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Selective Separation of Na-K Feldspar in Nepheline Syenite

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ABSTRACT: Differential flotation of albile and microcline in a synthetic feldspar mixture with amine (G-TAP) at natural pH is accomplished with monovalent inorganics at an optimum salt concentration of 5x10"[2] M. Testing of this concept on a nepheline syenite ore using magnetic separation followed by flotation resulted in a major increase in the total alkali content along with a significant removal of colored impurities. Particularly, the remarkable effect of slime coating on flotation recoveries is intriguing. Application of differential flotation using monovalent inorganics on a nepheline syenite ores has shown that perthitic texture of the ore hinders the selective separation of Na and K feldspars.

1 INTRODUCTION

Albite (NaAISUOx) and microcline and/or orthocla.se (KAlShOs), are the most important commercial feldspar minerals. They are generally found together with quartz, mica and colored impurities. Beneficiation of feldspar minerals is mainly performed by separation methods including gravity, magnetic separation, and flotation. Although the concentration scheme is usually dependent upon the quality ot the end product, flotation is the most widely used beneficiation method for the separation of quartz, mica and sometime of colored impurities. The main application of flotation is in the treatment ol typical feldspar containing rocks such of pegmatites, nepheline syenites and granites. Among the impurities the mica is normally removed first followed by flotation of ferruginous impurities. Once the mica and ferruginous impurities have been removed, the feldspar is then floated from the quartz.

In feldspar rocks where Na- and K-Feldspar minerals are found together, it is important to separate feldspar into individual phases of Na and K. In a typical rock, Na and K-mincrals exhibit NaiO or K;0 values in the range of 3 to 5 %. The aim for a practical application is often to raise one of the values of NaiO or KiO above 8 % while keeping the other below 3 %.

The floatability of individual feldspar minerals has not been well studied in the literature (Demir et al. 2001). Thus, their separation remains as a controversial subject. Our earlier micro flotation study revealed that the separation of albite from microcline is possible with cationic collectors at natural pH in the presence of monovalent inorganic electrolytes.

In this study, the applicability of this concept has been first tested on a set of synthetic feldspar minerals and then extended to an actual ore, nepheline syenite. The problems associated with this concept are elaborated on the basis of flotation data.

2 EXPERIMENTAL

Albite and microcline samples of high purity used in these experiments were obtained from Aydin-Cinc region of Turkey. The chemical analysis of the samples shown in Table 1 together with the XRD analysis (Figure 1) reveals that the samples are albite, and microcline with albite impurity. The lump sized materials were crushed by a hammer and ground in an agate mortar followed by wet screening to produce a sample of - 150 microns in size.

Mineralogical investigations on the feed sample were carried out through microscopic examinations. The chemical analysis of the feldspar ore used in this study is presented in Table 1. The chemical and microscopic analysis coupled with XRD determinations reveals that the ore contains albite, microcline, biotite, nepheline, chlorite, epidote, rutile, and opac minerals (magnetit, pyrite).

Table I. Complete chemical analysis of feldspars.

hem	Nepheline syenite °/<	Albite*	Mieiochne %
SiO:	5X %	66.02	65.30
A1,0,	18.34	19.92	18.72
Fe_20,	5.4	0.04	0.05
TiO	0.73	0.04	0.01
Na 0	4.22	10.68	2.84
K_20	6.3	0.42	11.81 •
CaO	2.3	1.74	0.24
M.aO	1.4	0.04	0.01
LOI	105	0.50	0.60

The ore sample received from the Sorgun-Yozgat region of Turkey was reduced down to 1 mm in size by a combination of jaw, cone and roll crusher. The sample was divided into three size fraction as -1+0.6, -0.6+0.3, and -0.3+0.2 mm and used for magnetic separation. The minus 0.2 mm size fraction was kept aside. The non-magnetic product was further ground to obtain a product of -0.2 mm in size. The grinding tests were carried out in a ceramic mill to prevent iron contamination. The grinding tests were conducted for 12, 15 and 20 minutes of which the 20-minute test result was selected because of its appropriate size distribution and also relatively less slime formation.

Magnetic separation tests were carried out by a rare-earth permanent magnetic roll separator abbreviated as the REMS. All REMS tests were carried out in a single-stage. In all experiments, the sample weight used for an each size fraction was 300 grams. The resultant magnetic and nonmagnetic fractions were collected and analyzed for TiO:, Fe^O.i, and K:0 using X-ray Flourescence (XRF). The effects of front splitter angle, back splitter angle, roll speed, and feed rate parameters were optimized.

Flotation tests for nepheline syenite were performed in a Denver cell equipped with a 1.5 I cell. A sample of 300 g was mixed with 1200 ml tap water at 1250-rpm impeller speed. Both conditioning and notation were carried out at the same impeller speed and percent solids by weight. Desliming was made prior to flotation. No desliming and no frother were used in the case of synthetic sample. Conditioning period of 5 min. for the first-stage conditioning and 3 min for the subsequent stages of collector addition was utilized. Percent solids by weight and natural pH of 7.7 were kept constant in most experiments unless otherwise specified. Aerofroth 88 was used as a frother. The float and unfloat fractions were analyzed for KjO by X-Ray fluorescence spectrometer (XRF) and Na^O by atomic absorption. All other chemical analyses were performed by wet chemistry and XRF methods. The cationic collector (Genamin-TAP) is a commercial reagent manufactured by Clariant of Germany. The reagent is in the solid form and was prepared at pH 3 as recommended by the manufacturer. The pH was adjusted by HCl and NaOH.

3 RESULTS AND DISCUSSION

Nepheline syenite, similar to feldspar, is an igneous rock composed of aluminum silicates together with an alkali ion such as Na and K. It is a light-colored, quartz-deficient feldspathic rock made up of mostly albite, microcline and nepheline, a mineral with the composition of (Na, K) AISİO4 (Burger, 1990: Kendall, 1993). The nepheline mineral which imparts industrial features to the rock is $Na_3KAI_4Si_4Oi6$ with a ratio of 3/I=Na/K.

Nepheline syenite is a raw material alternative to feldspars. While about 85 % of it is used in ceramic and glass industries, 15 % of it is used in the production of a variety of products including paints, fillers, and insulators. However, nepheline syenite has a higher alkali/alumina ratio than feldspar, and, thus a good fluxing effect. In glass nepheline syenite improves the workability and lowers the melting temperature and also supplies alumina, which provides increased resistance to scratching and breaking, improved endurance, and increased chemical durability (Potter, M J Min yearbook 1994). For colorless glass, the nepheline syenite like feldspar should not contain more than 0.1% Fe?Oi. Iron content may be up to 0.5% FeiOj in colored glass.

3.1 Magnetic Separation Texts

Magnetic separation tests were carried out by a dry rare-earth permanent magnetic roll separator (REMS). The results conducted in different size fractions as -1+0.6, -0.6+0.3, and -0.3+0.2 mm are shown in Table 2. Some parameters were fixed based on the previous studies (Çelik et al., 1999). The roll speed of 45 rpm, right splitter angle of 80° and left splitter angle of 140" were used in magnetic separation experiments (Yılmaz. 2001). The results were evaluated on the basis of TiOş, FeiCh, and KjO grades in the nepheline syenite concentrate.

The combined results of different size fractions are shown in Table 2. It can be seen that nepheline syenite concentrate (non-magnetic product) containing 0.76% Fc_20?, 0.82 $Ti0_2$, and 7.69% K 0 is obtained.

Table 2. Magnetic Separation Test Results

Size (mm.)	Products	Weight (%)	Fe,0., (%)	Ti0$_2$ (%)	K$_2$0 (%)
-1+0.6 (40.7%)	Cone.	45.8	0.78	0.76	7.96
	Middlings	43.3	4 49	0 42	5.87
	Tailings	10.9	10.54	0 02	4.61
-0.6+0.3 (27.3%)	Cone.	61.0	0.80	0 82	7.54
	Middlings	31.4	5.40	0.11	4.72
	Tailings	7.6	13.07	0 19	4.07
-0.3+0.2 (10.8% 1	Cone.	67.7	0 62	0 99	7.36
	Middlings	25 0	5 17	0.26	5 16
	Tailings	7.3	17 15	0 01	2 97
Combined Cone. -l+0.2mm		100 0	0.76	0 82	7.69

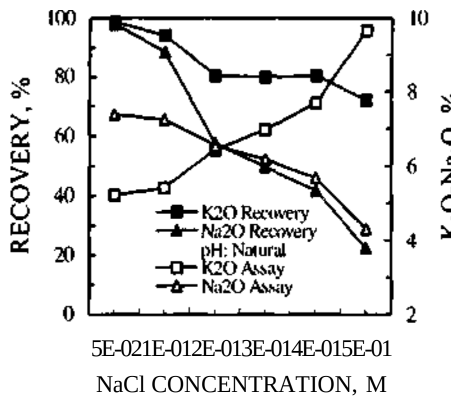


Figure I Floatabilny of feldspar minerals versus NaCl concentration.

3.2 Flotation Tests

Figure I shows that the flotation profile of syntehie sample composed of albite and microcline at lOOg/ton constant amine concentration as a function of NaCl concentration at natural pH. It can be seen that the selectivity between Na-feldspar and K-feldspar is improved upon increasing NaCl concentration. The most effective selectivity occurs between albite and microcline at amine solutions of 0.83 mg/l at the expense of recoveries. The reason for the depression of albite can be ascribed to the inability of albite to undergo an effective ion exchange process with NaCl and thereby remain less negatively charged surface unto which the adsorption of calionic collector is relatively hindered (Demir et al. 2001).

In this study, the nepheline syenite ore was first subjected to magnetic separation and the concentrate was treated by flotation to test the possibility of sodium-potassium feldspar separation using G-TAP as collector and NaCl as depressant. Flotation tests were conducted at 20 wt. "/<• solids. The effect of G-TAP concentration on grades (KjO) and recoveries is presented in Figure 2. A small amount of Aerofroth 88 (20 g/t) as frother was added. A series of experiments performed to determine an optimum flotation time resulted in a froth removal time of 60 sec.

The results do not show any significant trend to demonstrate an optimum amine dosage (Figure 2). The reasons for this could be attributed to the non-systematic desliming during flotation tests. A value of 150g/t G-TAP dosage given in previous works was used for optimization of desliming studies.

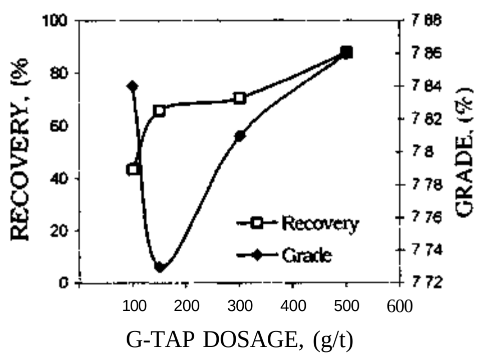


Figure 2 Effect of G-TAP Dosage on K.0 grade and recoveiy for nepheline syenite.

3.2 Effect of Slime in Flotation Tests

A series of desliming tests were designed to determine the effect of slime coating on flotation. The desliming tests were conducted in a 2 l graduated cylinder. The suspension of 1800 in volume was stirred and a portion of the upper part was removed and the particle size distribution and corresponding weight % was recorded. A separate test was performed for each desliming stage followed by a separate flotation experiment. The results shown in Table 3 and Figure 3 indicate that while desliming less than 12 % of the total material resulted in zero recovery, only at and above 24 % desliming was the nepheline syenite flotation restored. These results are unique as they demonstrate that even a portion of -0,074+0.038 mm size fraction had to be removed in order to avoid slime coating effect.

Tatile 3. Liberation of slime

Slime (%)	Particle Size (mm.)	Weight (%)
4	-0.038	100.0
8	-0.038	100.0
12	-0.038	100.0
16	-0.074+0.038 -0,038	44.7 56.3
24	-0.074+0.038 -0.038	38.2 61.8
32	+0.074 -0.074+0.038 -0.038	7.9 27.3 64.8

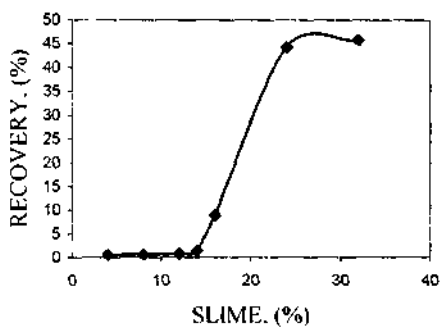


Figure 3 Effect of Slime coating on flotation recoveries of nepheline syenite.

3.4. *Effect of NaCI and KCl Addition in Flotation Separation*

The effect of NaCI and KCl dosage on the separation of sodium and potash feldspars was investigated with 150 g/t G-TAP (150 g/t) as collector at natural pH. Tables 4 and 5 present the effect of NaCI and KCl additions on separation. Figure 4 illustrates the combined results. The results are evaluated on the basis of NanO and KiO grades in the nepheline syenite concentrate.

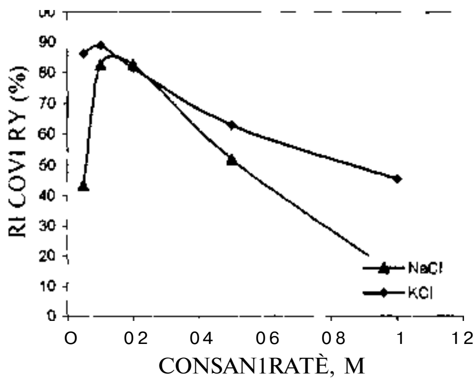
It is evident from Tables 4 and 5 together with Figure 4 that feldspar recoveries are substantially decreased with increasing both NaCI and KCl dosages. But depression is more pronounced with NaCI addition. These results are in line with our earlier reports (Demir et al., 2001). The absence of change in Na:0 and KiO grades is intriguing. Optical microscopic analysis indicates that in nepheline syenite (NatKAI$_4$SijOir.) potassium ions are not in the form of individual microcline or orthoclase but rather imbedded in the nepheline syenite matrix. This perthitic texture identified as potash rich feldspar containing intergrown plagioclase is probably crystallized as a product of exsolution. In other words, because potassium ions are largely part of nepheline structure, it is not possible to induce a selective separation between Na and K at natural pH of 7.7. It is believed that it might be possible to obtain a better separation in HF medium.

Table 4 Effect of NaCI on Flotation Recovery

NaCl conc (M)	Products	Weight (%)	K_2O (%)	Na_2O (%)	Rec. (%)
5.10-	Cone.	42.9	7.81	-	43.4
	Tailing	57.1	7.61.	-	56.6
	Feed	100.0	7.70	-	100
1.10'''	Cone.	80.0	7.95	5.47	82.4
	Tailing	20.0	7.27	5.36	17.6
	Feed	100.0	7.81	5.41	100
2.10^1	Cone.	81.5	7.83	4.48	82.6
	Tailing	18.5	6.62	4.52	17.4
	Feed	100.0	7.59	5.41	100
S.1O'	Cone.	50.8	7.88	-	51.8
	Tailing	49.2	7.75	-	48.2
	Feed	100.0	7.82	-	100
1	Cone.	13.6	7.78	4.52	13.7
	Tailing	86.4	8.39	4.91	86.3
	Feed	100.0	8.30	5.41	100

Table 5 Effect of KCl on Flotation Recovery

NaCI cone (M)	Products	Weight (%)	K_20 (ft)	Na_30 <%)	Ree. (%)
S.10^{-2}	Cone.	86.1	*1.14*	-	86.4
	Tailing	13.9	7.19	-	1.36
	Feed	100.0	7.66	-	100
U O^1	Cone.	86.8	7.90	-	88.8
	Tailing	13.2	7.30	-	11.2
	Feed	100.0	7.82	5.41	100
2.İCT	Cone.	80.0	7.87	4.89	81.5
	Tailing	20.0	7.15	-	18.5
	Feed	100.0	7.37	5.41	100
5.10"	Cone.	62.9	7.72	-	62.9
	Tailing	37.1	7.54	-	37 1
	Feed	100.0	7.65	5.41	100
1	Cone.	45.2	7.76	4.92	45.4
	Tailing	54.8	7.45	5.14	54.6
	Feed	100.0	7.59	5.41	100



Fıgııre 4 Combined Test Results on the effect ol inorganic electiolytes

4 CONCLUSIONS

Selective flotation of albite and microcline in a synthetic mixture with amine (G-TAP) at natural pH is achieved in the solutions of NaCI and KCl salts

Benefiuation of a nepheline syenite ore using magnetic sepaiation followed by flotation lesulted in a majoi unpiovement in the total alkali content with a significant ıemoval of coloied impurities The remaikable effect of slime coating on flotation tecovenes demonstrates the crucial eltecl of desliming

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REFERENCES

Buıgeı I I990 Feldspai and nephclme syenite at the meicy ol glass maikets *tntliisliial mmaals* 2! 26

Çelik MS Fren RH Uztek G Gürcuoglıı Doğan M Z 1999 Benefiuation ot Nepheline Syenite by Magnetic Sepaıalıon and Flotation Techniques *Pioiiitlintfs ol VIII Balkım Mııcıal Pıoı ıssııii, Conltiinii* Heiceg Novi Sepl l4 IX

Deınıı C Abiamov A A And Çelik MS 2001 Flotation sepaiation of na teldspai tiom k-leldspai by monovalent salts *Minimis enziminin,* 14 7"?^ 740

Kendall T 1991 Feldspai and nepheline syenite the alumina pıovıdeıs *IM Glass anil Ciiamits Sums* 17 19

Potteı M I 1994 Feldspai and Nepheline Syenite *US Geiihtiiial Stu\i\ Mini nils Yearbook* 26 126 7

Yılmaz I I I 2001 Recoverv ol Na-K I eldspar in Nepheline Syenite *Gıtuluattım lhı\ı\ Mumu; Itıult\ Istanbul* Tti/i/muf *Uimn\/* Istanbul Tuikey