This paper shows only one section of the above envisaged tests relating to thickening and filtration as research associated with a possibility of magnetic separation has been rather extensive both in view of application of various devices and in respect of application of different matrices in a highly gradient magnetic separator. Due to those facts such research has not been presented in this paper.

2. DETERMINATION OF PHYSICAL/CHEMICAL AND MINERALOGICAL PROPERTIES OF WASTE MATERIAL SAMPLES FROM THE FLOTATION PLANT "FELDSPAR" BUJANOVAC

2.1. Chemical composition of the waste material starting sample

Chemical analyses have been made on the starting sample in the Laboratory for chemical analysis of the ITNMS. Results of chemical analyses are given in Table 1.

Table 1. Chemical composition of the waste material starting sample

Composition	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	Cr ₂ O ₃	CaO	Na ₂ O	K ₂ O	LOI
Contents %	68,55	20,74	0,56	0,025	0,08	0,46	3,25	4,13	1,71

2.2. Chemical composition of the non-magnetic fraction of the class -0,063 mm of the waste material sample after magnetic separation.

After sizing the starting waste material sample, class -0,063 mm is treated on the magnetic separator for removal of iron surplus. Table 2 gives chemical composition of the non-magnetic fraction (NMF) of this class.

Table 2. Chemical composition of the NMF class -0,063 mm of the waste material sample

Composition	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	Cr ₂ O ₃	CaO	Na ₂ O	K ₂ O	LOI
Contents %	67,42	21,65	0,182	0,017	0,05	3,11	3,94	4,13	1,58

2.3. Mineralogical analysis of sample

Mineralogical analysis has been carried out in the Laboratory for mineralogical characterization of the ITNMS on five samples by classes of sizes 0,15 mm to 0,050 mm. Generally, all tested samples represent a feldspar-micaceous raw material with an increased quartz content. Mica content falls in lower classes. Feldspars are represented with microcline, orthoclase and Na-plagioclase. Microcline is the major material by its share. Na-plagioclase content rises in lower classes. All feldspars are poorly sericited and kaolinited. Of iron minerals limonine-getitite has been identified. Apart from mica, all other grains are acuteangular. No presence of middling has been noted in the whole sample (all classes). All samples are similar by their composition and only in the class -0,063 + 0,050 mm there is major presence of heavy minerals.

2.3.1. Microscopy analysis of the sample of the magnetic fraction of chats from class -0.063mm

Mineral composition: Quartz, feldspars, Fe hydroxides, micas, zircon, granates, apatite
Microdescription: Examined sample consists from dominant feldspar and quartz. From the mineral feldspar are presented potassium feldspars and plagioclases. From accessory minerals is fortified the presence of granate, zircon, and apatite. From the minerals carriers of iron is fortified presence of Fe hydroxides, and granatas which can content the iron. This minerals usually appears like free, or like inclusions in feldspars and quartz. The method of x-ray diffraction proved the presence of main minerals and the presence of Fe-hydroxides (lepidocrocite),too.

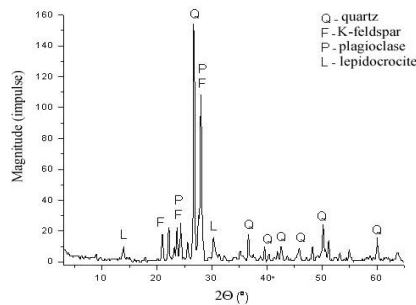


Figure 1. Diffractogram of parha magnetic fraction of the examined sample



Figure 2. Fe hydroxides, zoom of lens 20X, a missed light

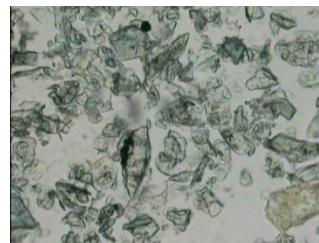


Figure 3. Fe hydroxides in the form of inclusion and the free, zoom of lens 10X, a missed light

3. EXPERIMENTAL WORK

3.1. Determination of composition according to grain sizes

As the starting sample of waste material from “Feldspar” – Bujanovac has been sieved wet through a sieve with holes of 0,063 mm, composition according to grain sizes has been determined so that the class -0,05 + 0,00 mm was sorted on cyclosizer and the class + 0,05 mm has been sieved wet through a series of sieves [5- 10]. Sorting and sieving results are shown in Table 3.

Table 3. Composition of waste material sample according to grain sizes

Size class, mm	M, %	↓ ΣM, %	↑ ΣM, %
-0,400+ 0,300	1,89	1,89	100,00
- 0,300 + 0,200	4,17	6,06	98,11
- 0,200 + 0,150	6,59	12,65	93,94
- 0,150 + 0,100	18,98	31,63	87,35
- 0,100 + 0,075	6,74	38,37	68,37
- 0,075 + 0,063	6,68	45,05	61,63
- 0,063 + 0,050	10,89	55,94	54,95
- 0,050 + 0,044	0,47	56,41	44,06
- 0,044 + 0,033	5,39	61,80	43,59
- 0,033 + 0,023	7,54	69,34	38,20
- 0,023 + 0,015	7,95	77,29	30,66
- 0,015 + 0,011	4,37	81,66	22,71
- 0,011 + 0,000	18,34	100,00	18,34
Input	100,00	/	/

Based on granulometric composition (Table 3., Figure 4.) it can be concluded that the upper size limit of the start sample is under the 0,2mm, apropos classing into the plant "Feldspat"- Bujanovac didn't work properly, because according the technology scheme, waste schoud have been under the 0,063mm.

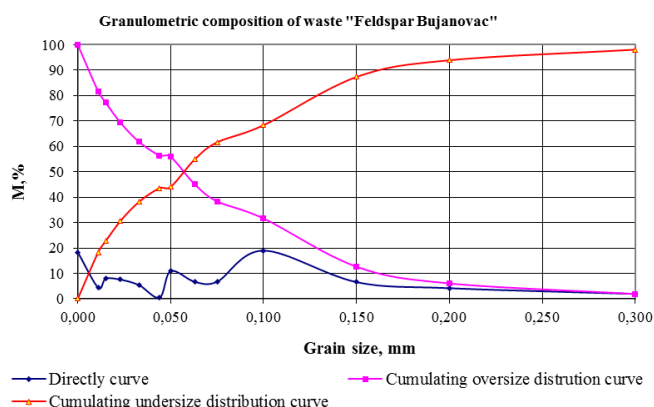


Figure 4. Granulometric composition of waste sample from “Feldspar Bujanovac”

Experimental work relating to this paper consisted of sorting the waste material starting sample. Then, on class -0,063 mm, specific areas of thickening and specific capacity of filtration have been determined. Magnetic separation tests have been done on this class. The waste material starting sample in the form of pulp had a mass of $m=8630$ g after drying. After drying this sample was sieved wet on a sieve with holes of 0,063 mm. From the class -0,063 mm samples have been taken for the tests of magnetic separation, sedimentation and thickening of $m=500$ g. Sedimentation tests were carried out by using the Kynch method and pH value of samples was changed as well as the percentage of solid phase in input raw material. For filtration tests the method used was that with the filter piece of paper. The written scheme of sample treatment is shown in Figure 5.

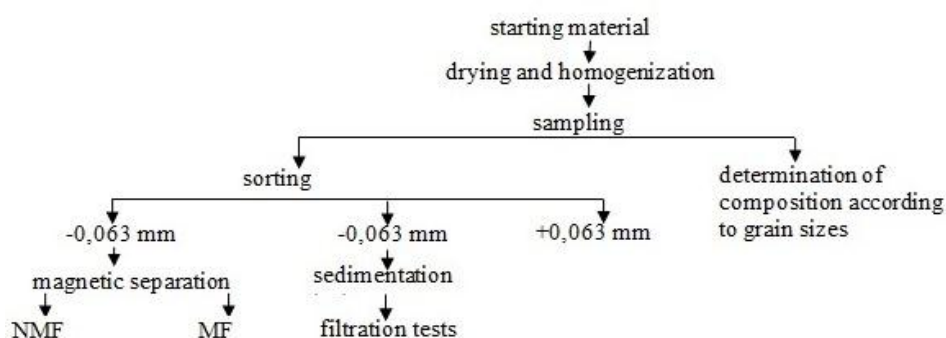


Figure 5. Scheme of laboratory treatment of waste material samples from the flotation plant “Feldspar” Bujanovac [3, 4]

3.2. Review of results of sedimentation tests on waste material samples “Feldspar” Bujanovac

Sedimentation tests have been carried out by using the Kynch method on waste material samples of the class -0,063 mm. During such tests on the starting raw material the percentage of solidity was 5, 10 and 15%. During the first three tests pH value was around 2,8 (just as in the plant) and during the next three tests pH value was around 5,5 just as in the waste material flotation plant. Test results have been shown as six equations. pH value of waste material coming out of the plant is around 2,5 where as pH value of waste material in the waste material flotation plant is around 5,5.

For 5% percentage of solidity $pH= 2,8$ and $pH= 5,8$ respectively:

$$S= 695 \cdot t_r/C_o \cdot H_o= 695 \cdot 8,5/ 51,6 \cdot 355= 0,322 \text{ m}^2/\text{t}/24\text{h} \quad (1)$$

$$S= 695 \cdot t_r/C_o \cdot H_o= 695 \cdot 18,7/ 51,6 \cdot 355= 0,709 \text{ m}^2/24\text{h} \quad (2)$$

For 10% percentage of solidity $pH= 2,7$ and $pH= 5,6$ respectively:

$$S= 695 \cdot t_r/C_o \cdot H_o= 695 \cdot 9/ 51,6 \cdot 355= 0,172 \text{ m}^2/24\text{h} \quad (3)$$

$$S = 695 \cdot t_r / C_0 \cdot H_0 = 695 \cdot 17,8 / 51,6 \cdot 355 = 0,341 \text{ m}^2/24\text{h} \quad (4)$$

For 15% percentage of solidity pH= 2,6 and pH= 5,5 respectively:

$$S = 695 \cdot t_r / C_0 \cdot H_0 = 695 \cdot 19 / 51,6 \cdot 355 = 0,234 \text{ m}^2/24\text{h} \quad (5)$$

$$S = 695 \cdot t_r / C_0 \cdot H_0 = 695 \cdot 20,3 / 51,6 \cdot 355 = 0,240 \text{ m}^2/24\text{h} \quad (6)$$

where is:

t_r – thickening time, min; C_0 – contents of solid, g/l; H_0 – column height of input pulp, mm

3.3. Review of results of filtration tests on waste material samples “Feldspar” – Bujanovac

For filtration tests the method with a piece of paper has been used. Within the tests several experiments have been carried out. Results of one of them are shown here and it has been performed on the class -0,063 mm. It was adopted that the percentage of solidity in the sediment or at filtration input be 40%. Based on laboratory data a calculation has been made of specific capacity of filtration by models:

a) Waste material sample for filtration has the following characteristics

-percentage of solidity at input (40% solidity)

-size class -0,063 mm

- sample mass $m=2$ kg

-specific sample mass $\gamma=2,65$ g/cm³

$$q_w = 0,6 \cdot q_0 / F' \cdot t = 0,6 \cdot 104,6 / 94,98 \cdot 3 = 0,22026 \text{ g/cm}^2\text{min}$$

$$q = q_w(100-w)/100 = 0,22026 \cdot 70,25 / 100 = 0,154733 \text{ g/cm}^2\text{min}$$

or it is:

$$q=0,0928398 \text{ t/m}^2/\text{h}$$

where:

q_w - specific filtration capacity of wet cake with moisture w ;

q -specific filtration capacity of dry cake;

t -filtration time in minutes

w -moisture in %

As the plant operates with a capacity of $Q = 4$ t/h and the mass of waste materials is around 40%, for this capacity (1,6 t/h) the area of filter cloth should be $F = 17,23$ m². After all investigation is proposed a new technological scheme of process of valorization of tailings from plant „Feldspar“ -Bujanovac.

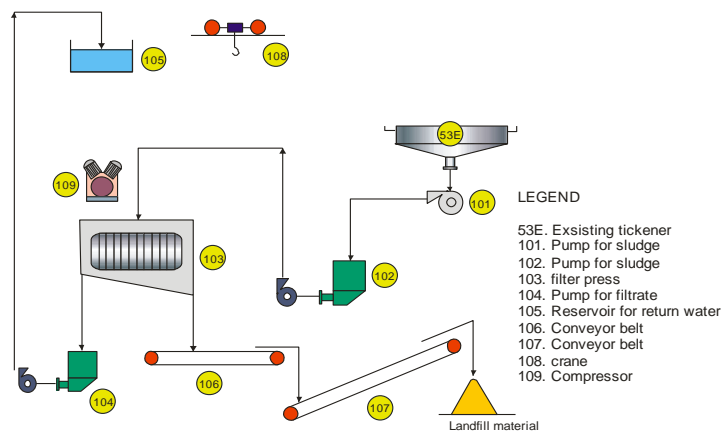


Figure 6. New proposed scheme of technological process of valorization of tailings from plant „Fedspar“-Bujanovac

4.CONCLUSION

Based on performed laboratory tests and analyses the following can be concluded:

- it is possible to obtain the product of satisfactory quality for the needs of ceramic industry from waste materials obtained at the flotation plant “Feldspar” – Bujanovac

- sorting in the flotation plant “Feldspar” – Bujanovac did not function as it should and this can be seen based on the composition according to grain sizes and upper size limit of waste material sample

- flotation process in the plant “Feldspar” – Bujanovac did not function as it should and this can be seen based on the mineralogical and chemical composition of waste materials.

Sorting problems could be resolved by regulating the operation of classifier and this would somewhat resolve the existing problems and enable emergence of useful minerals in waste materials. However, as the mineralogical analysis shows that there is no middling in any classes of sizes in samples of waste materials, special flotation of large and small classes should be introduced.

If operation continues under the existing conditions in the plant (with waste materials whose upper size limit is 0,15 mm) it would be possible to perform dewatering or thickening and filtration of flotation waste materials based on the results shown during operation (items 4 and 5). Based on the well known mass flow of waste materials and other technological parameters selection of thickening and filtration equipment and in this way a commercial products for ceramic industry can be obtained.

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REFERNCES

1. Tucan, F: "Special mineralogy", Zagreb, 1957.
2. Ilic, M: "Special mineralogy, Part I", Belgrade, 1978.
3. "Valorization of waste materials from the flotation plant "Feldspar" Bujanovac, Internal project, archives of the Institute for Technology of Nuclear and other Mineral Raw Materials, Belgrade, 2001.
4. "Re-examining the possibilities of valorization of flotation tailings from the plant "Feldspar" Bujanovac, Internal project, archives of the Institute for Technology of Nuclear and other Mineral Raw Materials, Belgrade, 2014.
5. Milosavljevic, R: "Methods of tests of mineral raw materials in the preparation of mineral raw materials", Belgrade, 1985.
6. Calic, N: "Theoretical bases of preparation of mineral raw materials", Belgrade, 1990.
7. Lesic, Dj, Markovic, S: "Preparation of mineral raw materials", Belgrade, 1968
8. Taggart, A.F.: "Handbook of mineral dressing", New York, Published by U.S.A.: John Wiley & Sons Inc, 1976.
9. Weis, N.L.: "SME Mineral processing handbook:, Volume 1, 1985, pp 2184 pages
10. M. C. Fuerstenau, K. N. Han, Principles of Mineral Processing, pp.561, Publisher Littleton, Colo: Society for Mining, Metallurgy and Exploration, 2003