Lynch Mining Pty Ltd

# EL7/2005 LUINA

# 5th YEAR REPORT

MAY 2010

BRIGHT PHASE

WILL GOODALL PhD BEng(Chem)(Hons)

Senior Technical Consultant +61 408 562 319 willg@brightphase.com.au

Bright Phase Pty Limited ACN 127 819 710 PO Box 256 Holland Park QLD 4121 Australia www.brightphase.com.au

# Mineralogical Evaluation of Cleveland Tailings by QEMSCAN

*Date: November 2009*

*Prepared by: Dr Will Goodall*

Sample: Head Sample CTD 201-221

## Executive Summary

Examination of Cleveland Tailings (CTD 201-220) sourced from the Cleveland project, Tasmania, Australia (EL7/2005) was completed using QEMSCAN by Bright Phase Pty Ltd. The primary focus of this program was to define the deportment of Sn and Cu, along with the root cause for poor recovery by conventional flotation and gravity separation.

The key outcomes of this study included:

- The measured particle size distribution (PSD) showed P80 of ~50 µm.
- The deportment of Sn was exclusively with cassiterite ($SnO_2$)
- The deportment of Cu was predominantly with chalcopyrite ($CuFeS_2$) and bornite ($Cu_5FeS_4$).
- Major minerals were quartz (28.6 % w/w), chlorite (15.68 % w/w), micas (11.23 % w/w), Fe oxides (10.68 % w/w), pyrrhotite (7.53 % w/w) and pyrite (3.51 % w/w). Significant pyrrhotite may cause environmental issues with Acid Mine Drainage.
- Grain size of cassiterite, chalcopyrite and bornite was consistent (5-20 µm) across all size fractions.
- Liberation of all ore minerals was poor in +38 µm fractions and increased in -38 µm fractions.
- Theoretical grade-recovery predictions indicated that for a low grade Sn concentrate (~50% Sn) recovery of 92% cassiterite would be maximum achievable. For a low grade Cu concentrate (20% Cu), recovery of 83% chalcopyrite would be maximum achievable.
- Coarse (+38 µm) particles occurred as agglomerates, aggregated by chlorite and mica. Disaggregation may be achieved by attritioning to liberate additional ore minerals and should be investigated.

*Economic recovery of Sn and Cu should be achievable from Cleveland Tailings if additional liberation can be achieved and solutions for fine particle flotation or gravity separation can be implemented*

## Table of Contents

## Table of Figures

## Material Characteristics

A sample of composite material (CTD 201-221) generated from the Cleveland tailings area was provided to Bright Phase Pty Ltd for mineralogical analysis. The focus of this program was to evaluate causes for poor recovery of Sn and Cu by conventional methods and define opportunities for alternative recovery circuit configurations to be examined.

The sample was screened and all fractions assayed for a suite of key elements. Screened fractions were subsequently examined by QEMSCAN using the Particle Mineral Analysis (PMA) and Bulk Mineral Analysis (BMA) modes. The results of screen fraction assays for key elements can be seen in Table 1.

**Table 1 - Size assays for composite sample of Cleveland tailings**

| Screened Sample Raw Assays | | | | | | |
|---|---|---|---|---|---|---|
| IDENT | PSD | **Fe** | **Sn** | **Cu** | **Pb** | **S** |
| UNITS | | % | ppm | ppm | ppm | % |
| DETECTION LIMIT | | 0.01 | 50 | 2 | 5 | 0.01 |
| **Screened Sample +106** | 33.09 | 16.4 | 2700 | 1000 | 20 | 5.78 |
| **Screened Sample -106/+38** | 23.12 | 17.7 | 2100 | 700 | 20 | 7.08 |
| **Screened Sample -38/+8** | 34.66 | 18.1 | 2300 | 1700 | 50 | 3.32 |
| **Screened Sample -8** | 9.13 | 18.3 | 4600 | 1500 | 30 | 5.76 |
| Cal Head | 100.00 | 17.46 | 2596 | 1219 | 31 | 5.23 |
| Measured Head | | 17.21 | 3200 | 1200 | 28 | 5.86 |

*The results in* Table 1 *indicate that Sn and Cu are evenly distributed across size fractions. This suggested a constant population of Sn and Cu hosting minerals that have not been preferentially liberated to a particular size fraction.*

Analysis for a full suite of elements was undertaken and has been provided in appendix 1.

The particle size distribution for the Cleveland tailings composite sample has been presented in Figure 1. The P80 of this material was approximately 50 µm.

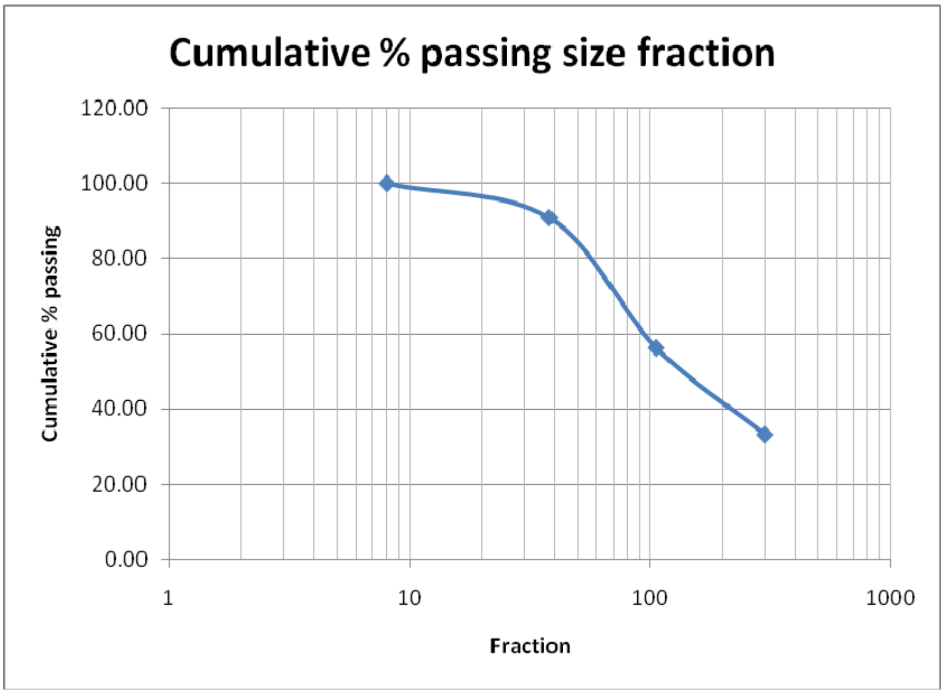



**Figure 1 - Particle size distribution for Cleaveland tailings composite. Calculated P80 of ~50µm**

## Mineral Abundance

The modal mineral abundance was determined by QEMSCAN BMA and has been presented in Table 2. The distribution of minerals was determined across size fractions to determine preferential deportment of key minerals.

The major minerals present were quartz (28.6 % w/w), Chlorite (15.68 % w/w), micas (11.23 % w/w), Fe oxides (10.68 % w/w), pyrrhotite (7.53 % w/w) and pyrite (3.51 % w/w).

The abundance of significant reactive sulphides (i.e. pyrrhotite) could result in a significant acid mine drainage environmental issue that should be considered in any processing application suggested.

**Table 2 - Modal mineral abundance by size for composite Cleveland tailings**

| | *+106* | *-106/+38* | *-38/+8* | *-8* | *Combined* |
|---|---|---|---|---|---|
| **Cassiterite** | 0.01 | 0.00 | 0.03 | 0.01 | 0.05 |
| **Chalcopyrite** | 0.07 | 0.03 | 0.13 | 0.01 | 0.24 |
| **Ccp intergrowths** | 0.07 | 0.01 | 0.01 | 0.04 | 0.13 |
| **Bornite** | 0.01 | 0.01 | 0.04 | 0.01 | 0.08 |
| **Sphalerite** | 0.08 | 0.04 | 0.11 | 0.03 | 0.26 |
| **Pyrite** | 0.98 | 0.92 | 1.55 | 0.06 | 3.51 |
| **Pyrrhotite** | 2.57 | 2.59 | 2.20 | 0.16 | 7.53 |
| **Other sulphides** | 0.04 | 0.02 | 0.06 | 0.02 | 0.14 |
| **Fluorite** | 0.65 | 0.86 | 0.92 | 0.00 | 2.43 |
| **Carbonates** | 0.58 | 0.46 | 1.91 | 0.29 | 3.24 |
| **Sulphates** | 3.59 | 1.10 | 2.06 | 1.38 | 8.13 |
| **Quartz** | 9.17 | 8.06 | 9.95 | 1.41 | 28.60 |
| **Feldspars** | 0.50 | 0.33 | 0.32 | 0.07 | 1.21 |
| **Amphibole/pyroxene** | 1.03 | 0.21 | 0.30 | 0.19 | 1.73 |
| **Chlorite** | 4.96 | 3.10 | 5.98 | 1.64 | 15.68 |
| **Clays** | 1.08 | 0.63 | 1.23 | 0.81 | 3.75 |
| **Micas** | 4.40 | 2.05 | 2.98 | 1.79 | 11.23 |
| **Other Silicates** | 0.23 | 0.10 | 0.18 | 0.15 | 0.66 |
| **Phosphates** | 0.10 | 0.08 | 0.15 | 0.04 | 0.37 |
| **Fe Oxides** | 2.87 | 2.43 | 4.39 | 0.99 | 10.68 |
| **Ti Minerals** | 0.09 | 0.08 | 0.11 | 0.01 | 0.29 |
| **Other Oxides** | 0.01 | 0.01 | 0.03 | 0.00 | 0.05 |
| **Others** | 0.01 | 0.00 | 0.01 | 0.01 | 0.02 |
| **Total** | **33.09** | **23.12** | **34.66** | **9.13** | **100.00** |

It was apparent from mineral abundance analysis that the major Sn bearing mineral was Cassiterite ($SnO_2$), while the major Cu bearing minerals were Bornite ($Cu_5FeS_4$) and Chalcopyrite ($CuFeS_2$).

# Elemental Deportment

## Tin

The elemental deportment of Sn has been shown in Figure 2. It was clearly shown that the single host for Sn was Cassiterite ($SnO_2$). This means that recovery processes can be specifically targeted to Cassiterite and losses due to deportment of Sn to other minerals should be minimised.

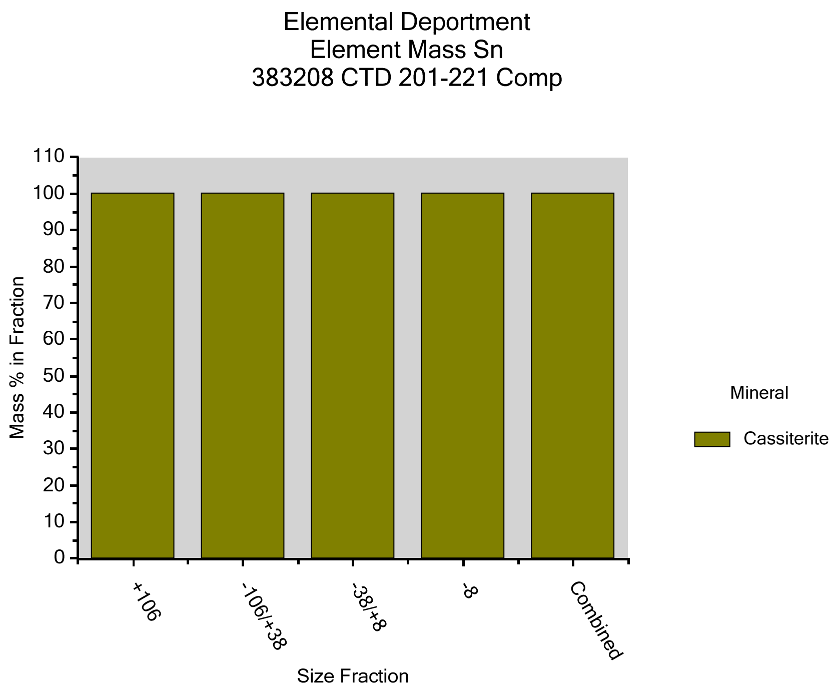



**Figure 2 - Elemental deportment by size fraction of Sn in Cleveland Tailings composite. Determined by QEMSCAN PMA analysis with resolution @ 2 µm**

## Copper

The elemental deportment of Cu by size fraction can be seen in Figure 3. It was apparent that Cu predominantly deported to the copper iron sulphides, bornite ($Cu_5FeS_4$) and chalcopyrite ($CuFeS_2$). These minerals have similar flotation characteristics and joint recovery to a concentrate should be possible depending on grain size distribution and liberation.

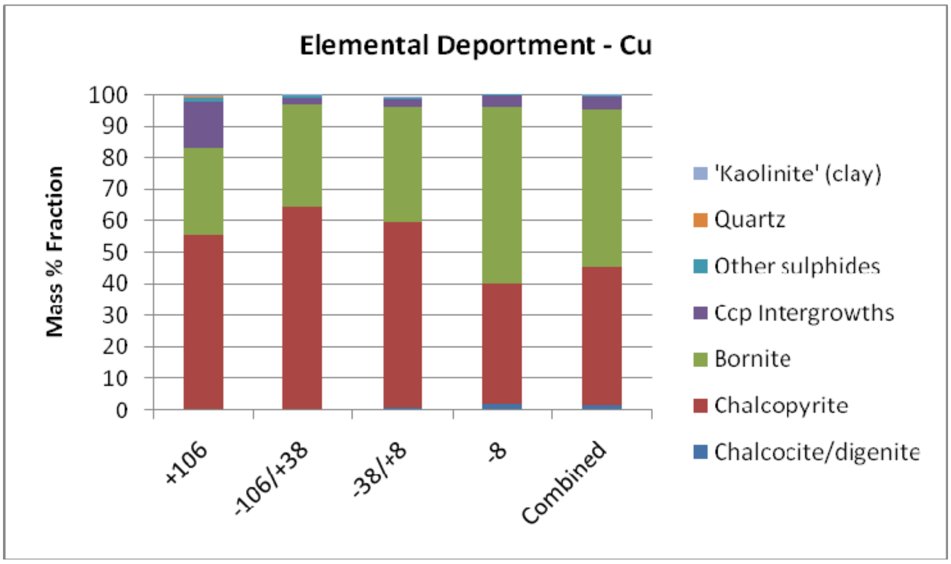



**Figure 3 - Elemental deportment by size fraction of Cu in Cleveland Tailings composite. Determined by QEMSCAN PMA analysis with resolution @ 2 µm**

## *Sulphur*

The elemental deportment of sulphur showed that the major sulphide minerals present were pyrrhotite (FeS) and pyrite ($FeS_2$) (see Figure 4). The association of these minerals will be important as depression will be required in any flotation process. It should be noted that a greater proportion of barite was seen in the -8 µm fraction, which could be attributed to oxidation of sulphide minerals present over time.

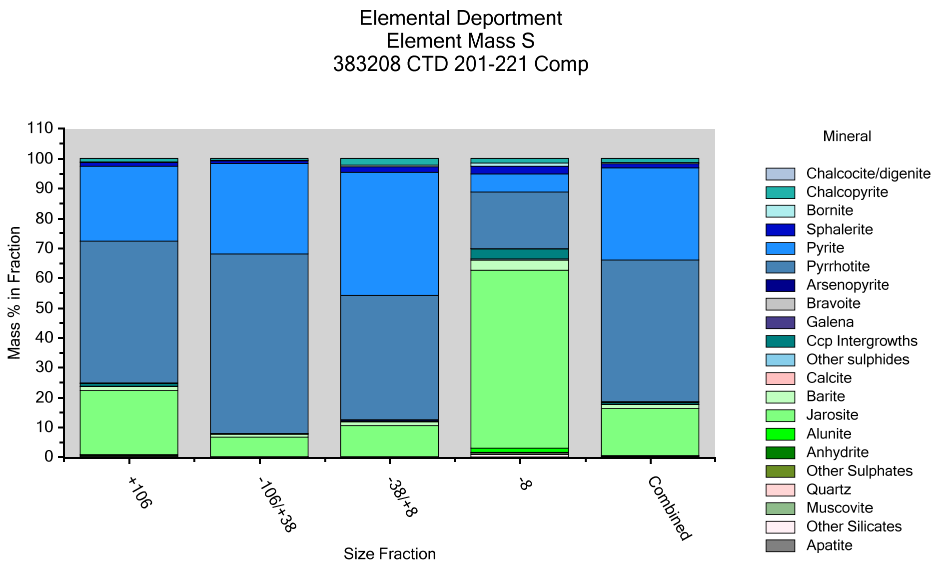



**Figure 4 - Elemental deportment by size fraction of S in Cleveland Tailings composite. Determined by QEMSCAN PMA analysis with resolution @ 2 µm**

# Grain Size and Liberation

The grain size of value bearing minerals in relation to the particle size has been presented in Figure 5. It can be seen that The grain size of both chalcopyrite and bornite is consistent at <10 µm. Although cassiterite showed grain sizes of up to 20 µm, the average was also below 10 µm. Importantly grain size for each of these minerals was independent of particle size, which suggested that the major population for each was fine grained.

The fine grained nature of all ore minerals suggested that traditional recovery methods would be inefficient. Gravity separation generally requires grain sizes >30 µm, while flotation is generally considered applicable for grain sizes >20 µm. There are flotation alternatives available, such as pneumatic flotation cells, that are designed for fine particle flotation and may be suitable for this material. Alternatively, fine particle gravity separators, such as the Falcon centrifugal concentrators, may be considered.

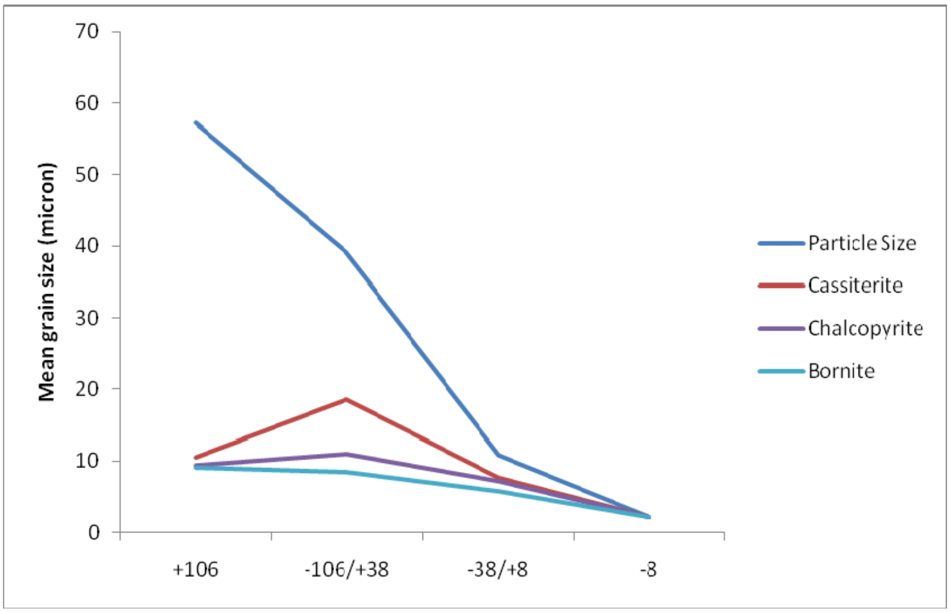



**Figure 5 - Mean particle size and grain size for ore minerals in Cleveland tailings composite. Determined by QEMSCAN PMA, resolution @ 2µm**

A closer inspection of the effect of ore mineral grain size on liberation characteristics has been presented in Figure 6. This showed that liberation of cassiterite in the coarser (+38 µm) fractions was poor with over 40% of the grains <30% liberated on a surface area basis. When this was coupled with the fine grained nature of cassiterite it was apparent that conventional flotation with no pre-conditioning would not provide good recovery of cassiterite. Liberation of cassiterite in the -38 µm fractions was increased as the grain size began to approach the particle size.

For recovery of cassiterite from this material it is suggested that a combination of size reduction for coarser particles and fine grain flotation solutions would provide the best processing option.

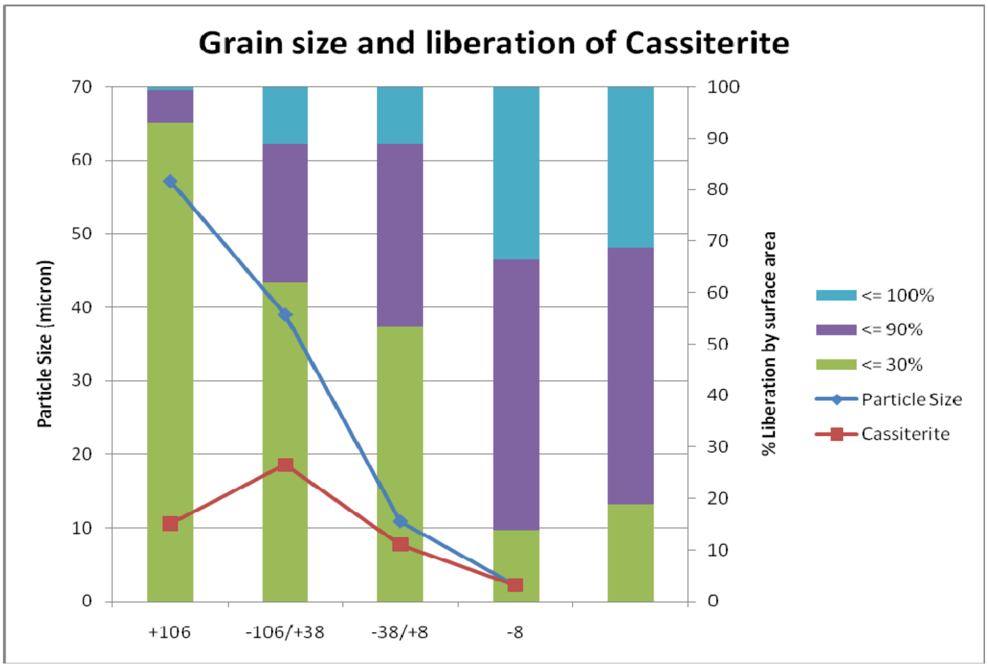



**Figure 6 - Grain size of cassiterite as a function of liberation by size fraction in Cleveland Tailings composite. Determined by QEMSCAN PMA, resolution @ 2µm**

The liberation of chalcopyrite showed a similar trend to cassiterite, which could be expected from the grain size distribution. Figure 7 shows that liberation in the +38 µm and +106 µm fractions (comprising 44 % w/w of the mass) was very poor but was more pronounced for -38 µm fractions.

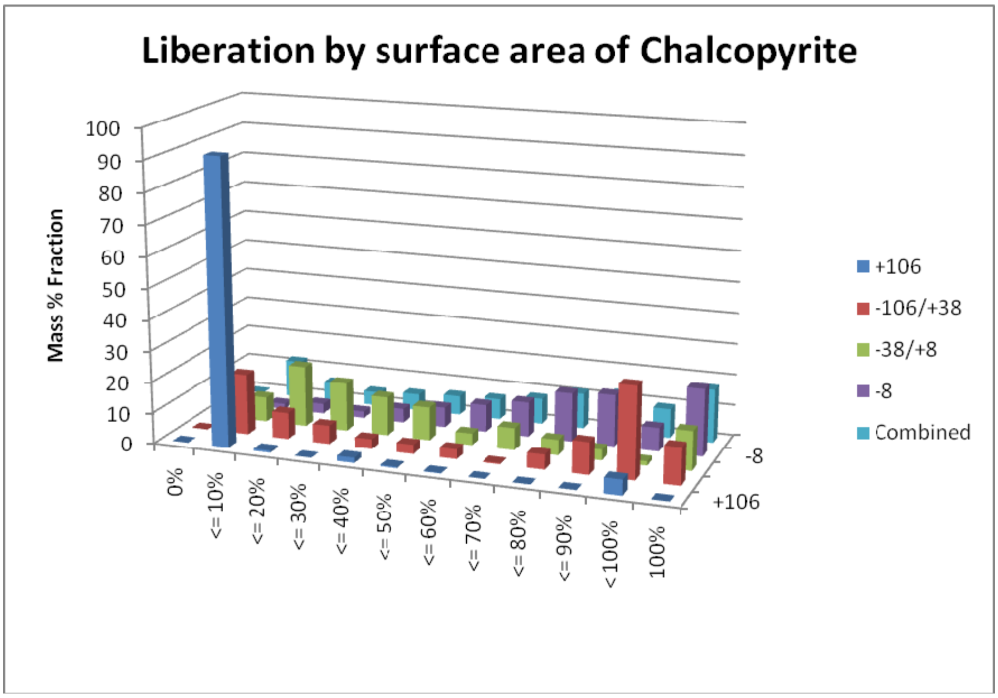



**Figure 7 - Liberation by surface area of chalcopyrite in sized fractions of Cleveland Tailings composite. Determined by QEMSCAN PMA, resolution @ 2µm**

As with chalcopyrite, Figure 8 showed that bornite was poorly liberated in +38 µm fractions and increasingly liberated as the particle sise decreased.

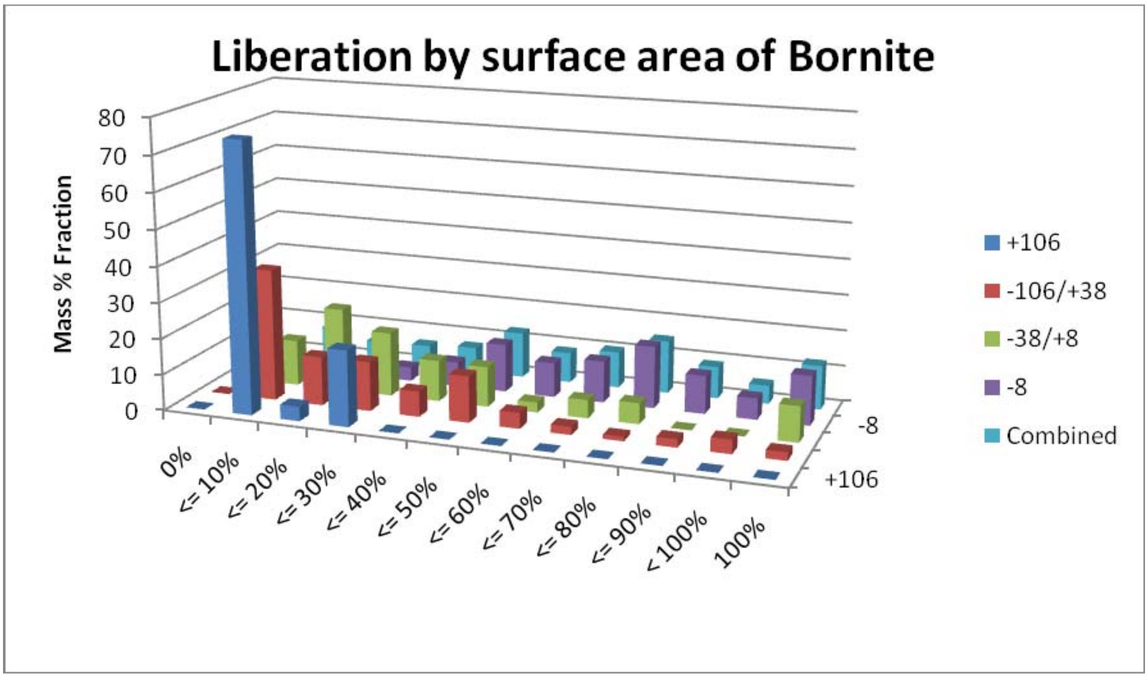



**Figure 8 - Liberation by surface area of bornite in sized fractions of Cleveland Tailings composite. Determined by QEMSCAN PMA, resolution @ 2µm**

The effect of ore mineral grain size and liberation on potential processing options will be significant. The poor liberation characteristics are likely to require that the material be further milled, or at least subjected to attritioning, for the ore minerals to be amenable to concentration by flotation or gravity separation. There should also be care taken that the fine grain size of liberated ore minerals will make recovery of a high grade concentrate difficult and multiple cleaning stages may be required.

## Theoretical Grade-Recovery

The theoretical grade-recovery curves for cassiterite, chalcopyrite and bornite have been presented in Figure 9. The theoretical grade-recovery curve provides the mineralogical limit for recovery at a required grade, based on surface area liberation. This provides a benchmark to determine if additional milling may be required to obtain saleable grade concentrates.

To obtain a low grade cassiterite concentrate (~50% Sn) a maximum recovery of ~92% cassiterite could be expected for the current grind size conditions. Based on the current theoretical grade-recovery curve it is suggested that for economic Sn recovery additional liberation of cassiterite would be required.

To achieve a low grade Cu concentrate (20% Cu) a grade of 60% chalcopyrite would be required. The current theoretical grade-recovery limits predict ~83% chalcopyrite recovery for this grade. A similar ratio is required for bornite.

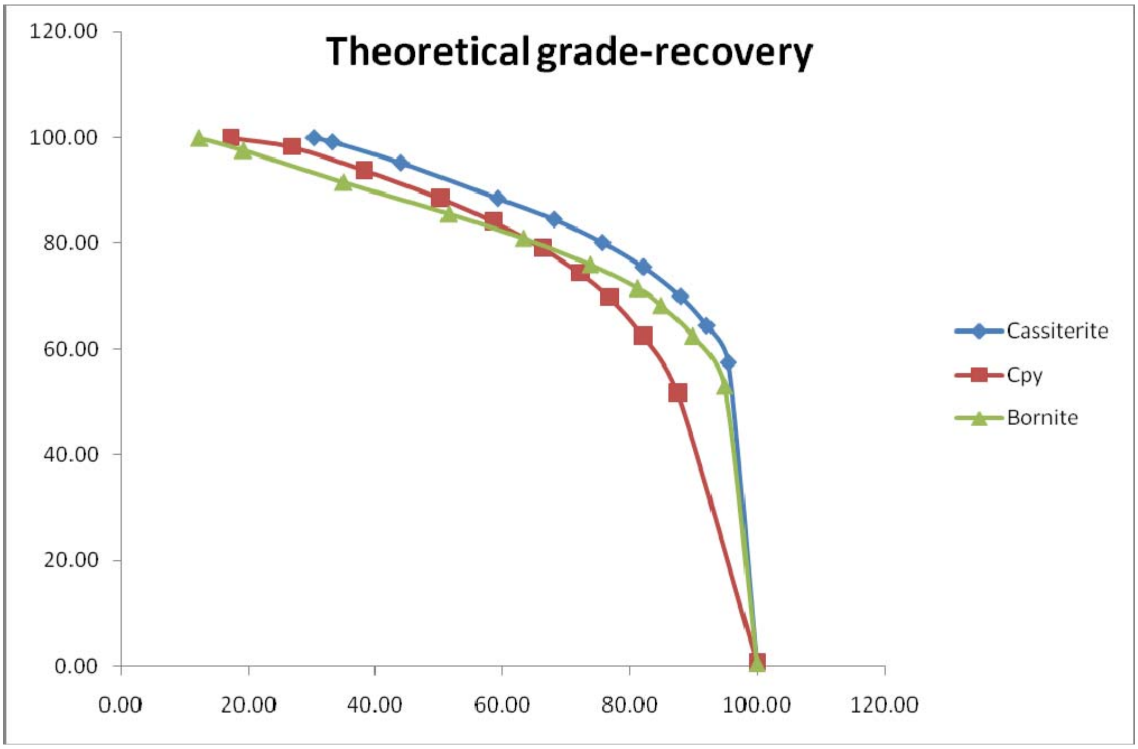



**Figure 9 - Theoretical grade-recovery curves for cassiterite, chalcopyrite and bornite in Cleveland Tailings composite. Determined based on liberation by surface area using QEMSCAN PMA, resolution @ 2µm**

The key outcomes of the theoretical grade-recovery analysis showed that with the current particle size distribution the maximum expected recoveries were still low. To achieve better recoveries of cassiterite and Cu sulphides some size reduction, whether by attrition or milling, would be required.

## Particle Images

Examination of the particle images generated by QEMSCAN PMA showed that coarse particles, >38 µm, occurred predominantly as agglomerates of finer particles (Figure 10 and Appendix 2, Figure 10 to Figure 11). As the particle size decreased below 38 µm a greater proportion of liberated grains, predominantly pyrrhotite and pyrite, were apparent (Appendix 2, Figure 12 to Figure 16)

The agglomerates were cemented mainly with micas and chlorite, with a large proportion of fine grained quartz also apparent. The nature of these minerals suggested that a hard cement should not be formed and agglomeration was more likely to occur by direct particle attachment. This would mean that disaggregation could be achieved by simple attritioning of the particles and additional milling may not be required.

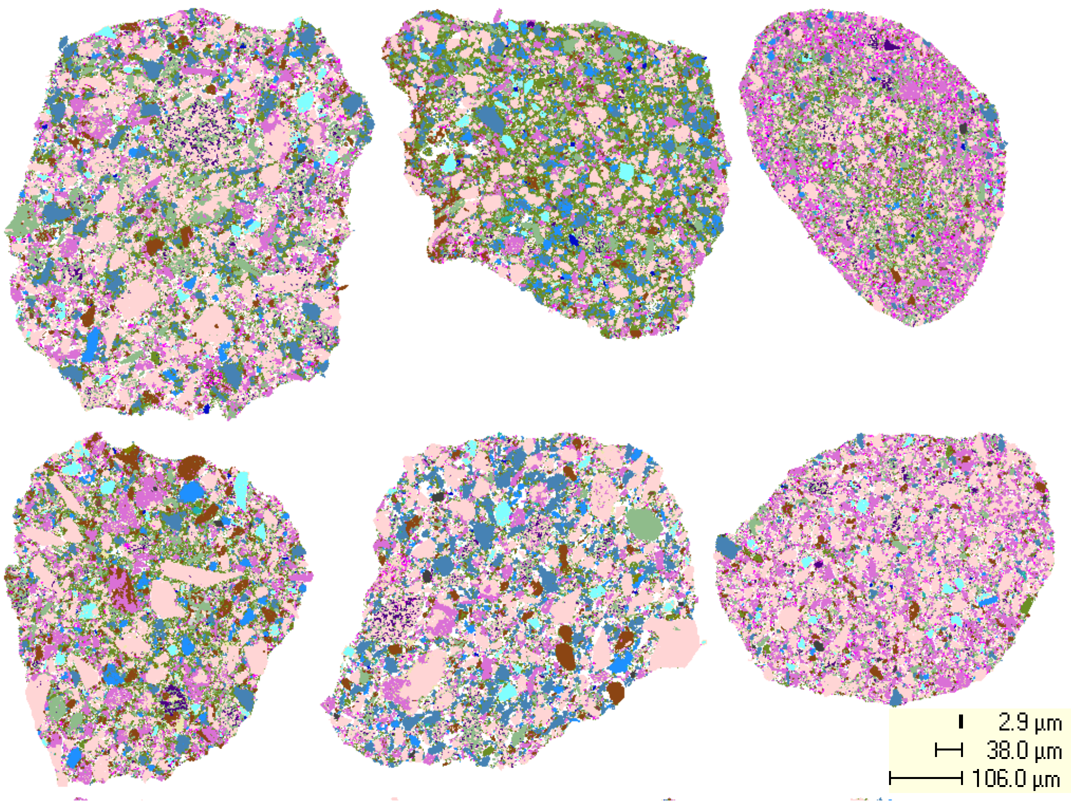



**Figure 10 - Particle map from QEMSCAN PMA analysis of +106µm fraction of Cleveland Tailings composite. Resolution @ 2µm**

# Appendix 1 – Multi-element Analysis

**Table 3 - Multi-element analysis for bulk Cleveland Tailings composite**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Al2O3** | **CaO** | **K2O** | **Fe2O3** | **MgO** | **MnO** | **Na2O** | **P2O5** | **SiO2** |
| % | % | % | % | % | % | % | % | % |
| IC4 | IC4 | IC4 | IC4 | IC4 | IC4 | IC4 | IC4 | IC4 |
| 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 8.26 | 4.91 | 1 | 24.6 | 1.73 | 0.46 | 0.19 | 0.15 | 44.8 |
| **Cr** | **Sr** | **Ba** | **LOI** | **Ta** | **Sn** | **W** | **Cu** | **Co** |
| ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | ppm |
| IC4 | IC4 | IC4 | GRAV7 | IC4M | IC4M | IC4M | IC3M | IC3M |
| 50 | 20 | 20 | 0.01A | 2 | 10 | 3 | 0.5 | 0.2 |
| 150 | 30 | 80 | 11.6 | <2 | 3200 | 90 | 1200 | 47 |
| **As** | **Ge** | **Se** | **Nb** | **Mo** | **Ag** | **Cd** | **In** | **Sb** |
| ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm |
| IC3M | IC3M | IC3M | IC3M | IC3M | IC3M | IC3M | IC3M | IC3M |
| 0.5 | 5 | 0.5 | 0.5 | 0.1 | 0.1 | 0.1 | 0.5 | 0.5 |
| 265 | <5 | 2.5 | 3.5 | 1.4 | 2.7 | 4.6 | 16.5 | 3 |
| **Bi** | **S** | **TiO2** | **Sc** | **V** | **Ni** | **Zn** | **Ga** | **Te** |
| ppm | % | % | ppm | ppm | ppm | ppm | ppm | ppm |
| IC3M | MET6A | IC4 | IC4 | IC4 | IC3M | IC3M | IC3M | IC3M |
| 0.1 | 0.01 | 0.005 | 5 | 20 | 2 | 0.5 | 0.1 | 0.2 |
| 85 | 5.86 | 0.44 | 10 | 65 | 44 | 1100 | 33 | <0.2 |
| **Cs** | **Pb** | | | | | | | |
| ppm | ppm | | | | | | | |
| IC3M | IC3M | | | | | | | |
| 0.1 | 0.5 | | | | | | | |
| 31.5 | 28 | | | | | | | |

# Appendix 1 – Particle Images

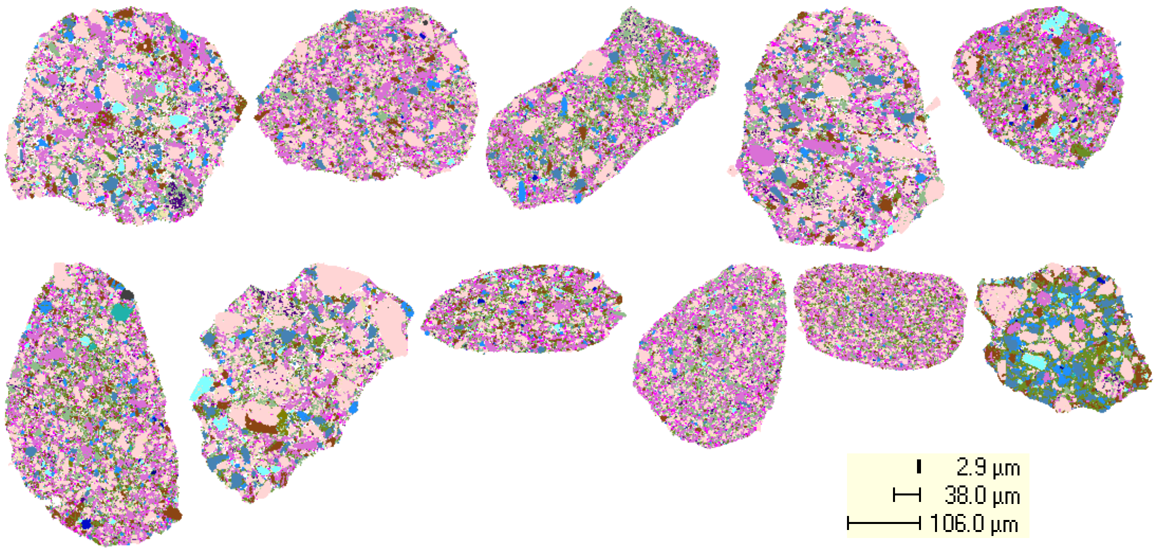



**Figure 11 - Particle map from QEMSCAN PMA analysis of -106µm +38µm fraction of Cleveland Tailings composite. Resolution @ 2µm**

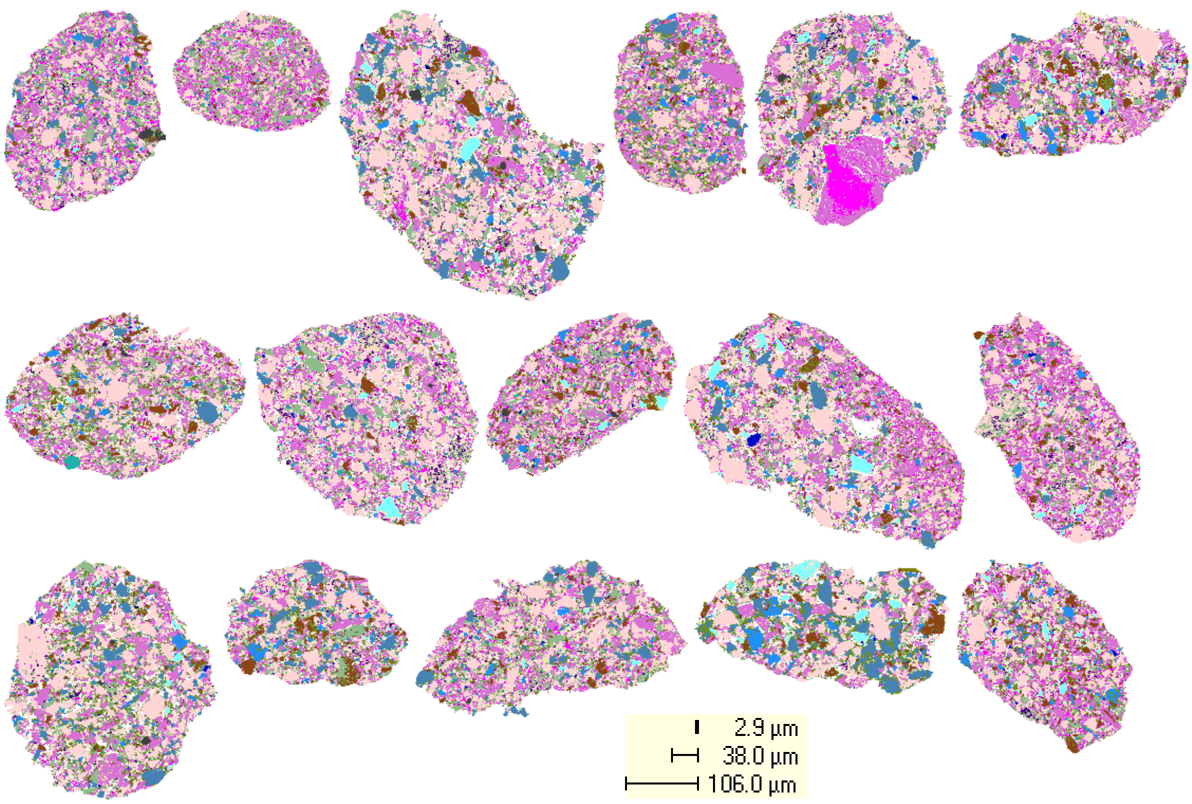



**Figure 12 - Particle map from QEMSCAN PMA analysis of -106µm +38µm fraction of Cleveland Tailings composite. Resolution @ 2µm**


**Figure 13 - Particle map from QEMSCAN PMA analysis of -38µm +8µm fraction of Clev Tailings composite. Resolution @ 2µm**

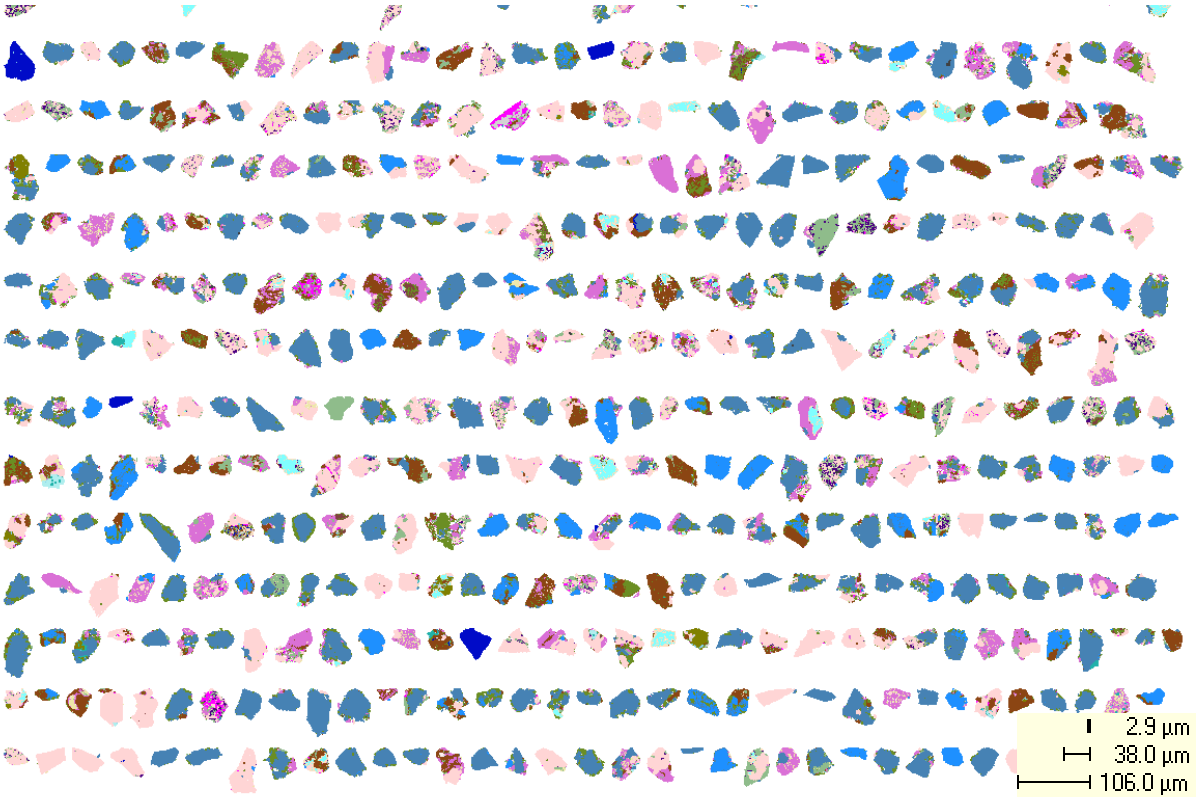



**Figure 14 - Particle map from QEMSCAN PMA analysis of -38µm +8µm fraction of Cleveland Tailings composite. Resolution @ 2µm**

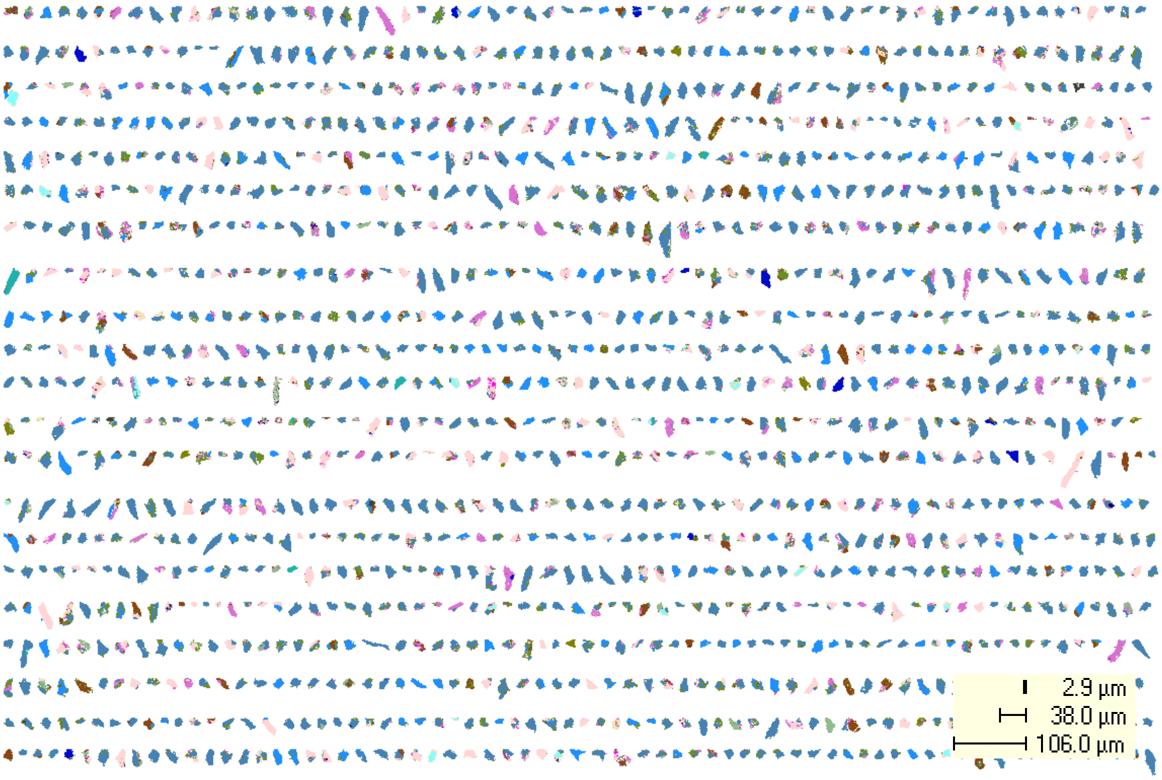



**Figure 15 - Particle map from QEMSCAN PMA analysis of -8µm fraction of Cleveland Tailings composite. Resolution @ 2µm**

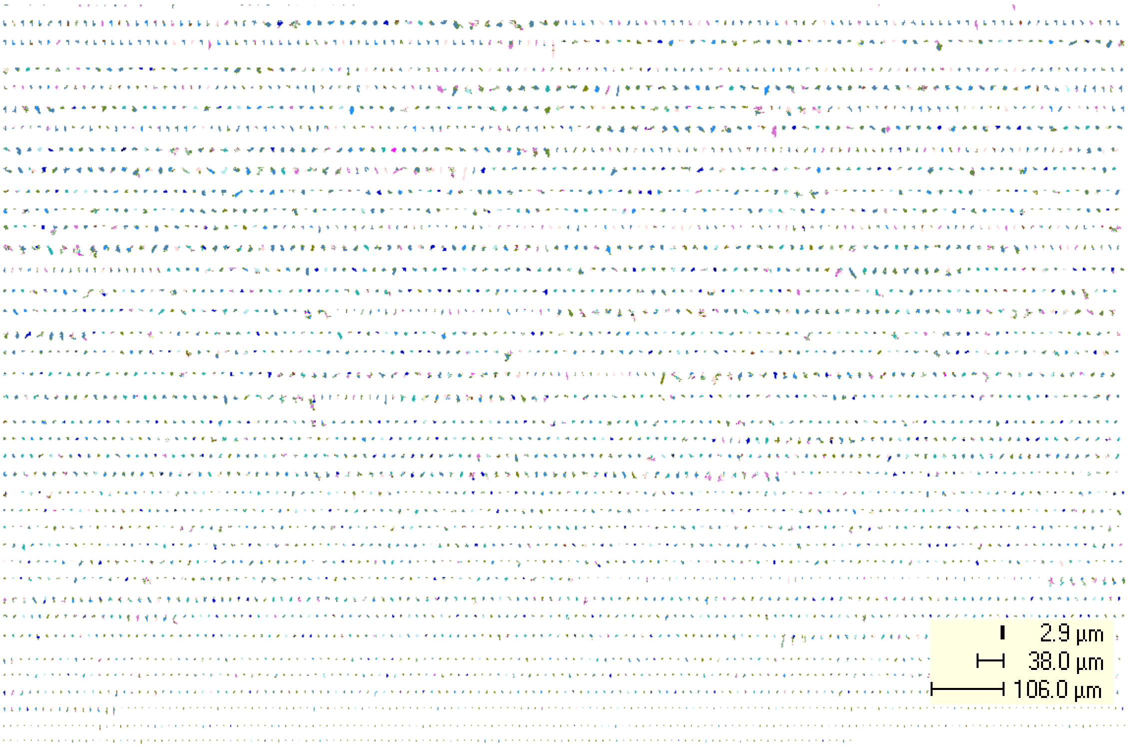



**Figure 16 - Particle map from QEMSCAN PMA analysis of -8µm fraction of Cleveland Tailings composite. Resolution @ 2µm**

# Appendix 3 - QEMSCAN Measurement Mode

*Extracts from iDiscover Technical Manual*

**Bulk Modal Analysis (BMA)**

Utilised for gangue mineralogy

The BMA measurement is a linear mode produces 'particles' that are single scan-lines across a SEM field of view; each one possibly intersecting several actual particles. The entire block is scanned producing an extremely high statistical population.

*Provides:*

Mineral Abundance

Grain Size Estimation *(indicative)*

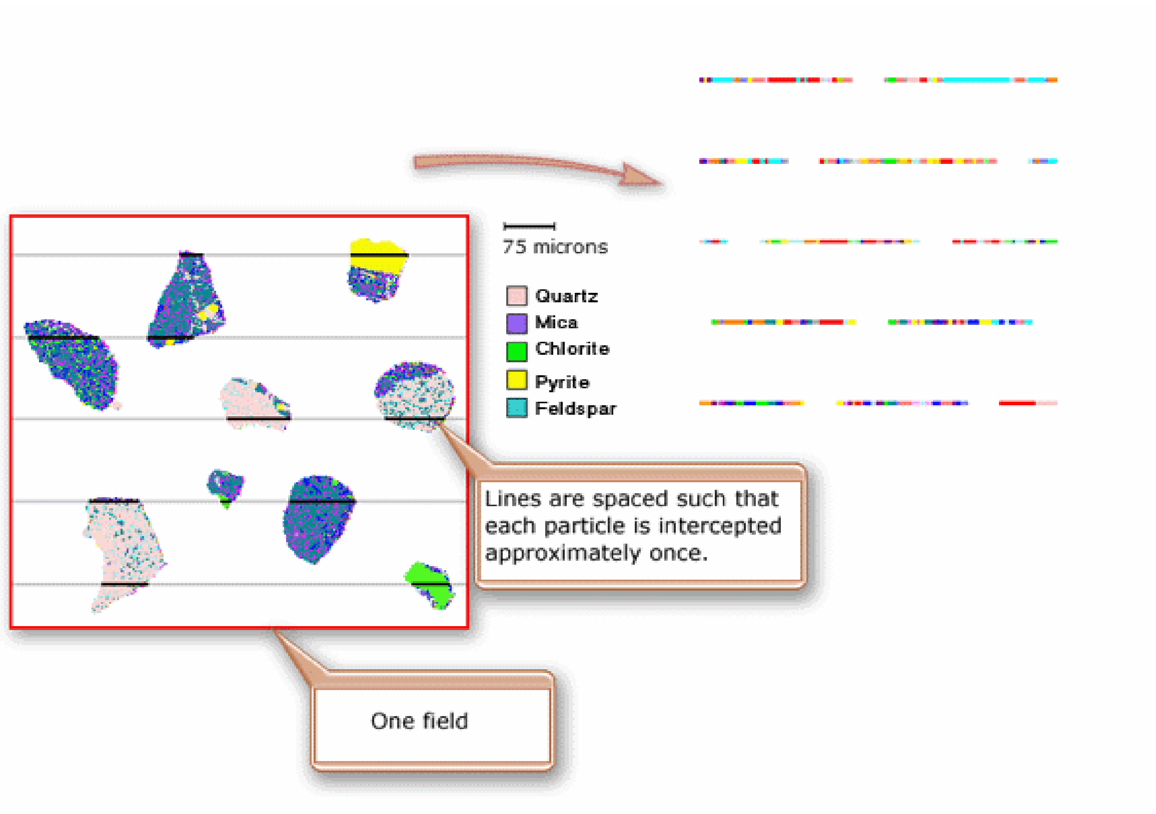
Elemental Deportment

Mineral Associations *(indicative)*

Liberation as area % only (*indicative)*

Locking as area % only (*indicative)*

Size-by-size elemental & mineralogical reconciliation




PGE s).

Sample requires pre-concentration by HLS, superpan etc and analysis of replicate blocks to obtain adequate particle stats for the rare phases such as Au.

The QEMSCAN differentiates the particles from resin (mounting media) on the basis of backscatter electron value (BSE). The entire area of each particle containing a bright phase (eg Cu, Au, Mo) is mapped

Recommended for good statistics on trace phases such as Uranium, Gold and Silver

*Provides:*

Mineral Species and Proportion

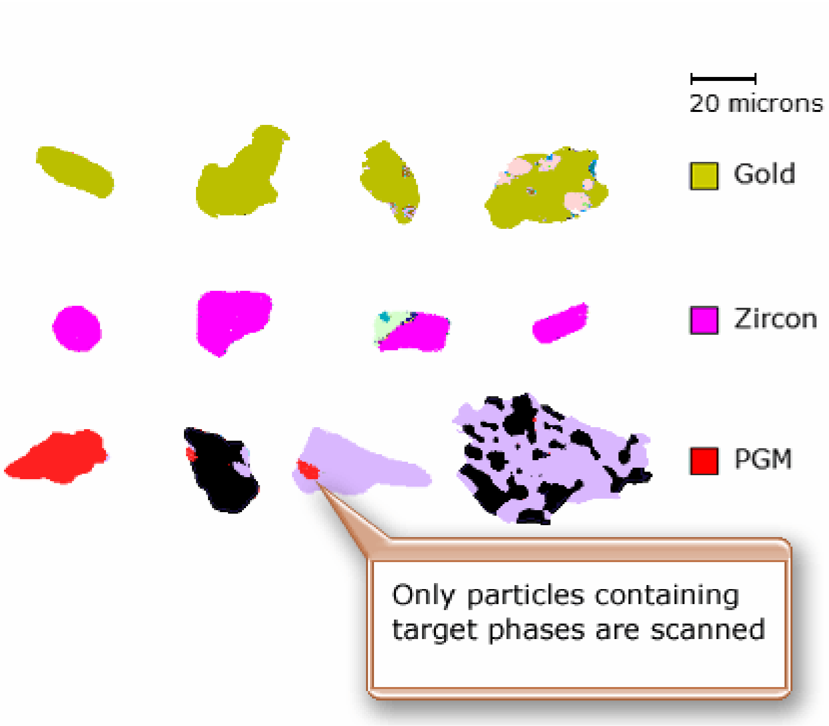
Grain Size Estimation

Elemental Deportment

Mineral Associations

Liberation (area % and surface area %)

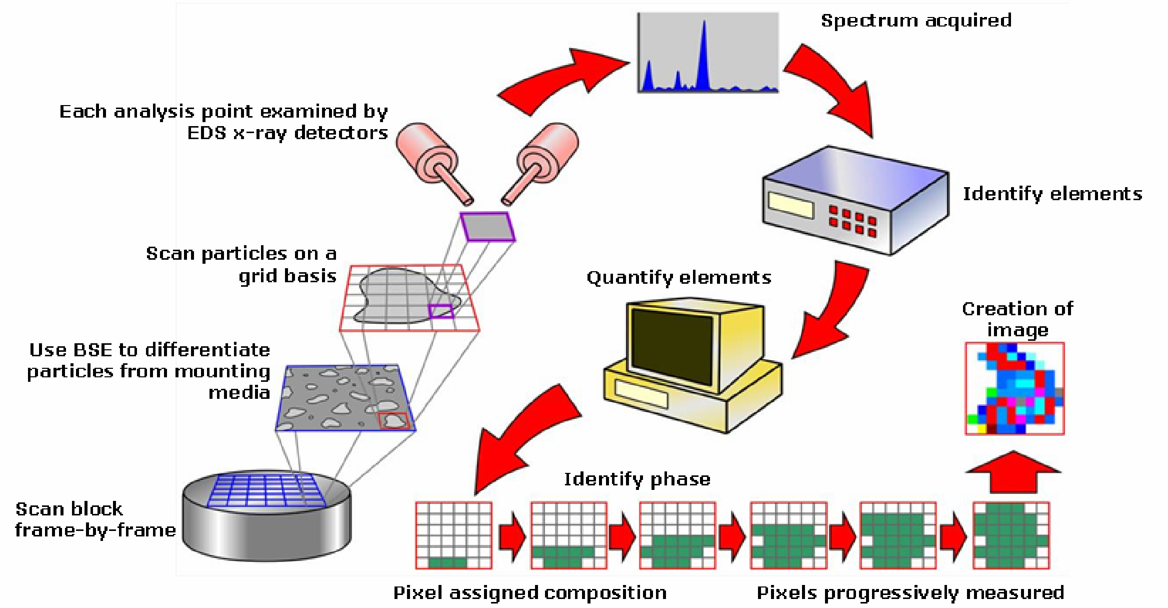
Locking (area % and surface area %)




Size-by-size elemental & mineralogical reconciliation

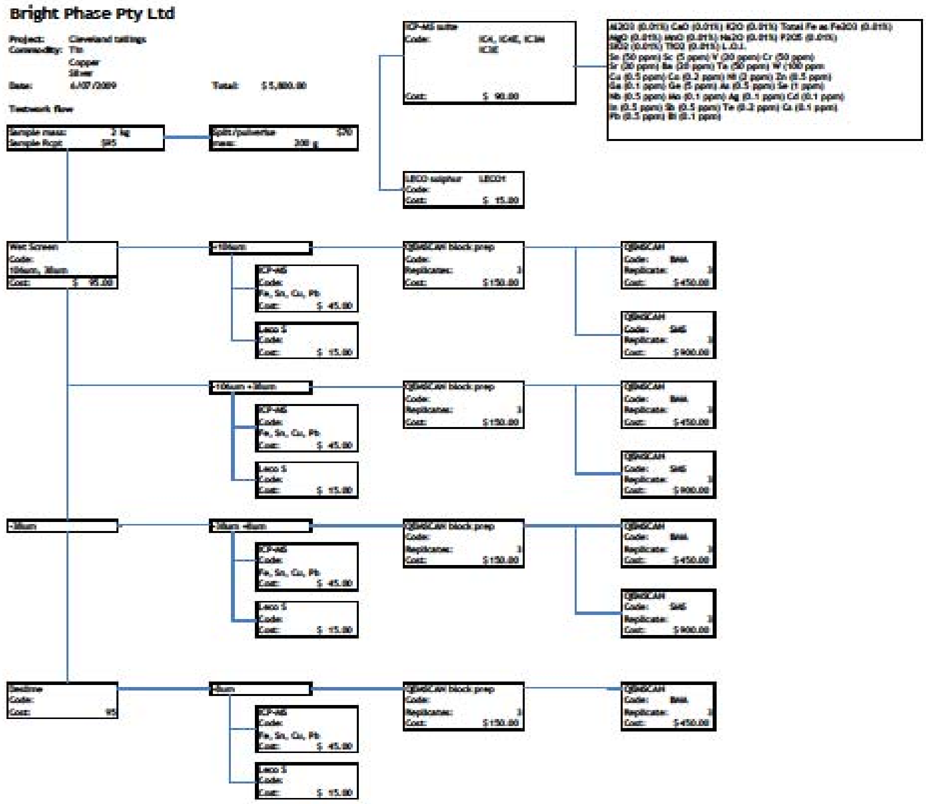
# Appendix 4 - QEMSCAN Identification of Minerals

The QEMSCAN system integrates Zeiss Leo scanning electron microscope (SEM) hardware with QEMSCAN software. The result is an automated image analysis instrument capable of performing high quality, quantitative mineralogical analysis. The system was originally developed by CSIRO to provide mineralogical support to concentrator process design and plant control in flotation circuits. The Amdel instrument offers the very latest in QEMSCAN technology and is equipped with four Bruker Silicon Drift Detectors (SDD) offering excellent light element detection, stability and speed; plus the new e-amp BSE pre-amplifier hardware that enables accurate and stable phase differentiation on the basis of backscatter.




When the electron beam hits the surface of a polished block characteristic x-rays and backscatter electrons (BSE) are generated. This combination of BSE information and characteristic x-rays is the basis for QEMSCAN mineral identification. As the information is collected it is automatically classified against a comprehensive reference library of mineral data that typically contains more than 200 entries. This reference library is known as the Species Identification Protocol (SIP) and consists of a series of categories defined by x-ray analytical information namely peaks present, peak heights and ratios of the peaks present; plus BSE values.

# Appendix 5 – Project workflow



ESKER Milling and Processing Pty Ltd

A.B.N. 13 009 566 750)

28 Marieville Esplanade
Sandy Bay
Hobart
Tasmania, 7005
Australia

Telephone: (61-3-62) 244-434
e-mail: moony@netspace.net.au
Facsimile: (61-3-62) 233-502
Mobile: (61-411) 857-706

**File Note**

Date: 28th April 2010
To: **John Lynch.**
At: Lynch Mining Pty. Ltd.
From: N. Moony.
Copies: Tony Choo, Adrian Brewer.
Subject; **Metallurgical test work on Cleveland Tailings in 2009**

≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈≈

Drill core drill samples were be collected and shipped to Burnie Research laboratories in late March 2008 and some 17 tests have been carried out since then.

**Stage One Continued (Burnie)**
**Number 1 Tailings Dam.**

**Summary**

A Blend TDI was made up on a weighted basis from each hole drilled in No.1 dam, and the following work carried out.

- Superpanning results have been reported in 2008/2009 and showed that cassiterite recovery was slightly lower than previous tests conducted in the early 19080's.

- Sighter Falcon tests were not satisfactory and more tests are required to find correct conditions.

- Cassiterite flotation work is continuing where it has been found that prefential iron oxide recovery caused difficulties in achieving good grade tin concentrates.

- Several depressants and alternative tin collectors have been tried to depress the fast flotation iron oxides with varying degrees of success (Folder attached).

- It has been demonstrated that high intensity magnetic separation removes the offending iron oxides, is simpler, incurs a smaller tin loss and allows cassiterite flotation to function normally. Aberfoyle test work also showed that this is a mandatory step. (Report attached)

- A full QEM- SEM analysis has been carried out on a sample TD1 and indicates the following points;
  - Most of the tin occurs as cassiterite with an average grain size in the 20µm to 5µm.
  - Agglomeration could cause problems in liberating cassiterite and copper minerals.
  - This study suggests that all the siderite in the Cleveland tailings has oxidized.

- In total 17 flotation tests have now been carried out.

- It is now intended to carry out whims testing on both TD1 and TD2 composites and as this seems the best way to go in order to achieve satisfactory results, this test programme will also include attritioning as several other investigations have shown this procedure has great value when treating tailings.

- When the whims/ flotation tests are complete it intended to see if pre concentration can work using closed cycle centrifuges, this procedure has also shown great promise on other tailings deposits.

## Test Work Notes

In early 2008 the Burnie Laboratory, Burnie, Tasmania (Ammtec subsidiary) was commissioned to carry out laboratory investigation on the retreatment of Cleveland Mine tin tailings (0.35-0.4%Sn) - by way of enhanced gravity (Falcon centrifugal concentrator) pre-treatment followed by flotation processes to achieve tin concentrate grade of greater than 15%Sn. The primary focus of the investigation was to evaluate the effectiveness of the Falcon Concentrator Ultrafine series (FCUF) – in simultaneously upgrading the head grade (Sn) and in rejecting waste material such as gangue minerals and slimes, which have been generally known to be unfriendly to flotation processes, especially to cassiterite tin flotation.

The current project, BRL TO383, was instigated by Esker Mineral Processing Pty Ltd (Nick Moony) for Lynch Mining, in the wake of FCUF's success reported in the Renison's Rentail project for the pre-treatment of the Renison Mine tin tailings. Metallurgical characteristics of Cleveland tailings were believed to be comparable to those of Renison. Drilled samples of Cleveland Tailings Dam 1 and 2 were obtained in late 2007 and despatched to BRL (Burnie Laboratory) for storage and experimentation. Material from Dam 1 was chosen first to commence laboratory investigation.

The preliminary results attained were less than satisfactory from all quarters – namely FCUF, sulphide flotation and cassiterite flotation – despite improved liberation of cassiterite from gangue minerals by grinding the existing tailings material finer.

Subsequently, using another master head composite made up of the remaining drilled samples from Dam 1, testwork recommenced in October 2008 in attempting to improve the performance of FCUF in order to achieve better flotation results. A regrind size of 98% finer than 38 micron was nominated for the FCUF feed – a compromise between liberating more cassiterite from gangue and generating a larger quantity of slimes, which would be harder to recover to grade.
Independently, a sub-sample of this FCUF feed was also put through superpan analysis (including sulphide flotation), in parallel, to assess the recovery potential (to grade) that could be expected from "freed" and "substantially freed" cassiterite in the sample. The results obtained were approximately 33% recovery to 39%Sn concentrate – which fell within the range estimated by AMS[1] (Aberfoyle Metallurgical Services) in 1984 for Dam 1 using the conventional processing option without matte fuming (AMS Internal Report No 84/8: Cleveland Tailings Retreatment – Pilot Plant and Laboratory Flotation Results). The results validated the "representativeness" of the drilled samples from Dam 1.

Evidently, the FCUF had not to date performed for Cleveland tailings as it had for Rentail – in that, without sacrificing recovery, the upgrading of head grade remained mediocre. Operating changes to a higher feed slurry density (10–15% solids) or to a higher energy spin (300–420 G) did not result in lowering Sn assay in reject tail. Furthermore, flotation results of the concentrate fraction from FCUF had not improved, indicating that FCUF had not fundamentally removed from tailings materials problematic to flotation. The adverse impact to flotation resulting from the by-products of oxidised iron (Fe)-bearing sulphides and carbonates in tailings had been previously highlighted in the aforementioned AMS report. Therefore, in light of the results obtained, the primary role of FCUF in the retreatment of Cleveland tailings will have to be reviewed.

It is also indicative that, because of the in-situ oxidation by-products, Cleveland tailings are metallurgically more complex than Renison tailings for flotation on the samples treated – including sulphide flotation. All the flotation results[1] reiterate the findings by AMS[2] – in that prerequisites to successful cassiterite flotation appear to be: vigorous desliming (and washing of soluble metal ions by extension); sulphide removal (flotation complemented by low intensity magnetic separation); and effective rejection of oxidised sulphide and sideritic carbonates (by high magnetic intensity). It is recommended that the next stage of test work on Cleveland tailings retreatment will need to go back to the basics in removing and/or suppressing these flotation-interfering components and that may have to also include attrition-cleaning (of mineral surfaces) in the feed preparation stage and the use of an effective dispersant during cassiterite flotation.

[1] BRL results 2008 -2010.

2 Internal Report No: AMS 84/8 Cleveland Tailings Retreatment – Pilot Plant and Laboratory Flotation Results.

BRIGHT PHASE

WILL GOODALL PhD BEng(Chem)(Hons)

Senior Technical Consultant +61 408 562 319 willg@brightphase.com.au

Bright Phase Pty Limited ACN 127 819 710 PO Box 256 Holland Park QLD 4121 Australia www.brightphase.com.au

# Mineralogical Evaluation of Cleveland Tailings by QEMSCAN

*Date: January 2010*

*Prepared by: Dr Will Goodall*

Sample: Head Sample CTD 201-221

## Summary of Findings

Examination of Cleveland Tailings (CTD 201-220) sourced from the Cleveland project, Tasmania, Australia (EL7/2005) was completed using QEMSCAN by Bright Phase Pty Ltd. The primary focus of this program was to define the deportment of Sn and Cu, along with the root cause for poor recovery by conventional flotation and gravity separation.

The key outcomes of this study included:

- All tin (Sn) occurred in Cassiterite ($SnO_2$), which is known to be a floatable mineral.
- All copper (Cu) occurred with floatable copper iron sulphide minerals.
- Average grain size of Sn minerals was 5-20 μm, which is below practical recovery size for conventional flotation or gravity processes.
- Liberation of Sn and Cu minerals was poor in coarse particles. However, coarse particles consisted of agglomerated fine particles and should be easily broken down, promoting liberation.
- Major contaminant minerals were pyrite and pyrrhotite, which must be depressed in flotation processes.

*Fine grain size and poor liberation caused by agglomeration of value minerals, adequately described why conventional gravity and flotation methods have been unsuccessful in obtaining saleable tin and copper concentrate.*

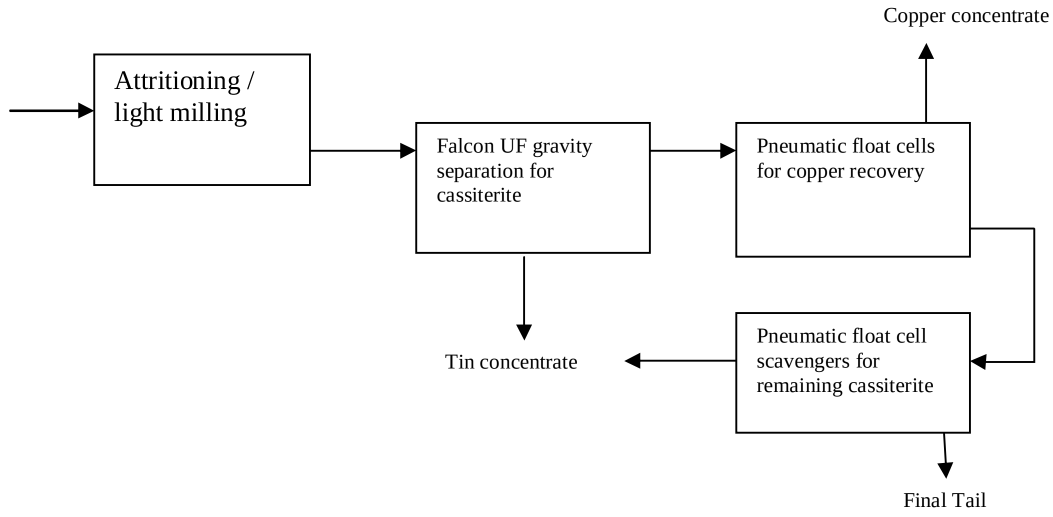
To overcome these difficulties a number of solutions may be examined, which must address the following key issues:

- Liberation of copper and tin minerals must be promoted by deagglomeration of coarse particles.
- Any solution must have the capability to recover fine particles, typically in the range of 5 – 20 μm.

Bright Phase Pty Ltd proposes that the key processing criteria for the Cleveland tailings may be addressed through use of the following technologies:

- Attritioning of agglomerated particles through use of high shear devices or light milling.
- Ultra-fine gravity separation devices, such as the new Falcon UF series centrifugal concentrators.
- Fine particle flotation systems, such as pneumatic float cells.

A potential block diagram flowsheet that may be suggested from the findings of this study may be seen below:




*Economic recovery of Sn and Cu should be achievable from Cleveland Tailings if additional liberation can be achieved and solutions for fine particle flotation or gravity separation can be implemented*

**Next Steps:**

1. Undertake amenability testing of Cleveland tailings with vendors of pneumatic float cells and ultra-fine gravity recovery solutions.
    a. BPPL has contacts with a number of vendors in this area and will be able to facilitate amenability testing in a fast and efficient manner.
    b. Consideration of the degree of deagglomeration required and amenable methods should be considered at this stage.
2. With positive results proceed to pilot scale testing of amenable flowsheet.
    a. Pilot scale plants are available for most technologies and may be set up directly on-site.
3. Using amenability and pilot scale testing results undertake engineering design and construction of process plant.