Ain Barbar Feldspar Magnetic Beneficiation

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Summary

Though Algeria has many mineral resources which have been already developed, there are other resources that have to be valued such as feldspar. This paper deals with potassium feldspar from Ain Barbar deposit. The demand for feldspar as a raw material for the ceramic industry is continuously increasing, which implies an increase in the imports of this material. It became therefore imperative to develop the deposit in question. The ore contains essentially quartz, potassium oxide and iron with respective grades: 74.97% SiO_2, 10.43% K_2O and 0.60% $Fe2O_3$. This latter is one of the principal impurities which will impart color and in turn degrade the quality of the ore.
The objective of this work is to reduce the iron found in oxide form. For this purpose, we used High Gradient Magnetic Separation (HGMS), firstly by the dry process. This operation has allowed to reduce the iron content, from 0.60 to 0.40% Fe_2O_3, which is acceptable only for stoneware tiles paste of type "porcellenato".
To further reduce this iron oxide content, a wet HGMS has been realized on a finer grain size (-40+20µm) and allowed to obtain a product with 0.19% Fe_2O_3, which can be used in the sanitary ceramics industry.

Keywords: feldspar, iron oxide, High Gradient Magnetic Separation, ceramics

Introduction

Algeria has many mineral deposits among which Ain Barbar feldspar one [7].The demand for feldspar[6] as a raw material for the ceramic industry will be continuously increasing, which implies an increase in the imports of this material [1]. It became therefore imperative to develop the local deposit which ore contains essentially quartz, potassium oxide and iron. This latter is one of the principal impurities which will impart color and in turn degrade the quality of the ore [4].

The objective of this work is to reduce the iron found in oxide form and which is a harmful element during the feldspar use in the ceramics industry.

For this purpose, dry and wet high gradient magnetic separation (HGMS) processes were realized and led to a product with 0.19% Fe_2O_3, answering the requirements of the mentioned industry [5].

Geology of the deposit

The feldspar deposit of Ain Barbar is located in north-eastern Algeria, 40km from the coastal city of Annaba. It occurs in the form of East-West oriented dykes, with a length of about 200m and a variable thickness from 10 to 40m with a 50% average dip. Its reserves are about 7Mt [7] [8].

Sample preparation

The sample on which the experiments have been carried out, was prepared by the enterprise: it consisted of digging a trench 20m long, 2m wide and 1m deep. The taken sample was subject to a mechanical preparation in the laboratory: 3 stages crushing to a particle size less than 4mm. The ore has then undergone a quartering to form several samples to be used for the physical and chemical characterization [7].

Mineralogical and chemical composition

The mineralogical composition is homogeneous and the prevailing minerals are potassium feldspar (51-53%) and quartz (39-40%). The potassium oxide (K_2O) content is high and homogeneous (8-10.5%) and the sodium oxide (Na_2O) one is unimportant (K_2O/ Na_2O = 27-41). Generally, the Fe content does not exceed 1%, the variation rate being about 40% [7].

The representative sample was ground to a particle size less than 74µm. It has been analyzed By XRF and

Tab. 1 Mineralogical and chemical composition of Ain Barbar feldspar

Tab. 1 Mineralogiczny i chemiczny skład skalenia z Ain Barbar

Product	Content, %	Product	Content, %
SiO_2	74.97	CaO	0.34
Al_2O_3	13.12	MgO	0.20
Fe_2O_3	0.60	Na_2O	0.30
TiO_2	0.06	K_2O	10.43
		LOI	0.40

wet chemical methods, including determinations of Fe_2O_3, MgO and CaO by atomic absorption spectrometry. The mineralogical and chemical composition is indicated in Table 1 [3].

We notice that the iron oxide content is high (0.60%), while generally, it must be less than 0.1%; the silica content is also high (≈ 75%); this proves that there is presence of free silica. Indeed, it's a potassium feldspar with a K_2O content of 10.43%.

The objective is to reduce the Fe_2O_3 content to a content required by the different user industries. Therefore, an iron removal was performed, in a first step, by a magnetic separation dry process.

As mentioned on the Table 2, the results of the granulochemical analysis allow to note that the iron is uniformly distributed in the different size fractions and therefore, it was found useful to perform, firstly, a High Gradient Magnetic Separation of the – 4 + 0.2mm granular fraction, which allows the elimination of the paramagnetic particles.

Dry magnetic processing experiments of the feldspar

In order to study the behaviour of the particles in the size fraction - 4 + 0.2mm, the material has been classified as follow : - 4 + 2mm ; - 2 + 1 mm and - 1 + 0.2mm. The classification was carried out using a screen plate provided with square mesh. Each of the three fractions has undergone a dry High Gradient Magnetic Separation process.

Tab. 2 Results of the granulochemical analysis

Tab. 2 Wyniki analizy granulochemicznej

Size fraction (mm)	Weight Yield (%)	Content of components (%)				
		SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O
+0.63	19.50	75.37	12.35	0.50	10.45	0.20
-0.63+0.50	7.00	75.35	12.16	0.48	10.50	0.31
-0.50+0.315	14.60	75.50	12.40	0.49	10.79	0.35
-0.315+0.20	9.50	75.27	12.02	0.57	11.02	0.30
-0.20+0.008	14.40	75.90	12.00	0.60	10.70	0.27
-0.08	35.00	74.24	12.50	0.75	10.30	0.20

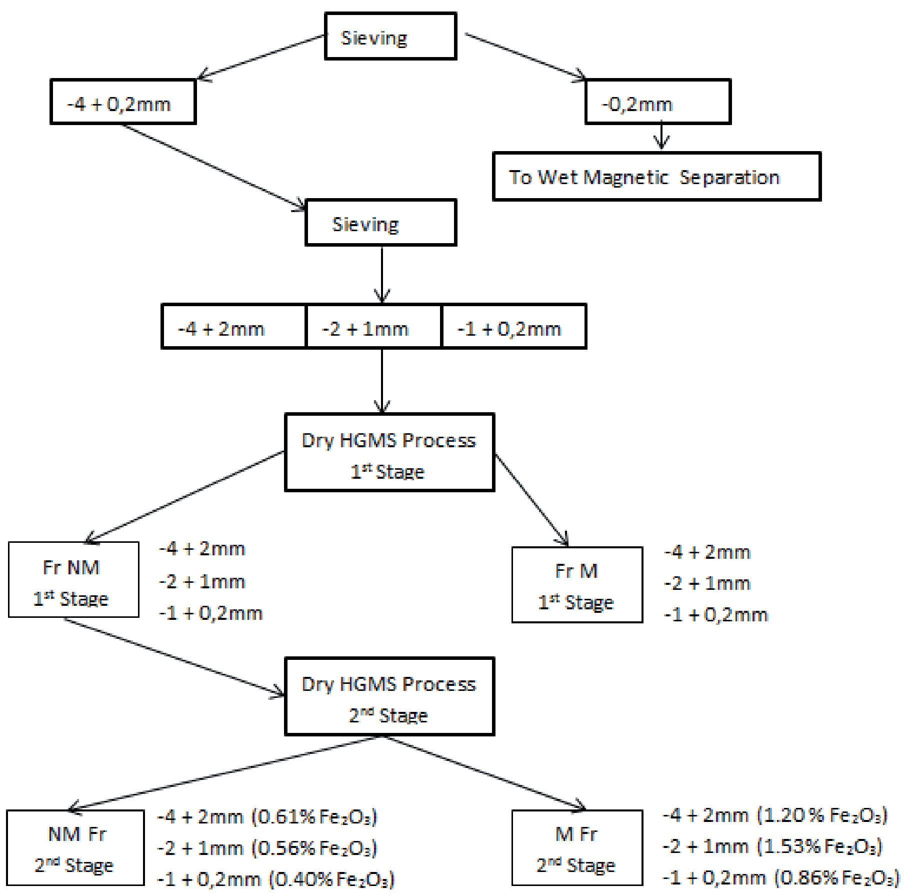

Fig. 1 Dry High Gradient Magnetic Separation processing diagram for the fraction -4+0.2mm

Rys. 1 Proces suchej wysokogradientowej separacji magnetycznej frakcji -4+0.2mm

The used equipment is a Carpco drum separator. The developed field by the separator is about 2 Tesla. The feeding of the particles is made via an adjustable vibrating feeder, allowing a monolayer constant flow.

The separation of the magnetic (M) and non magnetic (NM) products is made by using a position adjustment of the flap defining the separation zones of the magnetic and non magnetic particles.

Magnetic separation was performed in two steps for each particle size.

After the magnetic fraction removal during the first stage, the non magnetic fraction has undergone a second treatment under the same conditions (cf. Figure 1) [5]. The results obtained results are shown in Table 3.

The dry High Gradient Magnetic Separation process allows to reduce the iron content from 0.60% to 0.40% (i.e. 34.4%) in the finest particle sizes. Nevertheless, the 0.40% content is still high for the utilization in the sanitary ceramics, but acceptable for that of stoneware tiles paste of type "porcellenato".

For getting a product which can be used in other fields (ceramics, porcelain, sanitary ceramics), it would be well to carry on the processing by using the wet High Gradient Magnetic Separation on a product with much finer particle sizes.

Wet magnetic processing experiments

For the valorization of the fraction less than 200µm, a wet High Gradient Magnetic Separation has been performed. This fraction has undergone a separation in three classes (- 200+40µm, - 40+20µm and -20µm) by square mesh sieves. The results obtained were the following in Table 4.

In order to reduce the Fe_2O_3 content, a dry HGMS has been realized on the fraction - 200 + 40µm, as the available laboratory wet magnetic separators do not allow the purification to such a particle size.

As for the two others size fractions (- 40+20µm and -20µm), the wet HGMS was used.

Dry High Gradient Magnetic Separation of the fraction – 200 + 40µm

The used equipments for the realization of this experiment are the same that those used during the dry magnetic separation process of the different particle size fractions – 4 + 0.2mm. The operating conditions (field intensity, feeding flow, ...) are identical. The processing diagram is illustrated on Figure 2.

Given the obtained results indicated on the table 5, we can say that the dry magnetic separation helped to reduce, for this size, the Fe_2O_3 content from 0.57 to 0.23%, where 60.78% of the iron were removed.

Comparing the magnetic separation results of the grainy class (-4+0.2mm) to those of the fine one (-200+40 µm), we note that the quality of the finished product is proving better. Nevertheless, the Fe_2O_3 content (0.23% for this class) remains still high for an use in the sanitary ceramics and porcelain.

Wet High Gradient Magnetic Separation of the fraction – 40 + 20µm

For the diminution of Fe_2O_3 content in this fraction, a wet magnetic separation has been performed, using high gradient Johns separators. This separation, carried out in two stages, has given the results mentioned in Table 6.

The wet magnetic separation helped to reduce the oxide iron content to a value of 0.19% from a 0.58% Fe_2O_3 product, i.e. 78.54% of the oxide iron have been eliminated. This answers the requirements of the sanitary ceramics.

Wet High Gradient Magnetic Separation of the fraction – 20µm

This separation has was done with the same equipments that those used in the precedent class (40+20µm), in

Tab. 3 Dry Magnetic separation process results of the particle size – 4 + 0.2 mm

Tab. 3 Proces suchej separacji magnetycznej dla ziaren o wielkości -4+0.2mm

Particle size range and nature of the product		Weight yield %	Grades of the components, %									
			SiO_2		Al_2O_3		Fe_2O_3		K_2O		Na_2O	
			G	Rec	G	Rec	G	Rec	G	Rec	G	Rec
-4+2mm	M1	0.65	72.65	1.70	12.60	1.73	3.15	8.37	9.50	1.62	0.30	1.33
-4+2mm	M2	0.42	75.45	1.12	12.80	1.14	1.20	2.07	10.10	1.12	0.29	0.83
-4+2mm	NM2	35.90	75.30	97.18	12.80	97.13	0.61	89.56	10.30	97.26	0.40	97.84
Range – 4 + 2		36.97	75.24	100.00	12.80	100.00	0.66	100.00	10.28	100.00	0.40	100.00
-2+1mm	M1	0.62	70.25	2.26	12.62	2.41	4.70	16.82	9.10	2.12	0.29	2.19
-2+1mm	M2	0.38	74.30	1.46	12.70	1.48	1.53	3.36	9.80	1.40	0.30	1.39
-2+1mm	NM2	24.70	75.25	96.28	12.65	96.11	0.56	79.82	10.40	96.48	0.32	96.42
Range – 2 + 1		25.70	75.12	100.00	12.65	100.00	0.67	100.00	10.36	100.00	0.32	100.00
-1+0.2mm	M1	1.41	69.85	5.15	12.75	5.68	4.57	39.60	8.60	4.69	0.28	5.57
-1+0.2mm	M2	0.68	75.60	2.68	12.60	2.71	0.86	3.30	9.60	2.52	0.29	2.78
-1+0.2mm	NM2	23.20	76.01	92.17	12.50	91.61	0.40	57.10	10.35	92.79	0.28	91.65
Range – 1 + 0.2		25.29	75.66	100.00	12.52	100.00	0.64	100.00	10.23	100.00	0.28	100.00
• - 0.2 mm		12.04	74.90	100.00	12.66	100.00	0.94	100.00	9.75	100.00	0.30	100.00
Feed		100.00	75.25	100.00	11.15	100.00	0.69	100.00	10.23	100.00	0.33	100.00

Tab. 4 Particle size distribution of the fraction – 200 µm
Tab. 4 Rozkład wielkości ziaren dla frakcji – 200 µm

Particle size class, µm	% Weight yield	% Weight relative to mine ore
• - 200 + 40	60.45	7.28
• - 40 + 20	18.65	2.24
- 20	20.90	2.52
Total	100.00	12.04

Tab. 5 Dry Magnetic Separation process results of the particle size –200+40µm
Tab. 5 Proces suchej separacji magnetycznej dla ziaren o wielkości –200+40µm

Product	Weight Yield (%)	Grades of the components (%)									
		SiO_2		Al_2O_3		Fe_2O_3		K_2O		Na_2O	
		G	Rec	G	Rec	G	Rec	G	Rec	G	Rec
FM1+FM2+FM3	2.50	65.00	2.10	11.30	2.44	13.90	60.78	7.30	1.99	0.24	2.50
FNM3	97.50	77.80	97.90	11.60	97.56	0.23	39.22	9.20	98.00	0.24	97.50
Feed	100.00	77.48	100.0	11.59	100.0	0.57	100.0	9.15	100.0	0.24	100.0

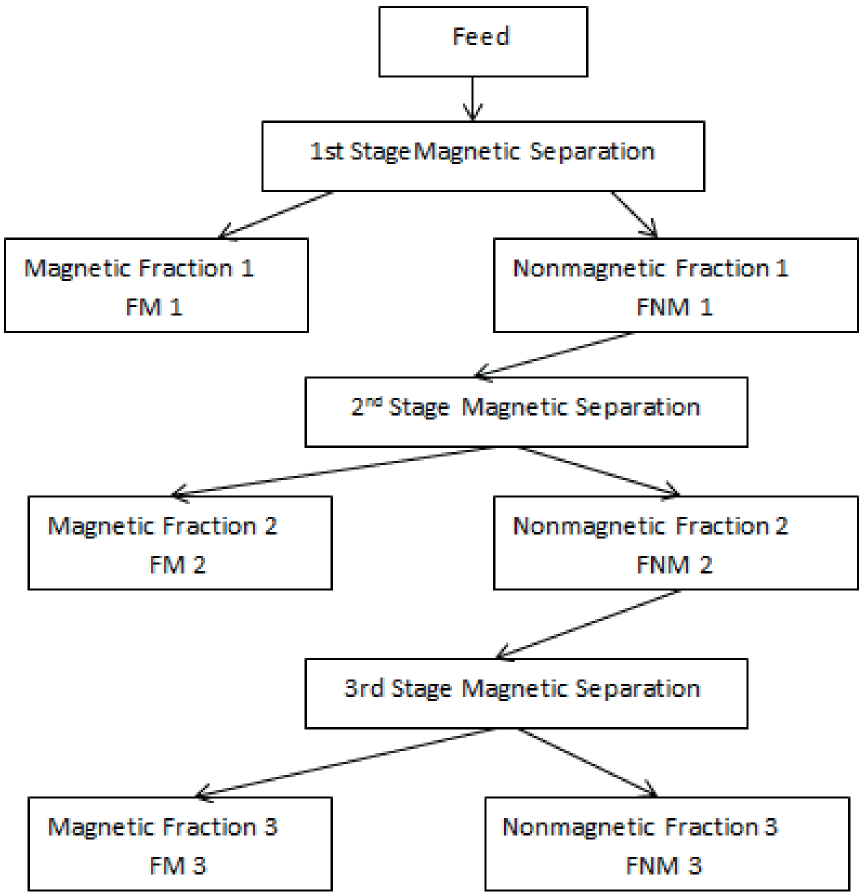

Fig. 2 Dry High Gradient Magnetic Separation processing diagram for the fraction -200+40µm
Rys. 2 Proces suchej wysokogradientowej separacji magnetycznej we frakcji -200+40µm

Tab. 6 Wet Magnetic Separation process results of the particle size –40+20µm

Tab. 6 Proces mokrej separacji magnetycznej dla ziaren o wielkości –40+20µm

Product	Weight Yield (%)	Grades of the components (%)									
		SiO_2		Al_2O_3		Fe_2O_3		K_2O		Na_2O	
		G	Rec	G	Rec	G	Rec	G	Rec	G	Rec
FM1+FM2	34.00	78.00	35.19	11.20	28.46	1.35	78.54	9.10	30.87	0.17	20.01
FNM2	66.00	74.00	64.81	14.50	71.54	**0.19**	21.46	10.50	69.13	0.35	79.99
Feed	100.00	75.36	100.00	13.38	100.00	0.58	100.00	10.02	100.00	0.29	100.00

Tab. 7 Wet Magnetic separation process results of the particle size –20 µm

Tab. 7 Proces mokrej separacji magnetycznej dla ziaren o wielkości –20 µm

Product	Weight Yield (%)	Grades of the components (%)									
		SiO_2		Al_2O_3		Fe_2O_3		K_2O		Na_2O	
		G	Rec	G	Rec	G	Rec	G	Rec	G	Rec
FM1+FM2(w)	43.00	67.70	42.46	15.00	41.27	2.50	61.11	10.90	40.66	0.30	43.00
FNM2(w)	57.00	69.20	57.54	16.10	58.73	1.20	38.89	12.00	59.34	0.30	57.00
Feed(w)	100.00	68.56	100.0	15.63	100.0	1.76	100.0	11.53	100.0	0.30	100.0

this case the Johns separator, by using a lower size air gap. The procedure is identical. The Table 7 shows the results obtained.

Conclusion on wet magnetic separation

The results reported on the table above-mentioned and obtained following the wet HGMS of the fraction – 20µm, show that the iron oxide content couldn't be reduced to the content required by the sanitary ceramics industry and porcelain.

Though 60% of the iron in the form of oxide were removed, the iron content in the nonmagnetic product remains still high. This explains itself by the low efficiency of this range of separators for the iron hydroxides which present a low magnetic susceptibility.

Nevertheless, a new generation of separators equipped with a supraconducting solenoid, could improve the quality of the finished product from the iron content point of view.

Conclusion

The dry and wet HGMS used for the potassium feldspar purification of the Ain Barbar deposit helped, for the grainy fractions, to remove a part of the iron that is present in form of hydroxide.

The iron content obtained in the end products remains somehow high for the use in the sanitary ceramics industry, a large consumer of feldspar.

In order to improve the quality of the end product and make it usable in various industries, it is necessary to consider a flotation processing, after fine grinding of the crude product.

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Magnetyczne wzbogacanie skalenia z AinBarbar

Chociaż Algieria posiada wiele zasobów mineralnych, które są rozwijane, istnieją inne zasoby, które muszą zostać ocenione takie jak skaleń. Artykuł ten zajmuje się skaleniem potasowym ze złoża AinBarbar. Zapotrzebowanie na skaleń jako surowiec w przemyśle ceramicznym nieprzerwanie rośnie, co skutkuje wzrostem importu tego materiału. Stało się więc koniecznym aby rozwinąć wspomniane złoże. Ruda ta zawiera zasadniczo kwarc, tlenek potasu i żelaza w następującym stopniu: 74,97% SiO_2, 10,43% K_2O i 0,60% Fe_2O_3. Ostatni z nich jest głównym zanieczyszczeniem, które wpływa na kolor oraz zmniejsza jakość rudy.

Celem tej pracy jest redukcja żelaza, które znajduje się w formie tlenku. W tym celu użyto wysoko-gradientowej separacji magnetycznej (HGMS), najpierw w procesie suchym. Operacja ta pozwoliła na zmniejszenie zawartości żelaza, z 0,60 do 0,40% Fe_2O_3, co mogło zostać zaakceptowane jedynie dla wyrobów kamionkowych typu porcellenato.

Aby dodatkowo zmniejszyć zawartość tlenku żelaza, mokra metoda HGMS została zrealizowana na próbkach o mniejszej wielkości ziarna (-40+20μm) co pozwoliło uzyskać produkt z 0,19% Fe_2O_3, który może zostać użyty w przemyśle ceramiki sanitarnej.

Słowa kluczowe: skaleń, tlenek żelaza, wysokogradientowa separacja magnetyczna, ceramika