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NEW CONDITION FOR SEPARATION OF ORTHOCLASE FROM QUARTZ BY FLOTATION; CASE OF AIN BARBAR QUARRY (ALGERIA)

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НОВІ УМОВИ СЕПАРАЦІЇ ОРТОКЛАЗУ ІЗ КВАРЦУ МЕТОДОМ ФЛОТАЦІЇ НА ПРИКЛАДІ КАР'ЄРУ АЙН-БАРБАР (АЛЖИР)

Purpose. The preliminary study of Ain Barbar (Algeria) feldspar quality improvement is aimed to obtain high purity of feldspar (orthoclase) without iron oxides and quartz to meet the standards of glass manufacturing and ceramics.

Methodology. The feldspar of Ain Barbar quarry was crushed and sieved. The mineral was characterized by X ray diffraction and chemical analyses with X ray fluorescence. The material (–250 +45 μm) was washed followed by physico-chemical concentration (magnetic separation and flotation) by new condition. The study of the main parameters of magnetic separation and flotation process in different ranges was realized.

Findings. Washing and high intensity magnetic separation (12 Ampere) afford to reduce the iron-bearing impurities up to 0.09 % Fe_2O_3, and the flotation is the best way for the separation of K-feldspar from quartz by appropriate reagents for this purpose (HBr, amine).

This method for beneficiation of feldspar ore (orthoclase) assaying on average, 15.16 % Al_2O_3, 70.40 % SiO_2, 0.03 % total iron oxides, 13.51 % K_2O and 0.14 % Na_2O, provided several types of products which can be used in the ceramic and glass making.

The most striking result in this experimental study is the depressive effect of HBr on quartz and activation of the orthoclase, HBr addition controls amine adsorption on k-feldspar through adsorption of Br^- ions onto mineral surfaces.

The use of HBr in flotation was found to increase the K-feldspar (orthoclase) grade in the concentrate. This study clearly demonstrates an effective separation of feldspar (orthoclase) from quartz.

Originality. The originality of this study consists in the use of hydrobromic acid as a new reagent to activate orthoclase and depress the quartz in the flotation process, with a comparison of the obtained results with the use of hydrofluoric acid or hydrobromic acid in orthoclase flotation, showing that the use of hydrobromic acid (800 g/t of HBr) gives a concentration of 90 % orthoclase and 8 % quartz with 13.51 % K_2O, while in feed it is 56 % orthoclase and 39 % quartz with a K_2O content of 7.78 %. On the other hand, the use of hydrofluoric acid (800 g/t HF) provides a concentrate of 80 % orthoclase and 18 % quartz, with a grade of 9.52 % of K_2O in the same conditions.

Practical value. The results obtained with magnetic separation followed by the flotation method can be suitable specifications for ceramics and glass. Besides, the use of hydrobromic acid is economical and less threatening for the environment in comparison with the use of hydrofluoric acid.

Keywords: *Ain Barbar, K-feldspar, magnetic separation, flotation, glass, ceramics*

Introduction. Feldspar is extensively used in various industrial applications such as glass and ceramics due to its alumina and alkali contents. The mineralogical composition of most feldspar minerals can be expressed in terms of the ternary system: orthoclase ($KAlSi_3O_8$), albite ($NaAlSi_3O_8$) and anorthite ($CaAl_2Si_2O_8$). Chemically, the feldspars are silicates of aluminum, containing sodium, potassium, iron, calcium, barium or combinations of these elements [1].

In industrial applications, the removal of colored impurities and quartz affects the quality, but the ratio of K_2O/Na_2O is more crucial for identifying the quality of the raw material. A ratio of 2/1 to 3/1 is required for ceramic products whereas for high-voltage insulators, abrasives and electrodes production, the ratio must be higher [2].

Feldspar is used in the manufacture of glass as a source of alumina and as a partial replacement for soda ash. It is also used in the production of ceramics. About 65 % of all feldspathic material is used in the glass industry, 30 % in ceramics and 5 % in fillers and other applications. Chemically, the specifications of feldspar products for application in both ceramic and glass industries are nearly the same, total SiO_2 65–68 %, free quartz < 8 %, Al_2O_3 18–19 %, K_2O and Na_2O 11.5–13.5 % and Fe_2O_3 0.08–0.2 %. However, the glass industry requires coarser feldspar concentrates (420 × 74 μm) in comparison with those necessary for ceramic production (98 % < 74 μm). Cengiz Demir [1],conducted differential flotation of Na–K feldspars by fluoride activation in the presence of 15 g/l NaCl and found an increase in the potassium content of the feldspar concentrate.

The best flotation results with Voineasa pegmatites containing equal amount of Na- and K-feldspars using amine collectors were achieved when Na-feldspar was depressed with NaCl [3]. Bayraktar et al studied Demirci-Turkey pegmatite containing 4.8 % K_2O and 2.40 % Na_2O; mica and oxides were first removed followed by separation of Na- and K-feldspars and quartz using NaCl, these researchers achieved a concentrate assaying 3.3 % Na_2O and 13.10 % K_2O.

Gülsoy et al [4] studied the similar feldspar ore from the same region assaying 5.94 % K_2O, 3.14 % Na_2O using magnetic separation followed by flotation with HF and NaCl; a concentrate assaying 3.1 % Na_2O and 12.65 % K_2O was achieved. Boulos, and al [5], confirmed that Na+ ions depress Na-feldspar in the presence of amine (G-TAP) at natural pH. Similarly, Na ions were found to be effective in the selective separation of feldspar minerals in HF medium.

Gülgönül [6] determined that various feldspar minerals particularly K-feldspars display different surface and floatability properties due to the presence of nano impurities on the mineral surface.

Demir and Gülgönül used mixtures of pure minerals to explain the separation mechanism of feldspar minerals by microflotation experiments. However, it was also observed that pure minerals do not always imitate real ores such as pegmatite, granite, syenite etc. The formation conditions of feldspar ores particularly the existence of perthitic structure in the ore or rock greatly influence the separation conditions.

Materials and Methods. ***Characterization studies.*** The fieldstone (feldspathic rhyolites) sample used in these experiments was obtained from AinBarbar quarry of Annaba (East of Algeria). The ore sample of 90 Kg was reduced to <1 mm in size by a jaw crushers, mixing, quartering and dividing to obtain representative samples of 500 g.

All the ore samples were ground in a ball mill to produce a sample below 500 μm, the particles of approximately 250 μm were separated by particle size analysis using a sieving device of RETSCH type with a diameter of 200 × 50 mm, the particle size measurement range is from 0.045 to 4 mm on a vibratory sieve for 20 min at an amplitude of 60, which amounted to about 80 % by weight of particles in the size range from 250 to 45 μm. The particle size analyses were carried out to determine the optimal mesh release.

The characterization was completed on representative samples by means of optic microscope, diffraction of ray X and X-ray fluorescence in order to better determine the aspect of the qualitative and quantitative characteristics of the feldspathic matter.

Experimental procedure. The separation of feldspar (orthoclase) from quartz is difficult because they reveal the similar surface properties. The froth flotation is one of the methods for feldspar separation from quartz. But all conditions of this method to get high selectivity are reported to be used in acidic medium with amine as collector and with addition of fluoride (hydrofluoric acid) as modifier; a shortcoming of this reagent system is that it is expensive and involves using environmental pollutants.

In our investigation, we applied physical and physico-chemical processes on samples for the reduction of iron oxides and quartz, the double sided linking by flotation with different collectors including petroleum sulfonate, diamine solution with HF and HBr as modifiers in order to obtain a quality product for ceramists. During this study, the examined parameters were effects of current intensity of the coil, pH, and concentration of different reagents used.

The material of 500 g of the size of fraction 250/45 μm was subjected to magnetic separation tests aimed to remove the ferriferous inclusions contained in the K-feldspar (orthoclase) material. The range of the current variation in the magnetic separator that was used is from 5 to 12 Amperes, and drum rotation rotor is 60 rpm.

The magnetic separation performance highly depends on the physical particle properties to be separated (and size of the magnetic nature), the quality of the applied magnetic field, and the difference in magnetic susceptibility between the separated particles. The magnetic separator of high intensity laboratory work dry is composed of three coils surrounding the electromagnet provided with a splined rotor rotating between the pole pieces of a magnetic circuit. The magnetic poles or pole pieces, between which the rotor rotates, are subjected to a magnetic induction [7].

The main magnetic separator parameters are the magnetic flux density which varies from 1.2 to 2 Tesla. The next step is enrichment by flotation concentrates obtained by magnetic separation.

The first condition to obtain good flotation is to achieve a grinding of the maximum releasing minerals from each other; and a suitable release of the particles to float, in our case the mesh of 250/45 μm is estimated at the release. In some cases, it is necessary to deslime pulp before the float and to avoid the recovery of the mineral particle surfaces. The pulp containing 20 % solids mixture with water, is stirred in a conditioning tank to ensure the homogeneity of the medium. The first time round, dispersants AP 801 and AP 840 are added to avoid any kind of agglomeration before floating the concentrate (feldspar), then the hydrofluoric acid or hydrobromic acid is added to modify the surface feldspar particles during conditioning to be driven to the surface by the air bubbles; this process is repeated every time before flotation concentrates for 5 min. After that, a diamine or petroleum sulfonate agent is added to the collector.

The flotation operation is repeated for each collector and modifier. After flotation, washing, drying and filtering follows, (Table 1). The tests were performed in laboratory of valorization of mining resources and environment, Mining Department, Badji Mokhtar University, Annaba.

Results and Discussion. ***Chemical analysis and X-ray Diffraction analysis.*** The results of chemical and mineralogical analyses are shown in Table 2 and Fig. 1, 2 respectively, these results demonstrate that the ore contains quartz and orthoclase with minor amounts of albite, anorthite, and small quantities of clay minerals. The sample has K_2O and Na_2O contents of 7.78 and 0.33 % respectively.

The XRD spectrum and tine section confirm that orthoclase is the principal mineral and other minerals present are very minor to trace their amount.

Particle size analyses. The collected results from chemical analysis of size fractions reveal that the totals of SiO_2 contents vary from 70.89 to 75.61 %. As for the ferriferous inclusions, their contents of Fe_2O_3 are 0.18 to 1.06 % showing an excess of iron in the raw material which does not meet the required standard ($Fe_2O_3 <$ < 0.03 % and quartz < 8 %). Besides, we noted that the iron oxide content increases as the particles diminish. The contents of K_2O and Na_2O and SiO_2 are homogeneous almost in all size fractions. The results of the chemical analysis of size fractions are given in Table 3.

Evaluation of efficiency of iron removal. The efficiency of iron removal can be calculated by the following equation

$$E(\%) = \left[1 - \left(\frac{Fe_2O_3 \text{content in concentrate}}{Fe_2O_3 \text{ content in feed}}\right)\right] \cdot 100.$$

Table 4 shows the effect of the current intensity on the effectiveness of iron oxide removal from feldspar,

Table 1

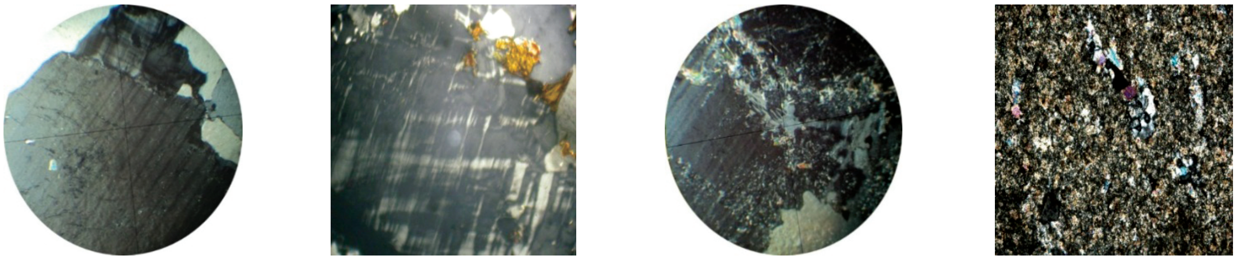
Conditions used in Denver flotation experiments

Parameters	Conditions
Temperature of medium	20–25 °C
Particle size	–250 +45 μm
Impeller speed	1200 rpm
Solids by wt.%	40
Collector type	Diamine, Petroleum sulfonate
Amount of collector	150 g/t
Frother type	Pine oil
Conditioning time for collector	5 min
pH	Acidic pH (1.5–4.0) HF, HBr
Conditioning time for HF	(300–1200 gr/t) H_2SO_4 as much as needed
Conditioning time for HBr	(300–1200 gr/t) H_2SO_4 as much as needed
Conditioning time for frother	3 min
Flotation time	5 min

Table 2

Chemical composition of the fieldstone sample

Oxides	SiO_2	Al_2O_3	K_2O	Na_2O	Fe_2O_3	CaO	P_2O_5	MgO	TiO_2	PbO	ZnO	MnO	PAF
Contents (%)	73.26	14.71	7.78	0.33	0.79	0.59	0.31	0.05	0.02	0.02	0.03	0.01	1.04



Plagioclase grains in contact with the quartz and orthoclase, +120 | Alteration of plagioclase and orthoclase by sericite (mica), +120 | Biotite aggregates on tahe contour of the grain of orthoclase, +120 | Pate with feldspar porphyritic quartz and feldspar and mica inclusions, +60

Fig. 1. Tine sections

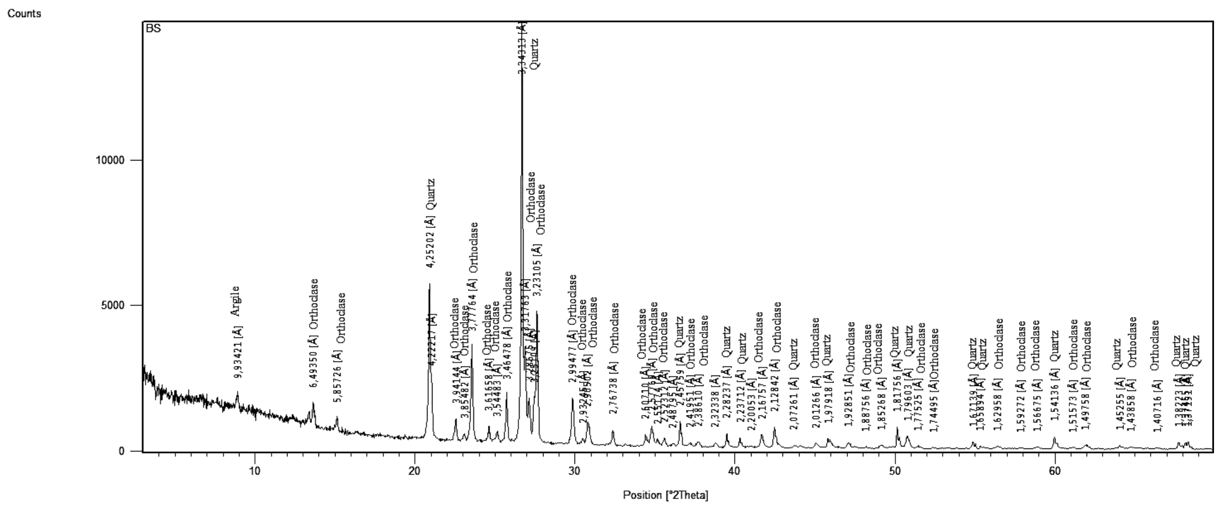


Fig. 2. XRD pattern of investigated fieldstone sample

Table 3

Results of chemical analysis of size fractions of *k*-feldspar sample

Fraction, mm	Yield (%)	SiO_2	Al_2O_3	K_2O	Na_2O	Fe_2O_3	CaO	MgO	P_2O_5	TiO_2	MnO	PAF
+4	26.02	73.25	15.39	8.45	0.30	0.18	0.52	0.01	0.31	0.01	0.02	0.82
–4 +2	30.54	75.61	13.18	8.81	0.33	0.20	0.30	0.02	0.29	0.00	0.02	0.61
–2 +1	13.00	75.60	12.31	8.48	0.30	0.55	0.60	0.02	0.31	0.02	0.01	1.27
–1 +0.5	07.11	70.89	16.76	8.56	0.34	0.65	0.21	0.03	0.30	0.02	0.01	0.89
–0.5 +0.25	04.04	73.46	13.46	7.98	0.28	1.06	0.87	0.01	0.32	0.00	0.01	0.98
–0.25 + 0.125	03.52	73.56	13.62	8.20	0.36	0.96	0.89	0.02	0.28	0.00	0.02	1.24
–0.125 +0.063	04.03	72.40	15.75	7.60	0.35	0.76	0.59	0.01	0.34	0.07	0.01	1.04
–0.063 +0.045	01.82	74.61	14.52	7.37	0.27	0.57	0.05	0.01	0.35	0.05	0.01	1.04
–0.045	09.92	74.12	14.46	8.50	0.32	0.70	0.20	0.01	0.33	0.03	0.01	1.14

according to obtained results by high intensity magnetic separation (MSHI), we found a significant improvement in feldspar content and a remarkable decrease of impurities such as hematite was obtained in the range between 10 and 12 Amperes. With the increase in the intensity of the electric current at 12 Ampere, it is noted that the iron impurity content decreases from 0.32 to 0.09 %. The optimum efficiency of removal of iron oxide was obtained in the range of 71.81 %.

Effect of the pH on separation of *k*-feldspar (orthoclase). Separation of feldspar from quartz can be

Table 4

Reduction of iron content in size fractions of the 250/45 μm material, at different intensities of magnetic field

Intensity (*A*)	Fe_2O_3 (%)	Fe_2O_3 (%)	*E* (%)
5	0.32	0.28	06.6
7		0.24	25.0
9		0.19	40.7
10		0.11	65.7
12		0.09	71.81

achieved with cationic collectors in acid circuit at a pH value in the vicinity of 1.5 to 2.5. Other works, found that at the pH range of 2.5 to 3, a maximum selectivity could be reached [8].

Fig. 3 and 4 show a maximum selectivity at pH of 1.8 to 2 in both cases, when using the HF or HBr modifier and diamine as a collector, at concentration of 150 g/t. The contents and recovery of K_2O achieve a maximum, when we use Diamine collectors and hydrobromic acid (HBr) as an activator of orthoclase and quartz depressor (12.65 %; 85 %) respectively.

The results obtained are justified by the point of zero charge of feldspar (1.5 to 2) and quartz varying from 2 to 3.7; at pH 1.5 to 2.5 above the value of the point of zero charge the surface orthoclase takes a positive sign whereas the quartz has a negative sign which allows creating new sites (a better surface activation of orthoclase) to increase the adsorption of collectors (diamine).

Considerable contents of SiO_2, more than 90.61 %, in tailing signify a better depress of the quartz when using HBr with 150 g/t Diamine at pH = 1.8. The use of HBr increases the quartz depression (increases the speed of sedimentation), compared with the use of HF because the molecular weight of HBr is greater than HF.

From Fig. 5 and 6 it is noted that the use of petroleum sulfonate as a collector in both cases (HF, HBr) reduces the recovery of K_2O, and the content of K_2O is almost constant when the pH ≥ 3, which means that the adsorption of the collector by the quartz surface is started (the start of flotation of quartz in this pH).

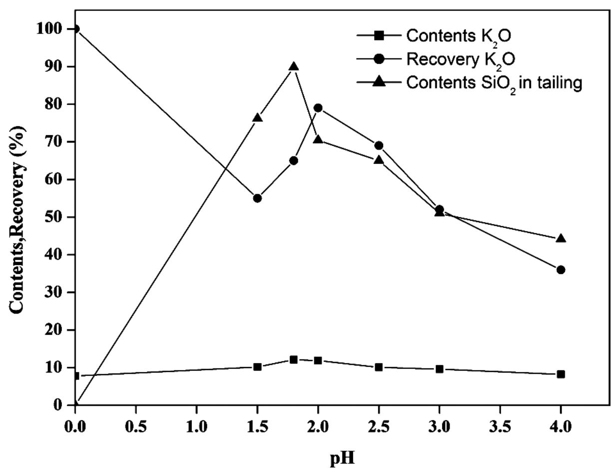


Fig. 3. Effect of pH on orthoclase separation with HF and Diamine (150 g/t)

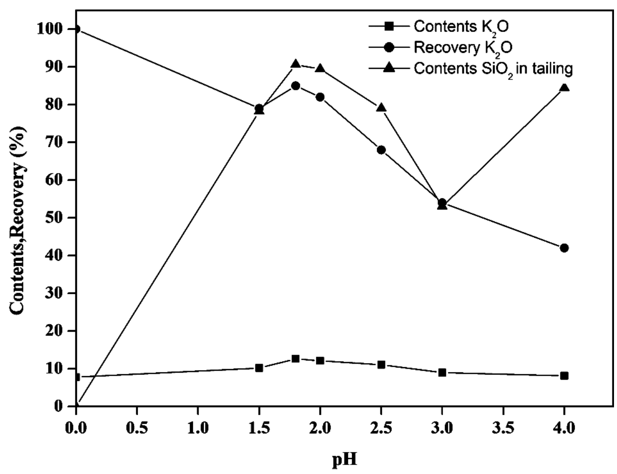


Fig. 4. Effect of pH on orthoclase separation with HBr and (150 g/t Diamine)

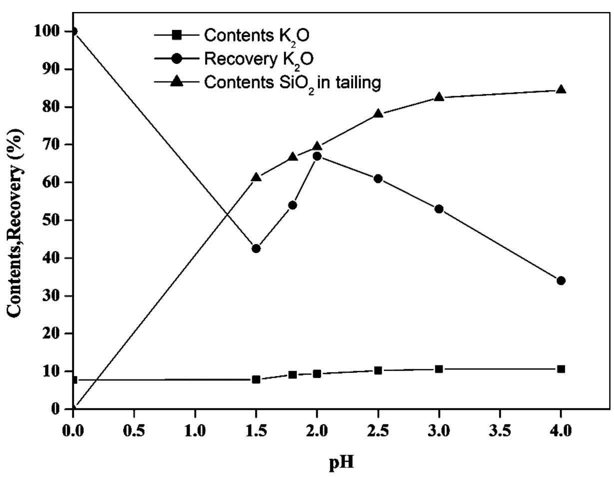


Fig. 5. Effect of pH on orthoclase separation with HF and petroleum sulfonate (150 g/t)

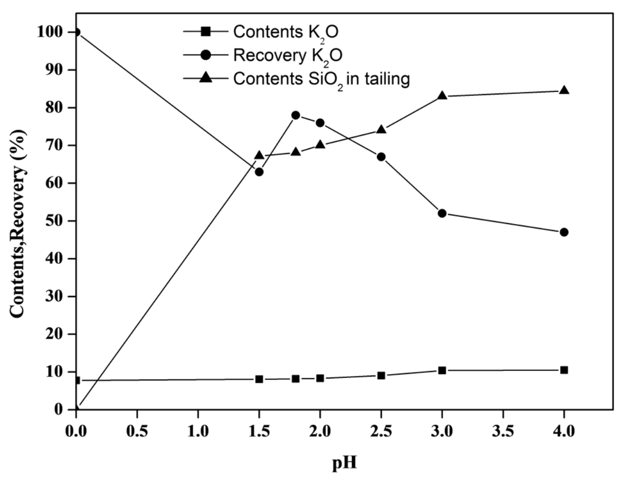


Fig. 6. Effect of pH on orthoclase separation with HBr and (150 g/t petroleum sulfonate)

Effect of the concentrate of hydrofluoric or hydrobromic acids on separation of orthoclase with pH = 1.8 : 2 and 150 g/t diamine. Flotation studies in acidic medium were carried out in two main parts: the amount of F^- and Br^- ions required to activate and depress the minerals (orthoclase) was systematically optimized by using 150 g/t of Diamine or petroleum sulfonate. All experiments were performed at pH 1.8 to 2 adjusted with H_2SO_4. Tables 5, 6 illustrate that some selective separation between *K*-feldspar (orthoclase) and quartz occurs at substantial recoveries.

It is also found in the present research that conditions of *k*-feldspar formation greatly affect the optimum dosage of HF and HBr. For instance, altered feldspar requires higher HF and HBr dosage for activation. HF and HBr removes altered layers and cleans the surface to facilitate the formation of alumina fluoride complexes.

Pine oil was added to the flotation cell as a frother because HF addition increases the collector consumption and deteriorates the quality of bubble.

The addition of either HF or HBr as pH regulators and modifiers increases the selectivity of the feldspar flotation and the quartz depression as shown in Table 5. The best results were recorded when we used HBr as a modifier with diamine as a collector at a concentration of 800 and 150 g/t respectively.

The use of petroleum sulfonate as a collector and HF or HBr as a modifier does not give satisfying results.

Comparison of obtained results with hydrofluoric or hydrobromic acids in orthoclase flotation. Comparing the obtained results with the use of hydrofluoric acid or hydrobromic acid in orthoclase flotation, shows that the use of hydrobromic acid (800 g/t of HBr) gives a concentration of 90 % orthoclase and 8 % quartz with 13.51 % K_2O, while in feed it is 56 and 39 % quartz orthoclase with a K_2O content of 7.78. On the other hand, the use of hydrofluoric acid (800 g/t HF) provides a concentrate of 80 % orthoclase and 18 % quartz, with a grade of 9.52 % of K_2O in the same conditions. Then the use 1200 g/t of HF gives concentrates of 86 % orthoclase and 12 % quartz with 12.55 % of K_2O as shown in Table 6.

Separation of orthoclase by magnetic separation followed by flotation. The operation of orthoclase processing from Ain Barbar quarry is diagrammed in Fig. 7.

Conclusion. The beneficiation of feldspar ore (orthoclase) assaying on average 15.16 % Al_2O_3, 70.40 % SiO_2, 0.03 % total iron oxides, 13.51 % K_2O and 0.14 % Na_2O, provide several types of products which can be used in the ceramic production and glassmaking.

Attrition by washing operation is necessary for the enrichment of *K*-feldspar, as well as magnetic separation is designed to remove the iron-bearing impurities as presented in our study.

The separation of orthoclase from quartz by flotation with conditions used in this study is very impor-

Table 5

Effect of the concentration of hydrofluoric or hydrobromic acids on orthoclase separation with pH = 1.8 to 2 and 150 g/t Diamine

Concentration of HF (g/t)	feed	300	500	800	1000	1200
Grade of K_2O (%)	7.78	8.92	10.70	11.32	12.50	12.55
Recover of K_2O (%)	100	56.41	63.25	70.0	76.92	78.00
Concentration of HBr (g/t)	feed	300	500	800	1000	1200
Grade of K_2O (%)	7.78	8.95	9.81	13.51	13.34	12.33
Recover of K_2O (%)	100	46.50	62.35	90.40	86.00	85.04
Feed: Condition without any addition (concentration of HBr and HF = 0 g/t); HBr: Hydrobromic acid; HF: Hydrofluoric acid; K_2O: Potassium oxide in concentrate						

Table 6

Effect of the concentration of hydrofluoric or hydrobromic acids on orthoclase separation with pH =1.8 to 2 and 150 g/t petroleum sulfonate

Concentration of HF (g/t)	feed	300	500	800	1000	1200
Grade of K_2O (%)	7.78	8.92	9.50	9.52	9.65	9.66
Recovery K_2O (%)	100	56.41	63.25	70.0	76.92	78.00
Concentration of HBr (g/t)	feed	300	500	800	1000	1200
Grade of K_2O (%)	7.78	8.42	8.54	9.22	9.24	9.30
Recovery K_2O (%)	100	46.50	62.35	78.40	84.00	85.04
Feed: Condition without any addition (concentration of HBr and HF = 0 g/t); HBr: Hydrobromic acid; HF: Hydrofluoric acid; K_2O: Potassium oxide in concentrate						

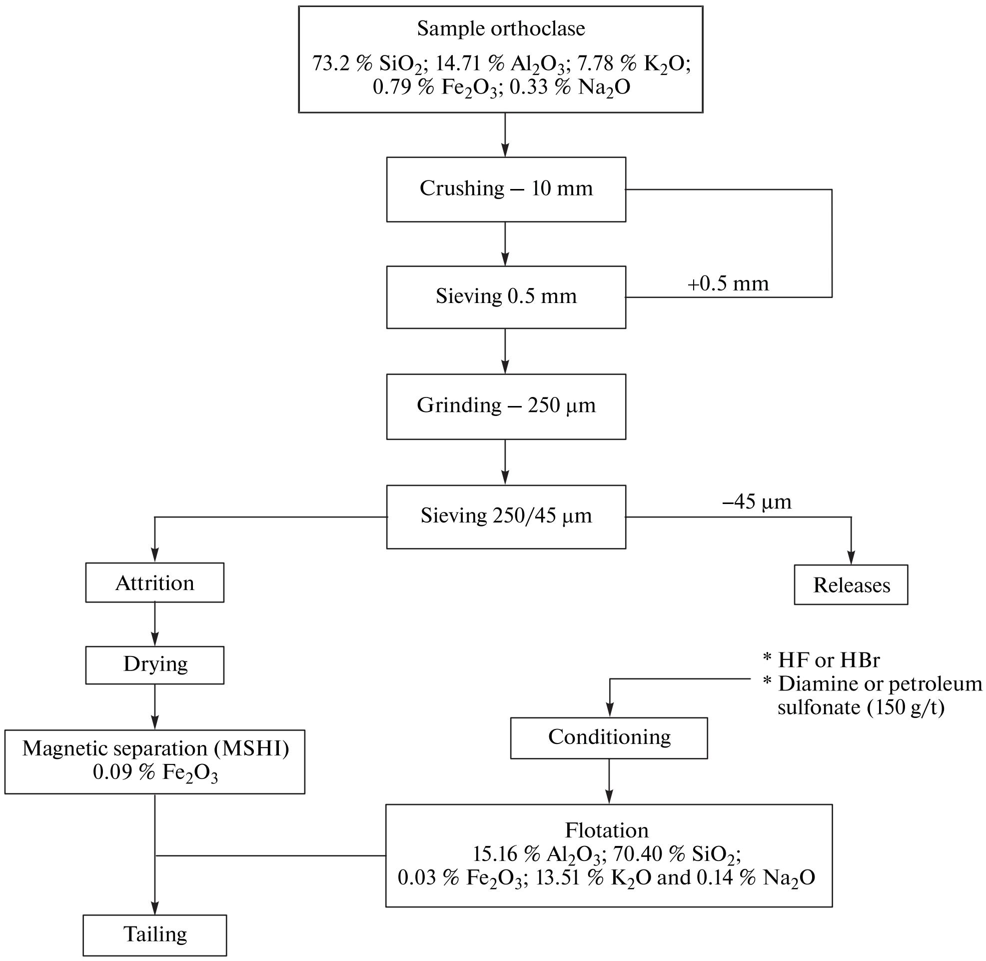


Fig. 7. Proposed flow sheet for orthoclase processing from Ain Barbar quarry

tant because it gives good results in terms of economic cost and protection of the environment (the use of HBr is economical and less hazardous than using HF).

Flotation of *K*-feldspar (orthoclase) with pH of 1.8; 2 by diamine as a collector and HBr as an activator at dosage of 800 g/t is better than the flotation by petroleum sulfonate and HF in the same conditions.

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Мета. Попереднє вивчення покращення якості польового шпату родовища Айн-Барбар (Алжир) з метою отримання польового шпату (ортоклаза) високого ступеня чистоти, без оксидів заліза та кварцу, що відповідає стандартам виробництва скла та кераміки.

Методика. Польовий шпат з кар'єру Айн-Барбар був подрібнений та просіяний. Отримана характеристика мінералу методами рентгеноструктурного аналізу (рентгенодифракційного аналізу), хімічного аналізу та рентгенофлуоресцентного аналізу. Матеріал (–250 +45 мкм) піддавався промиванню з наступною фізико-хімічною концентрацією (магнітна сепарація та флотація) в нових умовах. Вивчені основні параметри процесів магнітної сепарації та флотації в різних діапазонах.

Результати. Промивання та високоінтенсивна магнітна сепарація (12 Am) дозволяє зменшити долю залізовмісних домішок до 0,09 %, а флотація є кращим способом для відокремлення калієвого польового шпату від кварцу за допомогою відповідних реагентів (бромистий водень, амін).

У середньому, у пробі польового шпату, збагаченого цим методом, міститься 15,16 % Al_2O_3, 70,40 % SiO_2, 0,03 % оксидів заліза, 13,51 % K_2O та 0,14 % Na_2O, що дозволяє використовувати продукт у керамічній і скляній промисловості.

Найбільший інтерес представляє ефект, який бромистий водень здійснює на кварц (придушення) та ортоклаз (активація). Додавання бромистого водню дозволяє контролювати адсорбцію аміна калієвим польовим шпатом шляхом адсорбції іонів Br^- до поверхні мінералу.

Було виявлено, що використання бромистого водню у процесі флотації збільшує вміст калієвого польового шпату (ортоклазу) в концентраті. Дослідження показало ефективність відокремлення польового шпату (ортоклазу) від кварцу.

Наукова новизна. Використання бромисто-водневої кислоти в якості нового реагента для активації ортоклазу та пригнічення кварцу у процесі флотації. Проведене порівняння результатів дослідження фтористо-водневої та бромисто-водневої кислот у процесі флотації ортоклазу. При вмісті 56 % кварцу та 39 % ортоклазу, із вмістом K_2O у 7,78 % у вихідній сировині, застосування бромисто-водневої кислоти (800 г/т.) дає на виході співвідношення 90 % ортоклазу, 8 % кварцу з 13,51 % K_2O. За аналогічних умов, використання фтористо-водневої кислоти (800 г/т.) забезпечує вміст 80 % ортоклазу та 18 % кварцу, з 9,52 % K_2O в концентраті.

Практична значимість. Продукт, отриманий за допомогою магнітної сепарації з наступною флотацією, відповідає специфікації для кераміки й скла. Крім того, використання бромисто-водневої кислоти є економічно вигідним та менш шкідливе для навколишнього середовища у порівнянні з використанням фтористо-водневої кислоти.

Ключові слова: *Айн-Барбар, калієвий польовий шпат, магнітна сепарація, флотація, скло, кераміка*

Цель. Предварительное изучение улучшения качества полевого шпата месторождения Айн-Барбар (Алжир) с целью получения полевого шпата (ортоклаза) высокой степени чистоты, без окислов железа и кварца, соответствующего стандартам производства стекла и керамики.

Методика. Полевой шпат из карьера Айн-Барбар был измельчен и просеян. Получена характеристика минерала методами рентгеноструктурного анализа (рентгенодифракционного анализа), химического анализа и рентгенофлуоресцентного анализа. Материал (–250 +45 мкм) подвергался промывке с последующей физико-химической концентрацией (магнитная сепарация и флотация) в новых условиях. Изучены основные параметры процессов магнитной сепарации и флотации в различных диапазонах.

Результаты. Промывка и высокоинтенсивная магнитная сепарация (12 Am) позволяет уменьшить долю железосодержащих примесей до 0,09 %, а флотация является лучшим способом для отделения калиевого полевого шпата от кварца с помощью соответствующих реагентов (бромистый водород, амин).

В среднем, в пробе полевого шпата, обогащенного этим методом, содержится 15,16 % Al_2O_3, 70,40 % SiO_2, 0,03 % оксидов железа, 13,51 % K_2O и 0,14 % Na_2O, что позволяет использовать продукт в керамической и стекольной промышленности.

Наибольший интерес представляет эффект, который бромистый водород оказывает на кварц (подавление) и ортоклаз (активация). Добавление бромистого водорода позволяет контролировать адсорбцию амина калиевым полевым шпатом путем адсорбции ионов Br^- в поверхность минерала.

Было обнаружено, что использование бромистого водорода в процессе флотации увеличивает содержание калиевого полевого шпата (ортоклаза) в концентрате. Исследование показало эффективность отделения полевого шпата (ортоклаза) от кварца.

Научная новизна. Использование бромисто-водородной кислоты в качестве нового реагента для активации ортоклаза и угнетения кварца в процессе флотации. Проведено сравнение результатов использования фтористо-водородной и бромисто-водородной кислот в процессе флотации ортоклаза. При содержании 56 % кварца и 39 % ортоклаза, с содержанием K_2O в 7,78 % в исходном сырье, применение бромисто-водородной кислоты (800 г/т.) дает на выходе соотношение 90 % ортоклаза, 8 % кварца с 13,51 % K_2O. При аналогичных условиях, использование фтористо-водородной кислоты (800 г/т.) обеспечивает содержание 80 % ортоклаза и 18 % кварца, с 9,52 % K_2O в концентрате.

Практическая значимость. Продукт, полученный с помощью магнитной сепарации с последующей флотацией, соответствует спецификации для керамики и стекла. Кроме того, использование бромисто-водородной кислоты является экономически выгодным и менее опасно для окружающей среды по сравнению с использованием фтористо-водородной кислоты.

Ключевые слова: *Айн-Барбар, калиевый полевой шпат, магнитная сепарация, флотация, стекло, керамика*

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