

INVESTIGATION ON THE EFFECT OF COLLECTOR, ACTIVATOR AND DEPRESSANT ON THE SELECTIVE FLOTATION OF PYROCHLORE AND BARITE

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ABSTRACT

The flotation of pyrochlore is carried out in the Araxá plant using amine as collector at low pH, in the presence of fluosilicic acid or sodium fluosilicate as an activator and with the addition of a depressant. In the present work, electrophoretic and contact angle measurements for pyrochlore and barite were performed to investigate the joint effect of depressant, activator and collector.

The electrophoretic measurements showed that barite has an isoelectric point at pH=4.2 and that of pyrochlore is at pH=3.0. These results indicate that positive collector ions could not adsorb on the pyrochlore surface by electrostatic forces at pH=3.0. In fact, contact angle investigation showed that the hydrophilic character of the pyrochlore surface was not altered by the addition of the collector alone. By contrast, barite presented a contact angle of around 70° for collector concentrations higher than 50ppm. The addition of the activator (NaF) in the presence of amine collector promoted an increase in the pyrochlore contact angle to around 30° and the high floatability of barite is unchanged. The combined effect of depressant, activator and collector at controlled concentrations provide the selective flotation conditions for pyrochlore recovery.

Infrared spectra of three etoxilated fatty acids that have been used as depressants (Genagem, MC 553 and Canasol 1640) showed great similarity. The Genagem depressant at a concentration higher than 100ppm was shown to depress barite efficiently.

Keywords: Pyrochlore flotation; barite depression; niobium minerals

INTRODUCTION

The niobium mineral deposits located in Araxá, Brazil, present a very complex mineralogical composition and as far as the flotation process is concerned some interesting aspects are encountered. The main niobium mineral is a barium-pyrochlore, which represents about 4.0% by weight, whereas the barite content is around 20%, the other main minerals present being magnetite, goethite, limonite, monazite and quartz. The mineralogical composition of the ore is presented in Table I

Table I- Mineralogical composition of Araxá ore, MG

MINERAL	WEIGHT, %
Barium-pyrochlore (Ba) ₂ (Nb,Ta) ₂ (O,OH,F) ₇	4.6
Limonite, Goethite (FeO.OH)	35.0
Barite(BaSO ₄)	20.0
Magnetite(Fe ₃ O ₄)	16.0
Others (Monazite, Ilmenite, Quartz, etc.)	19.4

Typical chemical analysis of the Araxá ore and of the pyrochlore found in this deposit are presented in Table II.

In the selective flotation process industrially used for niobium mineral concentration, the final concentrate yields about 60% Nb₂O₅ by weight (De Fuccio, 1982). The flotation reagents used at the CBMM plant in Araxá at the beginning of this investigation were: (a) Collector - Acetadamine (Hoechst or Quimikao) - 120g/t; (b) Depressant - Canasol 1640 (Canamex) or MC553 (Henkel) - 300g/t; (c) Activator - fluosilicic acid or sodium fluosilicate - 2000g/t.

Table II: Chemical composition of the Araxá ore and of the pyrochlore mineral (De Fuccio, 1982)

COMPOSITION	ORE (WEIGHT, %)	PYROCHLORE (WEIGHT, %)
Nb ₂ O ₅	3.0	63.42
BaO	17.73	16.51
ThO ₂	0.13	2.34
TiO ₂	3.60	2.30

In a recently published work (Oliveira et al., 2000) a bench scale flotation kinetic testwork was conducted on some aspects of the process used. A rate model based on equations for fast floating and slow floating particles was used for describing the cumulative recovery versus time (Su et al., 1998; Klimpel, 1980; Ek, 1991). The results showed that the control of collector (amine acetate) at a minimum level was essential for an effective action of the activator and modifiers. In the rougher stage, best results were obtained with the collector at 100g/t. The use of NaF at a dosage higher than 1000g/t significantly affected the cleaner concentrate grade.

The present work aims at a better understanding of the influence of flotation reagents on the pyrochlore flotation. Electrophoretic and contact angle measurements of pyrochlore and barite were used to elucidate the isolated effect of depressants, activator and collector from a more fundamental approach.

EXPERIMENTAL

Electrophoretic mobilities of the pyrochlore and barite minerals were determined using KNO₃ as supporting electrolyte and HCl and KOH as pH regulators. A Rank Brothers Mark II equipment was used with a flat cell.

The pyrochlore and barite used in these studies were provided by CBMM. Commercial reagents, depressant Genagem SO 205 E and Hoechst collector 075/94, were used as received, without further purification. Sodium fluoride P.A. (Vetec) was used as activator. The hydrophobicity was evaluated by contact angle measurements in a Ramé-Hart model 100 goniometer, with computer interface and image analysis system. For experiments aimed at investigating the influence of the depressant or activator, the mineral was, initially, immersed in the depressant or activator

solution with the pH previously adjusted and the contact angle recorded. Subsequently, the mineral was contacted with a mixed solution of depressant, activator and collector for a new evaluation of the contact angle.

RESULTS AND DISCUSSION

The electrophoretic mobility of pyrochlore and barite as a function of pH in the presence of 1×10^{-3} M KNO₃ is presented in Figure 1. It can be seen that the isoelectric point of barite is at pH=4.2 and that of pyrochlore is at pH=3.0. These results indicate that at pH=3.0, the pyrochlore surface is neutral, hence positive collector ions are not electrostatically attracted to the mineral surface. This has been observed to be the case, as shown in Figure 2, which presents the influence of the collector addition. Pyrochlore presented a contact angle close to 0° for all collector concentrations investigated indicating that its hydrophilic character is not altered by the collector alone. On the other hand, barite presented a contact angle around 70° for collector concentrations higher than 50ppm. In spite of presenting a positive surface charge at pH=3.0, the adsorption of the amine collector occurs due to other specific interactions.

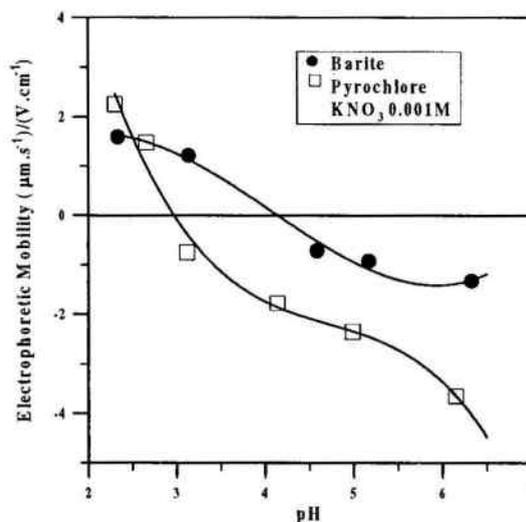


Figure 1 - Electrophoretic mobility of barite (●) and pyrochlore (□) as a function of pH, with KNO₃ as supporting electrolyte.

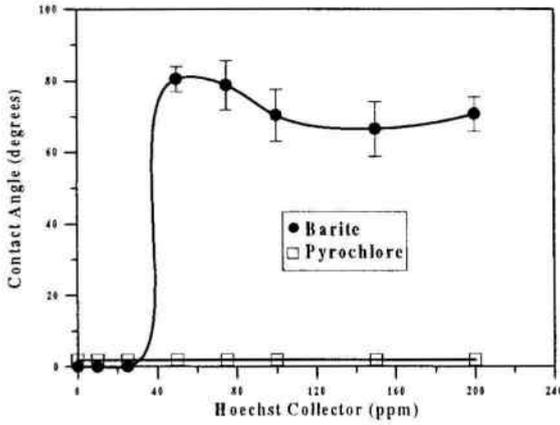
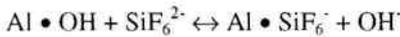


Figure 2 - Pyrochlore and barite contact angles as a function of Hoechst 075/94 collector at pH=3.0.

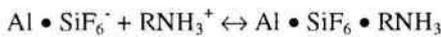
Amine collectors are commonly employed in the selective flotation of pyrochlore mineral. Hydroxamic acids have also been investigated by Bogdanov et al.,1973, in the flotation of pyrochlore associated with ferruginous feldspar and biotite.

In order to enhance the amine collector efficiency, it is necessary the previous addition of an activator. Several mechanisms responsible for the activation of minerals using fluoride ions are reported in the literature. Fuerstenau et al., 1985, interpreted the action of fluoride ions in the activation of microcline as a result of the adsorption of these ions on aluminium sites, according to the following steps:

1. HF reacts with surface silicic acid to form SiF_6^{2-} ;
2. Adsorption of fluosilicate ion on aluminium sites:



3. Adsorption of amine ions on aluminium-fluosilicate sites:



In the activation of pyrochlore by HF, the mechanism probably involves the removal of hydroxyl ions from the pyrochlore surface by ion exchange with fluoride ions and subsequent adsorption of the amine collector. Another possible mechanism would involve fluoride ions adsorption on Nb^{5+} surface sites, modifying the surface charge of the mineral, favoring the subsequent adsorption of amine ions. However, this aspect has not been investigated in the present work.

The combined influence of collector and NaF in the pyrochlore and barite hydrophobicity is shown in

Figure 3. It can be seen that, in the presence of the activator (200ppm), the pyrochlore contact angle was raised to around 30°. No significant effect was observed for barite contact angle in the presence of NaF, apart from a slight reduction to an average value of 60°.

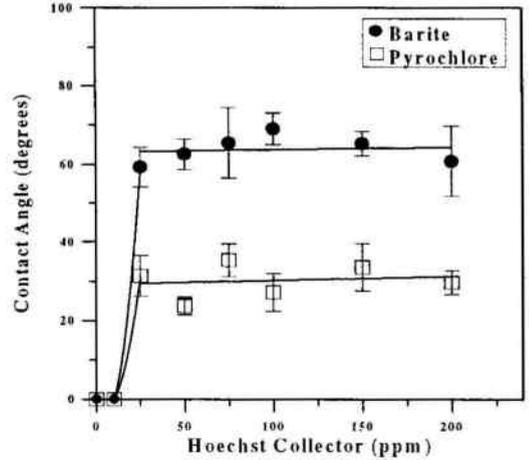


Figure 3 - Pyrochlore and barite contact angles as a function of Hoechst 075/94 collector in the presence of 200ppm NaF (activator) at pH = 3.0.

Figure 4 shows the pyrochlore and barite contact angle as a function of the barite depressant (Genagem SO205E) in the presence of NaF and at a collector concentration of 25ppm. It can be observed that the combined effect of depressant, activator and collector at controlled concentrations provides the selective flotation procedure. The depressant Genagem needs to be maintained at concentrations higher than 100ppm to depress barite completely.

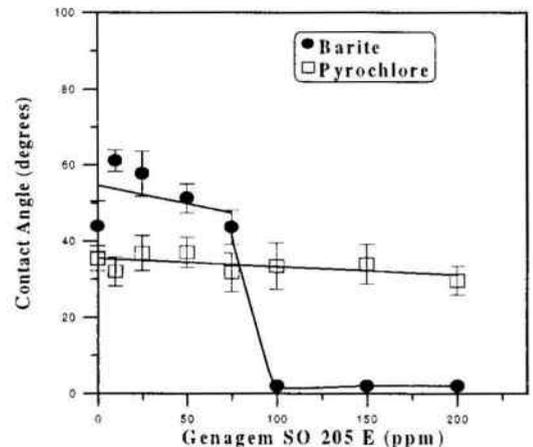


Figure 4 - Pyrochlore and barite contact angles as a function of Genagem concentration in the presence of

200ppm NaF and 25ppm of 075/94 Hoechst collector at pH=3.0.

Although the results presented so far were obtained using Genagem depressant, two similar ethoxilated fatty acid products (MC553 and Canasol tall 1640) have been employed interchangeably by the Araxa plant management. The infrared spectra of the three reagents is presented in Figure 5 and show a very striking similarity. Perhaps the only aspect that should be taken into consideration is the aliphatic C-H/C=O peak ratio presented in Table III. However, the effect of changing the depressant is quite remarkable. Figure 6 shows their influence on the Nb₂O₅ grade in the cleaner concentrate based on a bench scale flotation testwork, whose results have been published recently (Oliveira et al., 2000)

Table III – C-H/C=O ratio for infrared spectra for the depressants studied

DEPRESSANTS	C-H/C=O RATIO
Genagem	2.55
MC553	3.62
Canasol 1640	1.73

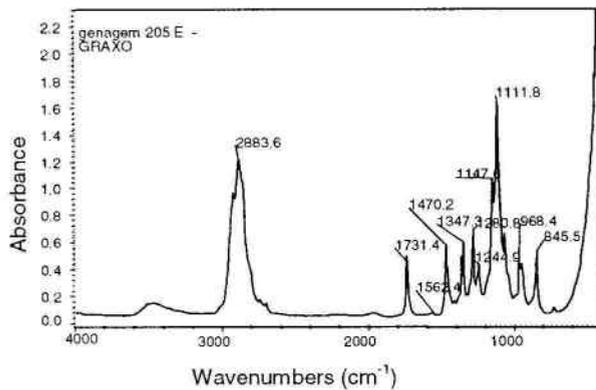
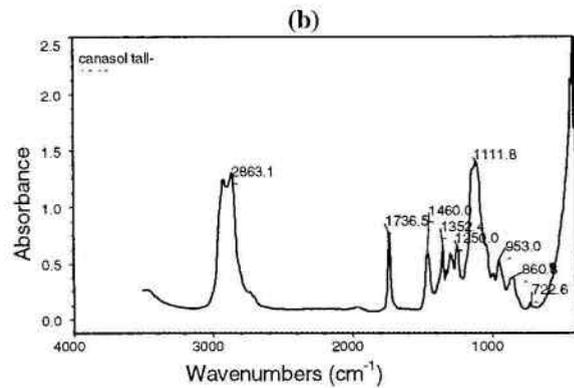
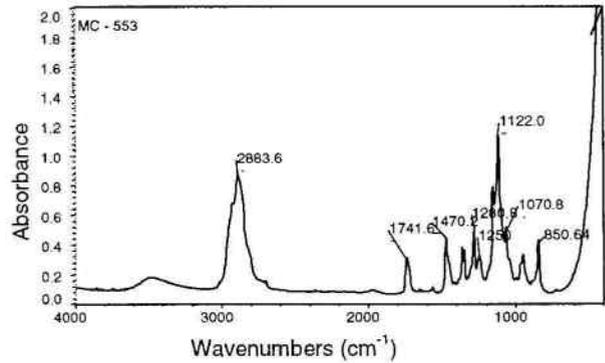


Fig. 5 – Infrared spectra of three etoxilated fatty acids: (a) Genagem (Hoechst), (b) MC553 (Henkel), (c) Canasol tall 1640 (Canamex).

(a)

(b)

(c)

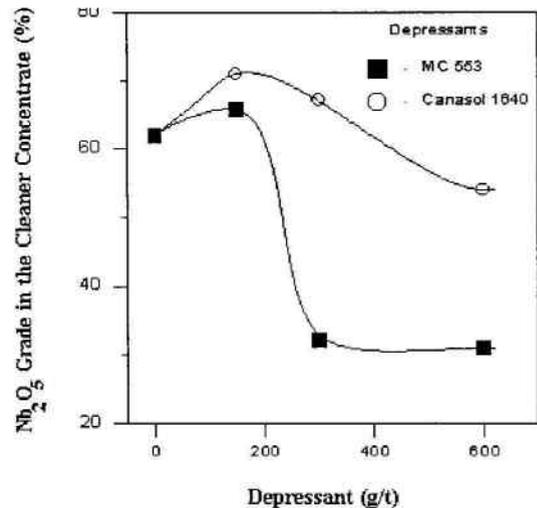


Figure 6 - Nb₂O₅ grade in the cleaner concentrate as a function of the depressant dosage (MC553 and Canasol 1640), using Acetadamin (120g/t) and NaF (2000g/t) at pH=3.0 (Oliveira et al., 2000).

CONCLUSIONS

Contact angle and electrophoretic measurements on barite and pyrochlore have shed some light on the isolated effect of depressants, activator and collector used in the pyrochlore flotation process. Electrophoretic and contact angle measurements have shown that the addition of the collector alone would not be sufficient to float pyrochlore in the absence of the activator selectively. An adequate combination of activator and depressant is crucial for the success of the process

Although the three depressants studied presented similar infrared spectra their effect on the recovery was significantly different, and this aspect should be taken into consideration in plant operation.

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