

# FUNDAMENTAL STUDIES ON PYRITE, PYRRHOTITE AND ARSENOPYRITE FLOATABILITY

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## *PİRİT, PİROTİT VE ARSENOPİRİT YÜZEBİLİRLİĞİ HAKKINDA TEMEL ÇALIŞMALAR*

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**Keywords :** Gold Flotation; Eh and pH in Flotation

### ÖZET

Geliştirilmiş Smith-Partridge hücresinde pirit, pirotit ve arsenopirit örnekleri üe mikro-flotasyon deneyleri yapılmıştır. PH'ın verim ve Eh üzerindeki etkisi araştırılmış, pH=7'de Eh'in verim ilişkisi değerlendirilmiştir. Arsenopirit ve pirit arasında seçimlilik sağlamak çok güçtür. Rrit ve diğer sülfürlü minerallerin ayrışma olasılıklarını belirlemek için daha fazla araştırma yapılması gereklidir.

### ABSTRACT

Microflotation tests were performed in a modified Smith- -Partridge cell with natural samples of pyrite, pyrrhotite and arsenopyrite. The effect of pH on recovery and rest potential was investigated and then the influence of the rest potential on recovery, at pH=7, was assesed. Selectivity between arsenopyrite and pyrrhotite is difficult, but the possibility of separation between pyrite and the other sulphides deserves further investigation.

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TÜRKİYE XML MADENCİLİK KONGRESİ, 1993

## 1. INTRODUCTION

Man has been searching for gold since remote eras. Gold may occur associated, at different proportions, with several sulphides. In this case the usual plant practice involves two basic steps: bulk sulphides flotation followed by hydrometallurgical gold extraction. In some instances there is a preferential association of gold with one or more sulphides and the selective previous elimination of part of the sulphides with lower gold content would represent significant costs reduction in the extraction stage.

Pyrite, pyrrhotite and arsenopyrite are sulphide minerals which bear iron in their structures and are collected in flotation plants by thio-compounds, for example: xanthates, dithiophosphates, mercaptans, mercaptobenzothiazole. Selective flotation among iron bearing minerals is always difficult to be achieved. The present flotation state-of-art indicates the control of pH and Eh as prospective methods in the search for selective flotation routes for these minerals.

It is worthwhile mentioning that pH control of sulphide flotation slurries is a conventional industrial practice, but Eh control, due to operation conditions limitations, is not common. The technical literature mentions the cases of the molibdenite circuit of the Andina concentrator, in Chile (ANONYMOUS, 1983), and of the Outokumpu plant in Finland (HEIMALA et alii, 1985).

## 2. MATERIALS AND METHODS

Arsenopyrite-FeAsS-, pyrite-FeS<sub>2</sub> and pyrrhotite-Fe<sub>1-x</sub>S samples, as pure as possible, were hand picked in the Iron Quadrangle (Minas Gerais, Brazil). These samples were ground in a rotating porcelain mill and screened to produce a fraction in the size range between -0.210 mm and 0.106 mm.

This product was then purified in a Frantz Isodynamic Separator. Samples were taken for X-rays diffraction and atomic absorption spectrometry. Quartz was the only impurity detected in two of the samples (arsenopyrite and pyrite ). Results of chemical analysis are shown in Table 1.

Table 1. Chemical analysis of the arsenopyrite, pyrite and

	ARSENOPYRITE %	PYRITE %	PYRRHOTITE %
Fe	36.40	40.98	60.47
S	28.18	45.60	36.45
As	32.30	1.48	0.71
Pb	1.54	0.01	0.01
Cu	0.03	< 0.01	0.02
Zn	0.01	0.02	0.03
Mn	< 0.01	< 0.01	0.01
sio <sub>2</sub>	1.50	6.36	0.22

Microflotation testwork was performed in a modified Smith-Partridge cell (Figure 1). This apparatus differs from the well-known modified Hallimond tube due to the mechanical agitation device. The ferromagnetic character of pyrrhotite is not compatible with the magnetic agitation of the Hallimond tube. The test parameters chosen were : solution volume - 570 ml; nitrogen flowrate - 100 ml/ min; flotation time - 1 min. A solution containing collector and Eh and pH modifiers was prepared in a beaker , conditioned for 2 minutes (magnetic agitation). After 10 minutes of rest, initial values of Eh and pH were registered. Ceased the gas flow, final Eh and pH values were registered after 10 minutes of rest. The platinum electrode was mechanically cleaned, washed and tested in a standard solution, according to procedure recommended by NATARAJAN and IWASAKI, 1973.

Oxidizing and reducing agents employed were potassium permanganate and sodium sulphide, respectively, and pH was

controlled via the addition of sodium hydroxide and hydrochloric acid. Commercial grade potassium amyl xanthate and a polyglycol ether were utilized as collector and frother. The mineral samples were stored under argon atmosphere to prevent oxidation.

### 3. RESULTS AND DISCUSSION

The results obtained may be summarized in three figures, with three curves each.

Figure 2 illustrates recovery as a function of pH for the three minerals. There is a trend for maximum floatability around the neutral pH range with a sharp drop when the pH changes to either acidic or alkaline conditions. Nevertheless pyrite retains its floatability level up to pH = 2.5, indicating a possibility of selectivity with respect to arsenopyrite and pyrrhotite.

Results of determinations of rest potential as a function of pH are presented in figure 3. The behaviour of the three minerals is very similar. Above pH = 4.5 the rest potential is independent of pH and stays at a value close to the reversible redox potential for the couple xanthate ion/dixanthogen.

MAJIMA and TAKEDA, 1968, investigating the electrochemical behaviour of pyrite, suggested that, when a mineral slurry is stirred in a solution containing xanthate, the system reaches the equilibrium at a rest potential which coincides with the redox potential of the xanthate ion/dixanthogen couple.

Plots of recovery as a function of the rest potential are shown in figure 4. The three curves present a plateau of constant recovery, with sharp drops when the conditions are changed towards either more oxidizing or more reducing

values. Once again pyrite displays a trend slightly different from that of arsenopyrite and pyrrhotite which retain a high floatability level above  $E_h = 300$  mv, point where the recovery of pyrite drops to near zero. A precipitate was visually observed on the pyrite surface above this limiting potential.

#### 4. CONCLUSIONS

Pyrite, pyrrhotite and arsenopyrite are very similar with respect to the response of rest potential to pH changes.

Despite the similarities of the floatability patterns of the three minerals as a function of either pH or  $E_h$ , pyrite presents two distinct features which deserve further investigation:

- i. at pH = 7, an anodic potential drift renders pyrite non floatable, at a point above which pyrrhotite and arsenopyrite still retain their floatability levels;
- ii. under acidic conditions pyrite retains its floatability below a limit where pyrrhotite and arsenopyrite are rendered hydrophilic.

#### 5. REFERENCES

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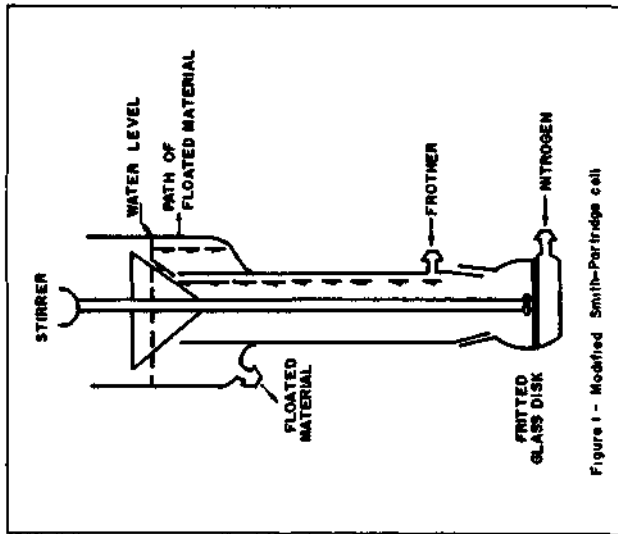


Figure 1 - Modified Smith-Partridge cell

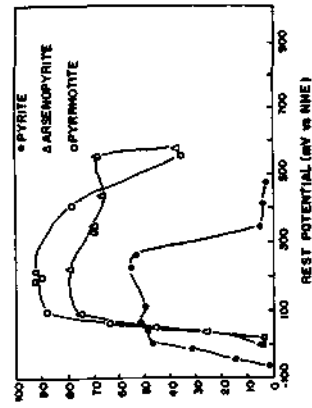


Figure 4 - Recovery as a function of rest potential for pyrite, arsenopyrite and pyrrhotite.

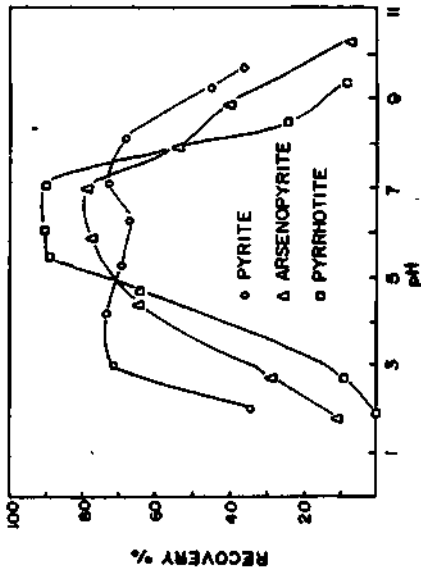


Figure 2 - Recovery as a function of pH for pyrite, arsenopyrite and pyrrhotite.

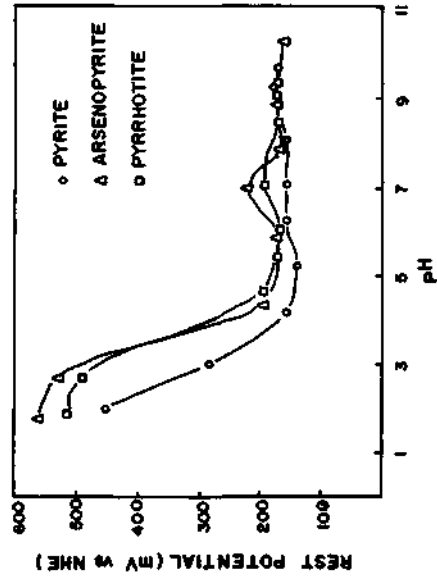


Figure 3 - Rest potential as a function of pH for pyrite, arsenopyrite and pyrrhotite.