THE USE OF PULP POTENTIAL CONTROL TO SEPARATE COPPER AND ARSENIC – AN OVERVIEW BASED ON SELECTED CASE STUDIES

L K Smith¹, K J Davey² and W J Bruckard³

ABSTRACT

Flotation work conducted by CSIRO on both single minerals and high-arsenic copper ores from a number of sources, has shown it is possible to produce separate low-arsenic copper concentrates and high-arsenic copper concentrates from high-arsenic copper ores. The procedure involves controlled separations at high or low pulp potential regions exploiting subtle differences in the flotation behavior of the arsenic-bearing and non-arsenic-bearing copper minerals.

An overview of several case studies investigating the applicability of the controlled potential flotation approach to the separation of copper and arsenic from sulfide copper ores is presented. It highlights the variables which influence the efficiency of the separation which include mineralogy, liberation and reagent selection. The procedure can produce a saleable low-arsenic copper concentrate, which can be directly smelted without penalty, and a high-arsenic low copper concentrate, which will require further processing.

Keywords: flotation, copper, arsenic, controlled-potential flotation

INTRODUCTION

Arsenic is a dangerous pollutant and, as such, is also a penalty element in many base metal concentrates destined for smelting to recover the valuable metals. It is, therefore, of economic and environmental interest to remove arsenic at the earliest possible point in the beneficiation process e.g. the flotation stage.

In copper deposits, arsenic is often present in the form of the copper-arsenic minerals, enargite (Cu₃AsS₄) and tennantite (Cu₁₂As₄S₁₃). Under normal circumstances, the flotation response of these minerals is generally similar to that of the common copper sulfide and copper-iron sulfide minerals using flotation conditions typical in most sulfide copper flotation circuits making arsenic rejection difficult. The most successful approaches to making a separation appear to be based on selective oxidation techniques (Fornasiero et al, 2001; Castro and Honores, 2000; Huch, 1993) or the exploitation of pulp potential effects (Menacho et al, 1993; Jaime and Cifuentes, 1995; Yen and Tajadod, 2000; Guo and Yen, 2005).

Over many years, CSIRO has conducted closely controlled batch flotation tests on mixtures of single minerals and quartz for most of the common sulfide minerals, including copper and arsenic-bearing minerals. This work found that it is possible to make a separation between copper-arsenic minerals and other copper minerals utilizing controlled pulp potential procedures. These procedures involve separations at high and low pulp potential regions.

References:
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exploiting subtle differences in the flotation response of arsenic-bearing and copper-bearing minerals at particular pulp potentials.

This paper details the background single mineral studies that form the basis of the separations and presents the results of several case studies on ores utilizing controlled pulp potential flotation. It highlights variables that influence the efficiency of the separation.

BACKGROUND SINGLE MINERAL STUDIES

CSIRO has investigated the effect of pulp potential on the flotation behavior of many sulfide minerals over a number of years (Heyes and Trahar, 1977, 1979; Guy and Trahar, 1984; Trahar, 1984; Senior et al, 2006). As a result, a significant database of information has been accumulated which has been used to identify flotation conditions where pulp potential and pH effects might be exploited to separate copper-arsenic minerals from other copper minerals.

Data in the database has been gathered from single mineral batch flotation tests on high-grade natural minerals using high grade quartz as the gangue (diluent). Batch flotation tests were chosen as the means of determining flotability. The minerals are prepared by wet grinding in a laboratory ball mill to produce a realistic feed size distribution. Quartz is used as the diluent mineral to ensure typical ore head grades and samples are floated at realistic pulp densities (i.e., the minerals are prepared and floated under conditions approximating plant practice but without the complication of liberation). The collector used in all these tests was potassium ethyl xanthate (KeX), added at concentrations that approximate plant practice.

Senior et al (2006) studied the effect of pulp potential on the flotation behavior of enargite, chalcocite and chalcopyrite, with the results presented in Figure 1. From this data it is possible to delineate areas of pulp potential where it should be possible to make a separation between the arsenic-bearing copper minerals and other copper minerals.

![Figure 1. Mineral recovery at 1 minute as a function of pulp potential for chalcopyrite at pH 8, enargite at pH 8 and 11 and chalcocite at pH 11](image)
The dependence of enargite flotation on pulp potential is largely independent of pH over the range tested. Between -100 mV and 0 mV SHE (standard hydrogen electrode scale) the mineral goes from being non-floatable to being strongly floatable. The threshold potential for the transition, defined as the potential at which recovery after 1 minute is 50%, is about -25 mV SHE. No upper limiting potential was found as far as it was tested (up to +400 mV SHE).

When the flotation response of enargite at pH 11 is compared with the flotation response of chalcocite at the same pH (refer Figure 1) two possible windows wherein separation of chalcocite and enargite should be possible are obvious. The first is a relatively narrow window between -150 mV and -25 mV SHE in which chalcocite floats ahead of enargite. The second is a region above +270 mV SHE where enargite floats but chalcocite does not.

A comparison of the flotation behavior of chalcopyrite at pH 8 with the flotation behavior of enargite at pH 8 (refer Figure 1) shows that there is a possible window of separation in the potential range -25 mV to +100 mV SHE where enargite floats ahead of chalcopyrite.

**CASE STUDIES ON COPPER ORES**

The data presented in the preceding section showed several possible pulp potential regions wherein it should be possible to separate the arsenic-bearing copper minerals from the other copper minerals by control of the pulp potential. In this section, we present several case studies on arsenic-bearing ore samples in which we seek to utilize differences in pulp potential to reject arsenic from the copper concentrates.

The approach taken in these studies was to produce a rougher-scavenger concentrate, using a standard laboratory procedure supplied by the client, and then to use pulp potential control during a subsequent flotation stage on this concentrate to make a copper-arsenic separation. In general, 500 g or 1000 g ore lots were wet ground in a mild steel laboratory mill to produce rougher feed of the required P \(_{80}\) (80% passing size). The exception was Ore C which was a copper-molybdenum concentrate produced in the client’s pilot plant. The flotation tests were conducted in Melbourne tap water.

**Ore A (Cu)**

**Ore sample**

Ore sample A was a composite of several drill core intersections from a high-arsenic section of a copper ore body. The head assays of the composite are given in Table 1.

<table>
<thead>
<tr>
<th>Head sample</th>
<th>Assay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As</td>
</tr>
<tr>
<td>Ore A (Cu)</td>
<td>0.11</td>
</tr>
<tr>
<td>Ore B (Cu-Pb-Zn)</td>
<td>0.061</td>
</tr>
<tr>
<td>Ore C (Cu Con)</td>
<td>0.34</td>
</tr>
<tr>
<td>Ore D</td>
<td>0.073</td>
</tr>
</tbody>
</table>

_Assay (%)_ indicates that the data presented in the preceding section showed several possible pulp potential regions wherein it should be possible to separate the arsenic-bearing copper minerals from the other copper minerals by control of the pulp potential. In this section, we present several case studies on arsenic-bearing ore samples in which we seek to utilize differences in pulp potential to reject arsenic from the copper concentrates.

_A rougher-scavenger concentrate, which contained over 94% of the copper and arsenic in the feed, was produced for mineralogical analysis. The major sulfides detected by x-ray diffraction (XRD) were bornite (Cu$_5$FeS$_4$), chalcopyrite (CuFeS$_2$) and tennantite (Cu$_{12}$As$_4$S$_{13}$). A small amount of pyrite was also detected. The non-sulfides identified were quartz, muscovite, dolomite and kaolinite. Quantitative mineralogy undertaken on a bulk copper cleaner concentrate, using the MLA (Minerals Liberation Analyzer) system, showed that approximately 46% of the tennantite was contained in liberated particles (90-100% liberation class). Liberation decreased significantly as the particle size increased. Of the tennantite contained in locked particles approximately 31% was composite with other sulfide minerals and 23% locked with non-sulfide gangue._
Conventional flotation

The rougher flotation feed $P_{80}$ by weight was 90 µm. The pH of the rougher-scavenger was the natural pH of the sample and, in these tests, was approximately pH 9.8. The rougher-scavenger concentrate was made using sodium hydrosulfide (NaHS), sodium isobutyl xanthate (SiBX) and AP 208 (a dithiophosphate).

Copper recovery in the rougher-scavenger was 93% and the concentrate assayed about 14% Cu and 1.3% As. After one stage of cleaning at pH 12, the grade of the cleaner concentrate increased to 24% Cu at a copper recovery of 91%. The pH was raised in the cleaner to assist with pyrite rejection. The arsenic grade of the cleaner concentrate, however, was very high at 2.3% As. Under the conventional flotation scheme utilized here, both copper and arsenic minerals floated very strongly and there was no selectivity between copper and arsenic.

Arsenic separation using pulp potential control

If the flotation behavior of tennantite were similar to that of enargite, the most likely pulp potential region for making a separation between copper-iron sulfides (such as chalcopyrite and bornite) and tennantite is at reducing conditions as illustrated in Figure 1. While the data in Figure 1 was obtained at pH 8, the dependence of enargite and chalcopyrite flotability on pulp potential has been shown to be largely independent of pH (Senior et al., 2006; Trahar, 1984) so a similar separation should be possible at higher pH values.

The results of the tests investigating the use of reducing conditions are shown in Figure 2, a plot of component recovery (after 4 minutes flotation) as a function of pulp potential at pH 12. Arsenic assays were used to determine tennantite (51.6% Cu; 20.3% As), and copper not accounted for in tennantite has been termed “non-tennantite copper”, or NTCu, and will include copper present in bornite and chalcopyrite. The results show that between –200 and –130 mV SHE there is a region where tennantite can be floated from the other non-tennantite copper minerals. Recovery of arsenic in this region is between 80 and 90% while recovery of NTCu is about 30%. Below –200 mV SHE the flotability of tennantite begins to decrease and above –130 mV SHE the flotability of the other copper minerals begins to increase, and so selectivity between copper and arsenic is reduced.

![Figure 2. Recovery of arsenic and non-tennantite copper (NTCu) from Ore A after 4 minutes flotation as a function of pulp potential at pH 12 using reducing conditions](image-url)
The recovery of NTCu at reducing conditions is higher than expected from entrainment alone. The mineralogy undertaken on the rougher-scavenger concentrate had indicated that the tennantite was largely liberated but, where it was locked, it tended to be with bornite. The additional recovery above that of entrainment for the NTCu may be a function of locking. Regrinding of the rougher-scavenger was not investigated in this study but may prove beneficial given that locking of the tennantite with other sulfides is indicated. Regrinding may increase tennantite liberation leading to a cleaner separation while regrinding in a steel mill would also help to provide the reducing environment needed for the separation.

The pulp potential region at which the separation of tennantite from chalcopyrite and bornite was possible with this ore is lower than that expected from the single mineral data shown in Figure 1, assuming that tennantite behaves in a similar manner to enargite and bornite in a similar manner to chalcopyrite. The threshold potential for the flotation of both tennantite and the non-tennantite minerals has been shifted about 100 mV SHE in a more reducing direction. There could be several reasons for this shift in the pulp potential. It may be due to differences in the flotation behavior between tennantite and enargite on the one hand and between chalcopyrite and bornite on the other, or it may be due to hysteresis effects. In some systems, hysteresis in the threshold potential occurs depending upon whether the potential is being shifted to more reducing conditions or more oxidizing conditions (Heyes and Trahar, 1977). In the single mineral tests in Figure 1, the potential was always shifted from a low potential to a higher one whereas in the test work on the current ore the pulp potential in the arsenic rejection stage was shifted down from a high potential to a lower one because the bulk copper-arsenic concentrate was floated in air before the arsenic rejection step. Whatever the reason for the shift in pulp potential, it was still possible to make a separation of tennantite from chalcopyrite and bornite under reducing conditions.

Tests at oxidizing conditions above the air-set potential showed no selectivity between arsenic and NTCu as might be expected from Figure 1.

**Ore B (Cu-Pb-Zn)**

**Ore sample**

Ore sample B consisted of three samples of rod mill feed from a Cu-Pb-Zn operation. There are copper-arsenic minerals present in the ore and these tend to be concentrated with the other copper minerals in the final copper concentrate. The head assays of the ore are given in Table 1. Mineralogy of the sample was determined by qualitative X-ray diffraction of a typical rougher concentrate. The sulfide minerals identified were chalcopyrite, galena, sphalerite and pyrite. No arsenic-bearing minerals were identified by XRD probably due to the low concentration of these minerals in the concentrate. From discussions with plant personnel the arsenic is understood to be present as the tetrahedrite/tennantite solid solution series of minerals.

**Conventional flotation**

The P_{80} by weight of the rougher flotation feed was 90 μm. Reagents were also added to the mill in the quantities listed in Table 2. The amount of lime added to the mill was sufficient to raise the pH of the ground pulp to 11.5 when it was placed in the cell. The pH decreased slowly over the course of the test and was about 11.1 at the end of the rougher.

**Table 2. Rougher test procedure for Ore B**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Ca(OH)\textsubscript{2}</th>
<th>ZnSO\textsubscript{4}</th>
<th>Dextrin</th>
<th>SMP*</th>
<th>3894</th>
<th>5100</th>
<th>MIBC*</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grind</td>
<td>1000</td>
<td>500</td>
<td>200</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Cu Ro 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Cu Ro 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
</tbody>
</table>

*SMP – sodium monophosphate; MIBC – methyl isobutyl carbinol*

The procedure used in the rougher stage is also described in Table 2 and is based on a laboratory procedure for a locked cycle flotation test supplied by the client. The Cytec collectors, Aero 3894 and Aero 5100, are thionocarbamates. As this was a Cu-Pb-Zn ore, additional reagents, other than collector and frother, are used in
the copper rougher to depress galena, sphalerite and pyrite. Copper recovery in the rougher was approximately 88-91% and the concentrate assayed 5-6% Cu and 0.33-0.36% As. There was no selectivity between copper and arsenic. Cleaning the rougher concentrate at pH 11 by refloating without any reagent additions produced a concentrate containing 95% of the copper and 90% of the arsenic from the rougher concentrate at a grade of 9.2% Cu and 0.50% As.

**Arsenic separation using pulp potential control**

Given that the arsenic and copper minerals in the ore are tennantite and chalcopyrite (similar to Ore A) it was expected that a separation would be possible in the reducing region. However as the results in Figure 3 show there was little recovery of either arsenic or NTCu at reducing potentials. There was, however, a separation between NTCu and As at potentials above the air-set potential (+230 mV SHE). At +400 mV SHE 80% of the NTCu (70% of the copper) and only 25% of the arsenic was recovered. The grade of the concentrate was 9.2% copper which was the same as the grade achieved with conventional cleaning but the arsenic grade was halved (0.23% As). Again, regrinding of the rougher-scavenger was not investigated in this study but the separation may have been improved if locking between the chalcopyrite and tennantite was shown to be an issue.

![Figure 3. Recovery of NTCu and As (at 4 minutes) from Ore B as a function of pulp potential](image)

One of the possible explanations for the unexpected separation of copper and arsenic at high potentials is the collector used in the rougher stage. As stated previously, the collector used to produce the data in Figure 1 was
xanthate. From Figure 1, assuming that tennantite behaves in the same manner as enargite, it would be expected that both chalcopyrite and tennantite would float at high potentials and this was found to be the case for Ore A which was floated with xanthate. The collectors used in the rougher stage in this study were thionocarbamates rather than xanthates. No data exists for the effect of pulp potential on these minerals floated with thionocarbamates but it is possible that the flotation response of the minerals to pulp potential may vary according to collector type or that the mechanism by which flotability is achieved differs significantly with this collector type and mineral system. Regardless of the reasons for the differences observed, it was possible to make a separation between the arsenic-bearing minerals and the other copper minerals using pulp potential control.

**Ore C (Cu-Mo concentrate)**

**Concentrate sample**

Conceptually, the client was considering making a bulk Cu-Mo concentrate, and then separating the copper and molybdenum to produce a molybdenum concentrate and a copper concentrate but without concentrating the arsenic minerals in either of these concentrates. A 45 kg drum of copper concentrate slurry obtained during a pilot plant run to produce the bulk Cu-Mo was received. The head assays of the slurry are given in Table 1 (Ore C). The concentrate was obtained using reagents AP 3894 (thionocarbamate), AX 343 (xanthate), diesel, and Aerofroth 70. The pH in the rougher was 10.5, and in the cleaner and scavenger, 12.5. A regrind was part of the pilot plant run so the P_{80} of the concentrate was approximately 25 µm.

The copper mineralogy of the sample was determined by qualitative X-ray diffraction of the copper concentrate. The sulfide minerals identified were chalcopyrite, pyrite and molybdenite. No arsenic-bearing minerals were identified by XRD probably due to the low concentration of these minerals in the concentrate. Information from the client identified the arsenic mineral as tennantite.

**Arsenic separation using pulp potential control**

From the Cu-Mo concentrate, a molybdenum concentrate was produced using standard Mo flotation conditions (low potential with NaHS and diesel addition under nitrogen). The pH in this stage was 11.2 and the pulp potential was approximately -340 mV SHE. The Mo concentrate contained about 80% of the molybdenum and 5% of the copper and arsenic.

At the end of the Mo flotation stage, the flotation gas was changed to air and a quantity of sodium hypochlorite (NaOCl) added to raise the pulp potential to a set value. The behavior of the minerals was similar to that observed for Ore B (i.e., no separation between NTCu and arsenic was observed at low potentials but at high potentials NTCu was recovered ahead of arsenic). In the best test, 76% of the copper was recovered in a copper concentrate assaying 0.26% As. At shorter flotation times the arsenic grade of the concentrate could be reduced to 0.2% As but this increased copper losses. The minerals involved in this study were the same as for Ore B (chalcopyrite and tennantite) and the collectors used in the rougher stage were a combination of thionocarbamate (which was used in the study for Ore B) and xanthate so the similarity of the results were not unexpected.

**Ore D (Cu)**

**Ore sample**

Ore D was a composite of several drill core intersections from a copper ore body. The head assays of the composite are given in Table 1. Copper minerals identified by XRD were enargite and covellite (CuS), while the non-copper sulfide minerals were pyrite, galena, sphalerite and molybdenite. The deportment of the arsenic and the liberation of the copper and arsenic minerals were not determined for this sample.

**Conventional flotation**

The rougher flotation feed P_{80} by weight was 150 µm. Rougher flotation was done using fresh samples of Cytec collectors Aero 3894 (a thionocarbamate) and Aero 3302 (a xanthate ester), made up as 1% solutions. The pH of the pulp was adjusted to 10 using lime.

Copper recovery for a 16 minute rougher float was typically 92%, while arsenic recovery averaged 91% indicating negligible Cu/As selectivity in the rougher floats. The average grades of the rougher concentrate were 1.85% Cu
and 0.29% As, compared to the rougher feed grades of 0.48% Cu and 0.073% As. Rougher recovery of other sulfide minerals, iron sulfides and sphalerite, was typically high for this ore and rougher flotation procedure.

Refloating the rougher concentrate for eight minutes, after adjusting the pH with lime to pH 11.8 without any further collector additions, typically produced a cleaner concentrate containing 95% of the copper and 95% of the arsenic from the rougher concentrate at a grade of 4.8% Cu and 0.79% As. Hence conventional cleaner flotation did not produce any selectivity between Cu and As. The low cleaner copper grade may have been a result of incomplete liberation as iron sulfide recovery was high in the rougher stage and significant recovery of iron sulfides occurred in the single cleaning stage. Non-sulfide gangue recovery also contributed to the low copper grade.

**Arsenic separation using pulp potential control**

For each cleaner float, the pH of the re-pulped rougher-scavenger concentrate was raised to pH 11.8 with lime and the pulp potential of the pulp adjusted to the required value. In some tests, the potential was controlled for the first two minutes only while in others it was controlled throughout the cleaner float.

Cleaner flotation performance of enargite and non-enargite copper as a function of pulp potential at oxidizing potentials is shown in Figure 4 for flotation at pH 11.8, where the recovery of arsenic is assumed to be indicative of enargite recovery and copper not accounted for in enargite has been termed "non-enargite copper", or NECu, and represents the copper present in covellite. Recovery values are those calculated after 2 minutes of flotation during which period the pulp potential was controlled in all of the tests between +300 mV and +550 mV SHE. NECu recovery remains high as the pulp potential increases from +200 mV to +500 mV SHE whereas enargite (arsenic) recovery decreases consistently with increasing pulp potential; so selectivity between non-arsenic bearing copper mineral and arsenic bearing copper mineral increases with increasing pulp potential. Not unexpectedly above +500 mV SHE the recovery of NECu appears to drop fairly rapidly with a sharp decrease in total copper recovery above this pulp potential.

From Figure 1, it was expected that a separation at high potential would be possible if covellite behaved in a similar manner to chalcocite, another copper sulfide. However, it was expected from Figure 1, that enargite would float ahead of covellite but this was not the case. As mentioned previously, data in Figure 1 were obtained using xanthate as the collector. In this study, the collectors used in the rougher stage were a thionocarbamate and a xanthate ester. As for ores B and C, it would appear that the choice of collector in the rougher stage has an influence on the subsequent flotation behavior of the minerals in the separation stage.

If indeed the performance shown in Figure 4 is a reflection of the actual mineral behaviour, this result also indicates that the two major copper mineral phases must be reasonably well liberated at the grind size used.

For tests done at pulp potentials below the air set potential, As and Cu recovery remained high between +200 mV SHE and +50 mV SHE; at lower potentials the recovery of both elements decreased quite sharply. The sharp decrease in recoveries between +50 mV and 0 mV, for both As and Cu, would suggest that it would be difficult in practice to make a separation at reducing potentials for this ore using this reagent scheme.

**Summary**

The results from the above case studies are summarized in Table 3. The table lists the major copper and arsenic minerals in each ore and the collector type used in the rougher stage and compares the copper-arsenic selectivity obtained for a conventionally produced copper concentrate and a low-arsenic copper concentrate utilizing controlled-potential flotation. The pulp potentials at which these concentrates were produced are included in the table. The selectivity is measured by the ratio of the copper recovery to the arsenic recovery. No selectivity is indicated by a value of 1; a value greater than 1 indicates selectivity of copper over arsenic. For all ores tested, conventional flotation produced a concentrate with no selectivity between copper and arsenic but it was possible to make a separation between the arsenic-bearing copper minerals and the non-arsenic-bearing copper minerals utilizing controlled-potential flotation.
THE USE OF PULP POTENTIAL CONTROL TO SEPARATE COPPER AND ARSENIC – AN OVERVIEW BASED ON SELECTED CASE STUDIES

**Table 3.** Summary of results from case studies

<table>
<thead>
<tr>
<th>Ore</th>
<th>Major Cu minerals</th>
<th>Major As minerals</th>
<th>Collector type in rougher</th>
<th>Pulp potential (mV)</th>
<th>Cu/As selectivity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore A (Cu)</td>
<td>Chalcopyrite/bornite</td>
<td>Tennantite</td>
<td>Xanthate/dithiophosphate</td>
<td>+250</td>
<td>1.0</td>
</tr>
<tr>
<td>conventional</td>
<td></td>
<td></td>
<td></td>
<td>-200</td>
<td></td>
</tr>
<tr>
<td>low-arsenic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.7</td>
</tr>
<tr>
<td>Ore B (Cu-Pb-Zn)</td>
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<td>Tennantite</td>
<td>Thionocarbamate</td>
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<td>conventional</td>
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<td></td>
<td></td>
<td>+400</td>
<td>2.8</td>
</tr>
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<td>low-arsenic</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ore C (Cu Con)</td>
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<td>Tennantite</td>
<td>Thionocarbamate</td>
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<td></td>
</tr>
<tr>
<td>Ore D</td>
<td>Covellite</td>
<td>Enargite</td>
<td>Thionocarbamate/Xanthate ester</td>
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<td>2.8</td>
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<tr>
<td>low-arsenic</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

*Cu/As selectivity – ratio of Cu recovery to As recovery

The arsenic minerals, enargite and tennantite, have significant copper content. If they are present in significant quantities in the ore to be processed, then rejecting them will result in loss of valuable copper. The current process is aimed at producing a low-arsenic copper concentrate that can be sent directly to smelters for metal recovery.
production and a high-arsenic copper concentrate that can be further treated to recover the valuable copper content. The above case studies have shown that it is possible to produce low and high-arsenic copper concentrates utilizing controlled potential flotation.

CONCLUSION

Flotation work conducted by CSIRO has shown it is possible to produce separate low-arsenic copper concentrates and high-arsenic copper concentrates from several high-arsenic copper ores. The procedure involves controlled separations at high or low pulp potential regions exploiting subtle differences in the flotation behavior of the arsenic-bearing and non-arsenic-bearing copper minerals at particular pulp potential windows.

The efficiency of the separation and the selection of the pulp potential region suitable for the separation is dependent upon a number of variables including the degree of liberation of the arsenic-bearing minerals from the other copper minerals, the mineralogy of the ore, i.e., which copper and arsenic minerals are present, and the reagent scheme, in particular the collector type, used in producing the bulk copper-arsenic rougher concentrate. The products from the flotation process are a low-arsenic copper concentrate that can be sent directly to the smelter and a low volume high-arsenic copper concentrate that could be further treated to recover the copper content.

REFERENCES


