Quantitative Automated Mineralogical Analysis

conducted on

Two (2) Cassiterite Sulphidic Ores from Queen Hill Project

for

Stellar Resources/Burnie Research Laboratory

Mineralogy Report No. MIN575(E)

November 2010

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SUMMARY

Two (2) unsized and coarse (P_{80} @ 250 µm) composites of skarn cassiterite ores were received from the Queen Hill for quantitative automated mineralogical analysis.

A summary of significant findings follows:

1. Quantitative Mineralogy

- Both composites have similar mineralogical composition and represent sulphidic (pyrite) cassiterite skarn ore.

- **Composite 1** contains minor cassiterite associated with dominant pyrite and accessory quartz and Fe oxides (1.96%, 43.4%, 21.2% and 18.9% of the sample mass, respectively).

  The sample contains minor sphalerite (0.4%) and traces of other sulphides especially pyrrhotite.

  Minor gangue minerals include muscovite, fluorite, biotite/chlorite and some apatite.

- **Composite 2** contains less cassiterite (1.28%) and is associated with a noticeably more sulphidic ore type.

  The sample contains more sphalerite (0.9%) and the gangue minerals are dominated by pyrite, accessory quartz and iron oxides (59.2%, 17.2% and 13.4%, respectively).

  Pyrrhotite is relatively common at 4.3% and fluorite occurs as a minor gangue mineral (1.7%).

  All other minerals including micas occur as traces.

2. *Locking of Cassiterite*

- Due to the absence of spot microanalysis data, the Sn is assumed to be contained entirely by cassiterite.
- The majority of **cassiterite** is typically contained in five abundant particle types.
- More than 90% liberated and 60-90% liberated cassiterite account for less than half of all of the cassiterite in both composites,
- The binary particles with pyrite enclose 13.2% and 11.1% of all detected cassiterite in the Comp 1 and Comp 2 samples, respectively. The average cassiterite grain size in this particle type is 14.6 µm and 17.2 µm in Comp 1 and Comp 2, respectively.
- The binary particles with iron oxides contain 18.1% and 21.6% of cassiterite in Comp 1 and Comp 2, respectively. The cassiterite in those particles is marginally coarser and averages 18.6 µm and 20.8 µm in size for Comp 1 and Comp 2, respectively.
- Low grade cassiterite middlings contain 23.7% and 19.5% of all cassiterite mass in Comp 1 and Comp 2, respectively. The average cassiterite grain size in both composites slightly exceeds 17 µm.
- Other particle types carry negligible cassiterite.

3. *Theoretical Grade Recoveries - Upgrading Potential of Cassiterite and Sphalerite at the Established Grind*

- Both composites contain a significant proportion of locked cassiterite and sphalerite.
- Theoretically just about 70% of all cassiterite-bound **tin** can be extracted at close to 53% Sn grade from both composites.
- Comp 2 contains sphalerite that can be upgraded to ~59% concentrate with about half of the sphalerite-bound **zinc** recovered. Comp 1 contains little upgradable sphalerite at the established grind.

1. INTRODUCTION

Two (2) unsized and coarse (P_{80} @ 250 µm) composites of skarn cassiterite ores were received from the Queen Hill project for quantitative automated mineralogical analysis.

The aim of these examinations is to characterise the following:

- Quantitative mineralogy of the tin minerals, potentially economic by-products and gangue minerals,
- Liberation and locking characteristics of key minerals for initial beneficiation studies,
- Elemental deportment of tin.

The mineralogical work was requested by **Mr John Glen** (AMMTEC Burnie Research Laboratory) on behalf of the project operator and was undertaken and supervised by **Mr Ian Lach** (AMMTEC Mineralogy).

ROD SMITH
Managing Director

IAN LACH
Senior Process Metallurgist

2. SAMPLES RECEIVED

The following samples were received:

Sample/ P_{80} @ 250 µm	Mass Retained (%)	Sn (%)	Cu (%)	Mn (%)	Fe (%)	S (%)	Mineralogy Sample No.
Comp 1 N# 587001	100	1.00	0.02	0.24	25.11	15.51	MIN575A1A
Comp 2 N# 587002	100	0.93	0.04	0.19	29.63	23.08	MIN575A2A

3. SAMPLE PREPARATION

The samples were micro-riffled, mixed with graded graphite; dry de-agglomerated then cold set in epoxy resin.

Two (2) 30 mm diameter polished blocks were prepared for QEMSCAN analysis and loaded for measurement.

4. ANALYTICAL PROCEDURES

The Quantitative Automated Mineralogy QEMSCAN mode of measurement used to analyse the sample is listed below:

- Particle Mineralogical Analysis (PMA) of the randomly selected initial 10,000+ particles.

PMA was performed with pixel spacing set at 5 µm for both samples. Consequently all particle intercepts larger than 15 µm have been analysed.

5. RESULTS

5.1 Quantitative Mineralogy

During automated analysis, the data resulted in an extensive mineral list.

Data validation allowed simplification of the mineral list into following mineral groupings:

Mineral Group	Abbreviation Used	Mineral Formula or Description
Cassiterite	Cst	***SnO_2*** *Potentially contains some impurities especially Fe and Ti - requires spot microanalysis follow up*
Sphalerite	Sph	***(Zn,Fe)S*** *- Allocated 2.9% Fe. The Fe content in sphalerite ought to be established with spot microanalysis methods*
Galena	Gal	*Minor* ***PbS***
Chalcopyrite	Cpy	***$CuFeS_2$*** *- may contain traces of other Cu minerals*
Minor Sulphides		*Traces of other sulphides particularly arsenopyrite, pentlandite and violarite*
Pyrite	Py	*Dominant sulphide gangue* ***FeS_2*** *most likely contain some trace impurities including Zn*
Pyrrhotite		*Accessory* ***$Fe_{1-x}S$***
Quartz	Qtz	***SiO_2*** *may contains minor impurities*
Muscovite		***$KAl_2[Si_3AlO_{10}](OH,F)_2$***
Biotite/Chlorite		*Combined* ***ferromagnesian silicates*** *including dominant* ***biotite*** *and* ***chlorite***
Clays		*Minor aluminium rich clays*
Fe Oxides	FeOx	*Combined* ***iron oxides / oxyhydroxides***
Fluorite	Fl	*Relatively common* ***CaF_2***
Apatite		***$Ca_5[(PO_4)_3(F, Cl, OH)]$*** *likely fluoro-apatite*
Minor Phases		*Combined minor minerals predominantly rutile, silicates, carbonates, tourmaline etc.*

The following table illustrates quantitative mineralogy for the sample and a bar chart illustrating the data appears in Appendix I:

5.1.1 Queen Hill Skarn Mineral Abundances

Mineral Grouping	MINERAL MASS PERCENT (%) IN SAMPLE	
	Queen Hill Project	
	Comp 1	Comp 2
Cassiterite	1.96	1.28
Sphalerite	0.42	0.87
Galena	0.04	0.16
Chalcopyrite	0.01	0.02
Minor Sulphides	0.02	0.02
Pyrite	43.44	59.22
Pyrrhotite	0.17	4.30
Quartz	21.02	17.15
Muscovite	6.72	0.92
Biotite/Chlorite	1.75	0.06
Clays	0.53	0.35
Fe Oxides	18.90	13.37
Fluorite	3.30	1.66
Apatite	0.41	0.08
Minor Phases	1.31	0.55
TOTAL	100.0	100.0

- Both composites have similar mineralogical composition and represent sulphidic (pyrite) cassiterite skarn ore.

- **Composite 1** contains minor cassiterite associated with dominant pyrite and accessory quartz and Fe oxides (1.96%, 43.4%, 21.2% and 18.9% of the sample mass, respectively).

  The sample contains minor sphalerite (0.4%) and traces of other sulphides especially pyrrhotite.

  Minor gangue minerals include muscovite, fluorite, biotite/chlorite and some apatite.

- **Composite 2** contains less cassiterite (1.28%) and is associated with noticeably more sulphidic ore type.

  The sample contains more sphalerite (0.9%) and the gangue minerals are dominated by pyrite, accessory quartz and iron oxides (59.2, 17.2 and 13.4%, respectively).

  Pyrrhotite is relatively common at 4.3% and fluorite occurs as minor gangue mineral (1.7%).

  All other minerals including micas occur as traces.

5.2 Calculated Grain Size

The average grain size estimations are produced from two-dimensional random sections of mineral grains and approximated to spheres of a certain diameter. Typically both particle and grain sizes are to some extent under-estimated especially in an unsized sample. Statistics of some minor minerals can be affected by the small number of grains intercepted with random particle selection. All particle intercepts larger than 15 µm have been accepted from each fraction.

Mineral grain sizes are shown in the following table and appear diagrammatically in Appendix II.

5.2.1 Queen Hill Skarn Particle/Grain Sizing

Mineral Grouping	AVERAGE PARTICLE AND GRAIN SIZES (μm)	
	Queen Hill Project	
	Comp 1	Comp 2
D_{50} Particle Size	86	90
Cassiterite	22	25
Sphalerite	33	41
Galena	12	16
Chalcopyrite	14	21
Minor Sulphides	14	
Pyrite	60	73
Pyrrhotite	17	55
Quartz	57	65
Muscovite	32	25
Biotite/Chlorite	24	13
Clays	25	26
Fe Oxides	44	47
Fluorite	36	42
Apatite	23	18
Minor Phases	19	18

- The average particle size of both composites is similar and ranges from 86 μm in Comp 1 to 90 μm in Comp 2.
- Pyrite and quartz are relatively coarse in both composites.
- Pyrrhotite from Comp 2 also forms coarse grains.
- Iron oxides and fluorite occur as medium sized grains in both composites.
- Cassiterite and sphalerite have, on average, fine to medium sized grains (22-25 μm and 33-41 μm range in the Comp 1 and Comp 2, respectively).
- Remaining minerals form comparatively small grains.

5.3 Mineral Associations

Mineral association data are created based on transition numbers (grain contacts) created during the PMA scan, which are normalised to 100%. The data are illustrated in bar charts in Appendix III. Relative to 100%, the columns emphasise the proportions of mineral associations for each individual mineral. Large background/surface exposure ratio is an indication of good liberation of a particular mineral.

5.3.1 Queen Hill Skarn Mineral Associations

- Both composites show relatively extensive intergrowths of potentially economic minerals with gangue indicating poor liberation characteristics of minerals of interest at the established grind.
- The majority of sphalerite in both composites is inter-grown with iron oxides, pyrite, quartz, some fluorite and muscovite.
- Sphalerite is marginally better liberated and extensive inter-growths include pyrite, iron oxides, quartz and some muscovite.
- Galena and chalcopyrite are mainly associated with pyrite.
- Abundant pyrite is marginally inter-grown with iron oxides and quartz.
- Relatively common pyrrhotite in Comp 2 is weakly associated with pyrite, iron oxides and quartz.
- Abundant quartz is moderately inter-grown with muscovite, iron oxides and pyrite in the Comp 1. In the other sample quartz is marginally associated with iron oxides and pyrite.
- The other non-sulphide gangue minerals are largely associated with pyrite, quartz and each other.

5.4 Textural Indications (Particle Images)

Particle maps are produced as a part of the automated mineralogical analysis to visualise textural relationships, liberation and locking characteristics between mineral phases. PMA analyses random subpopulation of about 10,000+ particles and the particles are sorted in order of decreasing particle, cassiterite and sphalerite area.

Particle images illustrating particle maps and textural characteristic appear in Appendix IV.

5.5 Elemental Deportment (Fe and S)

Deportment of Fe and S is presented in the following tables and as bar chart diagrams in Appendix V. Due to the absence of spot microanalysis data the analytical Sn and Zn is assumed to be contained entirely by cassiterite and sphalerite, respectively.

5.5.1 Iron (Fe)

Mineral Grouping	MASS Fe % IN SAMPLE/FRACTION	
	Queen Hill Project	
	Comp 1	Comp 2
Cassiterite	0.0	0.0
Sphalerite	0.0	0.1
Chalcopyrite	0.0	0.0
Minor Sulphides	0.0	0.0
Pyrite	63.6	71.9
Pyrrhotite	0.3	7.0
Biotite/Chlorite	0.5	0.0
Clays	0.0	0.0
Fe Oxides	35.4	20.9
Minor Phases	0.0	0.0

- Iron is essentially contained in dominant pyrite and accessory iron oxides (63.6-71.9% and 35.4-20.9% range in the Comp 1 and Comp 2, respectively).
- Other minerals hold traces of iron with an exception of pyrrhotite in the Comp 2 that encapsulates 7.0% of accounted iron.
- The degree of Fe substitution in sphalerite ought to be established by some spot microanalysis methods.

5.5.2 Sulphur (S)

Mineral Grouping	MASS S % IN SAMPLE/FRACTION	
	Queen Hill Project	
	Comp 1	Comp 2
Sphalerite	0.5	0.8
Galena	0.0	0.1
Chalcopyrite	0.0	0.0
Minor Sulphides	0.0	0.0
Pyrite	99.3	94.4
Pyrrhotite	0.2	4.7
Minor Phases	0.0	0.0

- Sulphur is distributed proportionally to the abundance of major sulphides and the great majority of sulphur is contained by pyrite (99.3% and 94.4% in Comp 1 and Comp 2, respectively).
- Minor sulphur from Comp 2 is contained by pyrrhotite (4.7%).

5.6 Liberation and Locking of Cassiterite and Sphalerite

The particles are sub-categorised by the liberation of the above mineral groupings. Mineral content has been expressed in mass % to represent minerals of interest.

5.6.1 Liberation and Mass Distribution of Selected Minerals (by Area %)

Liberation of selected minerals measured in increments of 10% (0-100%) is provided in the following tables and diagrammatically in Appendix VI. Liberation categories in this report are defined by liberation of individual mineral groupings from the mineral list and area % method (accounts for inclusions). Due to analysis of an unsized sample the liberation of the selected minerals is likely to be somewhat over-estimated.

5.6.1.1 Cassiterite Liberation

MASS % OF CASSITERITE IN LIBERATION CATEGORIES											
Sample	Liberation Categories (by Area % ≈Vol %)										
	≤10%	≤20%	≤30%	≤40%	≤50%	≤60%	≤70%	≤80%	≤90%	<100%	100%
Comp 1	23.5	10.0	7.5	8.6	7.0	2.8	19.0	3.4	1.7	11.4	5.2
Comp 2	25.0	4.6	8.5	2.6	12.5	1.1	18.0	7.5	1.0	6.9	12.3

- Cassiterite is poorly to moderately liberated and the majority of the cassiterite mass occurs as less than 50% liberated grains.
- More than 60% liberated cassiterite accounts for 40.7% and 45.7% of all cassiterite in Comp 1 and Comp 2, respectively.
- Well liberated (>90% liberated) cassiterite contains just 16.6% and 19.2% of all the sphalerite mass in Comp 1 and Comp 2, respectively.

5.6.1.2 Sphalerite Liberation

MASS % OF SPHALERITE IN LIBERATION CATEGORIES											
Sample	Liberation Categories (by Area % ≈Vol %)										
	≤10%	≤20%	≤30%	≤40%	≤50%	≤60%	≤70%	≤80%	≤90%	<100%	100%
Comp 1	17.0	1.4	10.0	1.5	22.2	1.7	13.1	2.8	13.8	12.4	4.2
Comp 2	3.1	11.5	5.9	14.2	7.3	0.2	4.9	0.7	9.4	27.4	15.4

- Sphalerite is noticeably better liberated than cassiterite and more than 60% liberated grains account for 46.2% and 57.8% of all sphalerite in Comp 1 and Comp 2, respectively.
- More than 90% liberated sphalerite contains 16.5% of sphalerite from Comp 1 and 42.7% from Comp 2.

5.7 Mass Distribution of Cassiterite and Sphalerite in Particle Locking Categories

Particles are sorted in order of volume area % set arbitrarily at different levels. Locking characteristics measured by volume area % comprise particles with selected mineral area % and includes grains locked inside particles at the selection process.

The liberation and locking in the samples has been categorised as follows:

Particle Locking Categories	Description/Naming Convention (first fit - particles are selected in descending order by area %)
Lib Cst >= 90%	Particles containing **cassiterite** that occupies 90% or more of the particle volume **~ liberated cassiterite**
Lib Cst >= 60%	Particles containing **cassiterite** that occupies 60% or more of the particle volume but less than 90% selected earlier **~ 60-90% liberated cassiterite**
Lib Sph >= 90%	Particles containing **sphalerite** that occupies 90% or more of the particle volume **~ liberated sphalerite**
Lib Sph >= 60%	Particles containing **sphalerite** that occupies 60% or more of the particle volume but less than 90% selected earlier **~ 60-90% liberated sphalerite**
Bin Cst + Py >= 60%	Particles containing **combined cassiterite and pyrite** that occupy 60% or more of the particle volume but **Cst** itself does not exceed 60% of the particle volume - selected earlier **~ binary cassiterite-pyrite particles**
Bin Cst + FeOx >= 60%	Particles containing **combined cassiterite and iron oxides** that occupy 60% or more of the particle volume but **Cst** itself does not exceed 60% of the particle volume - selected earlier **~ binary cassiterite-iron oxide particles**
Bin Sph + Py >=90%	Particles containing **combined sphalerite and pyrite** that occupy 90% or more of the particle volume but **Sph** itself does not exceed 60% of the particle volume - selected earlier **~ binary sphalerite-pyrite particles**
Bin Sph + Qtz >=90%	Particles containing **combined sphalerite and quartz** that occupy 90% or more of the particle volume but **Sph** itself does not exceed 60% of the particle volume - selected earlier **~ binary sphalerite-quartz particles**
Tern Cst + Fl + Qtz >= 90%	Particles containing **combined cassiterite and fluorite/quartz** that occupy 90% or more of the particle volume **Cst** itself does not exceed 60% of the particle volume - selected earlier **~ ternary cassiterite-fluorite-quartz particles**
Other Cst	All other particles containing **cassiterite** and not selected before **~ typically low grade cassiterite middlings**
Other Sph	All other particles containing **sphalerite** and not selected before **~ typically low grade sphalerite middlings**
Barren Particles	All other particles free of **cassiterite and sphalerite** **~ liberated gangue**

The mass % distribution of selected minerals in locking categories is illustrated in the following tables and appears diagrammatically as bar charts and images of particles within each category in Appendix VII.

For the naming convention of particles refer to the above table.

5.7.1 Locking of Cassiterite

Particle Type	CASSITERITE MASS % IN PARTICLE LOCKING CATEGORIES	
	Queen Hill Project	
	Comp 1	Comp 2
Lib Cst >= 90%	16.6	19.4
Lib Cst >= 60%	24.5	26.3
Lib Sph >= 90%	0.0	0.1
Lib Sph >= 60%	0.0	0.1
Bin Cst + Py >= 60%	13.2	11.1
Bin Cst + FeOx >= 60%	18.1	21.6
Bin Sph + Py >=90%	0.0	0.0
Bin Sph + Qtz >=90%	0.1	0.0
Tern Cst + Fl + Qtz >= 90%	3.8	1.8
Other Cst	23.7	19.5
Other Sph	0.0	0.0
Barren Particles	0.0	0.0

- The majority of the **cassiterite** is typically contained in five abundant particle types.
- More than 90% liberated and 60-90% liberated cassiterite account for less than half of all of the cassiterite in both composites,
- The binary particles with pyrite enclose 13.2% and 11.1% of all detected cassiterite in Comp 1 and Comp 2, respectively. The average cassiterite grain size in this particle type is 14.6 µm and 17.2 µm in Comp 1 and Comp 2, respectively.
- The binary particles with iron oxides contain 18.1% and 21.6% of cassiterite in Comp 1 and Comp 2, respectively. The cassiterite in those particles is marginally coarser and averages 18.6 µm and 20.8 µm in size for Comp 1 and Comp 2, respectively.
- Low grade cassiterite middlings contain 23.7% and 19.5% of all cassiterite mass in Comp 1 and Comp 2, respectively. The average cassiterite grain size in both composites slightly exceeds 17 µm.
- Other particle types carry negligible cassiterite.

5.7.2 Locking of Sphalerite

Particle Type	SPHALERITE MASS % IN PARTICLE LOCKING CATEGORIES	
	Queen Hill Project	
	Comp 1	Comp 2
Lib Cst >= 90%	0.0	0.0
Lib Cst >= 60%	0.0	0.1
Lib Sph >= 90%	16.5	42.7
Lib Sph >= 60%	29.7	15.0
Bin Cst + Py >= 60%	0.2	1.2
Bin Cst + FeOx >= 60%	1.7	0.2
Bin Sph + Py >=90%	7.2	9.5
Bin Sph + Qtz >=90%	13.3	9.0
Tern Cst + Fl + Qtz >= 90%	0.0	0.0
Other Cst	3.9	11.1
Other Sph	27.5	11.0
Barren Particles	0.0	0.0

- The locking pattern of sphalerite differs noticeably in both composites.
- **Comp 1** contains slightly less than half of all of the sphalerite as >90% and 60-90% liberated grains, combined.

  Binary particles with quartz or pyrite include 13.3% and 7.2% of sphalerite mass, respectively. The average sphalerite corresponding grain size is 49.6 µm and 26.9 µm.

  Low grade sphalerite middlings contain 27.5% of this mineral mass and the average sphalerite grain size reaches 23.3 µm.

  Other particle types contain minor sphalerite.
- **Comp 2** contains the majority of sphalerite as combined >60% liberated grains (57.8% of sphalerite mass).

  Binary particles with pyrite or quartz comprise 9.5% and 9.0% of sphalerite mass, respectively. Sphalerite associated with quartz averages 58.4 µm in size and the other one is significantly finer (20.9 µm).

  Low grade sphalerite middlings encapsulate just 11.0% of this mineral mass and the average sphalerite grain size is 25.6 µm.

  An unusually large proportion of sphalerite is locked in low grade cassiterite middlings (11.1% with an average sphalerite grain size of 31.2 µm).

5.8 Theoretical Grade Recoveries – Upgrading Potential of Cassiterite and Sphalerite

PMA data provide indicative liberation data. Theoretical Grade Recoveries reflect relative liberation of minerals of interest and their chemical composition. Diagrams are constructed assuming only particles containing economic minerals depart to the concentrate. Elemental grade and recoveries are recalculated proportionally from optimal recoveries of liberated cassiterite/sphalerite grains progressively interlocked with gangue.

The theoretical grade recovery report is an additional tool assisting in optimising of the beneficiation process. They are many of the real world factors affecting actual grade and recovery as textural characteristic of ore, mineral inter-growths or coatings. The figure indicates the highest and ideal recovery irrespectively from all contributing factors except mineral Sn/Zn grade/mass, associated gangue and cassiterite/sphalerite liberation.

Graphs illustrating grade recovery profiles appear in Appendix VIII and grade recovery data of interest has been tabulated on the following table:

	Comp 1		Comp 2			Comp 1		Comp 2	
	Recovery	Grade	Recovery	Grade		Recovery	Grade	Recovery	Grade
Sn	12.0	78.1	17.0	77.9	Zn				
	18.5	76.6	20.4	77.1					
	21.8	75.0	28.1	74.0					
	40.8	68.4	31.0	72.7		10.1	62.0	28.8	62.8
	42.6	67.8	43.8	66.9		16.9	60.0	46.3	60.9
	48.4	65.7	51.7	64.1		33.8	56.4	52.0	59.7
	50.7	64.6	57.1	61.9		34.8	56.1	54.0	59.2
	57.1	60.9	59.0	61.0		47.1	52.3	54.0	59.2
	63.6	57.1	62.3	59.1		47.1	52.3	59.0	56.1
	64.5	56.5	64.7	57.1		60.3	46.7	64.8	52.8
	67.1	54.2	70.6	52.6		66.5	43.5	70.1	49.8
	70.9	49.9	72.5	50.8		71.9	40.9	78.5	44.4
	75.2	45.4	74.9	47.7		79.3	36.2	83.0	40.6
	82.7	35.9	81.5	38.4		84.1	32.6	86.3	37.9
	90.3	26.3	89.3	28.2		84.9	31.5	97.2	26.1
	100.0	1.5	100.0	1.0		100.0	0.2	100.0	0.5

- Both composites contain a significant proportion of locked cassiterite and sphalerite.

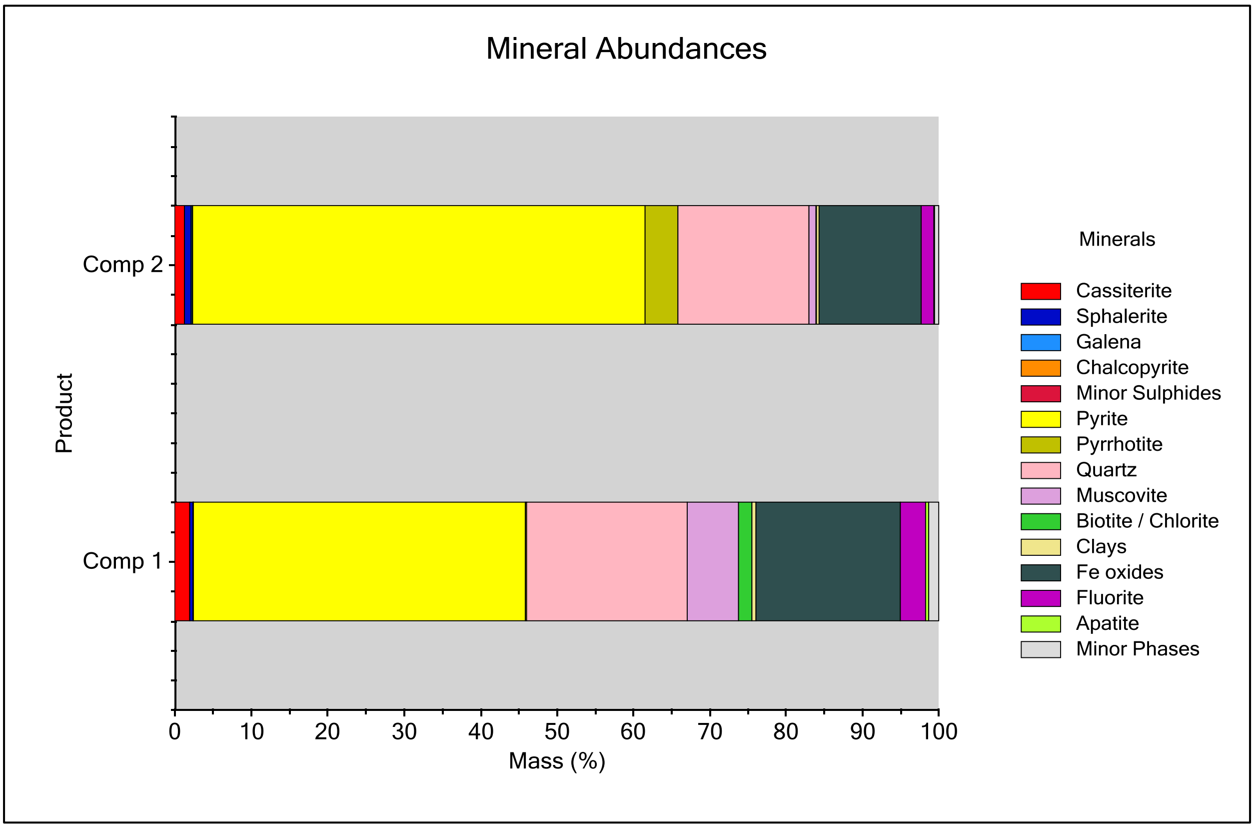
- Theoretically just about 70% of all of the cassiterite-bound **tin** can be extracted at close to 53% Sn grade from both composites.

- Comp 2 contains sphalerite that can be upgraded to ~59% concentrate with about half of the sphalerite-bound **zinc** recovered. Comp 1 contains little upgradable sphalerite at the established grind.

MINERALOGY APPENDICES

MINERALOGY
APPENDIX I

Quantitative Mineralogy


Mineral Abundances
Product
Comp 2
Comp 1
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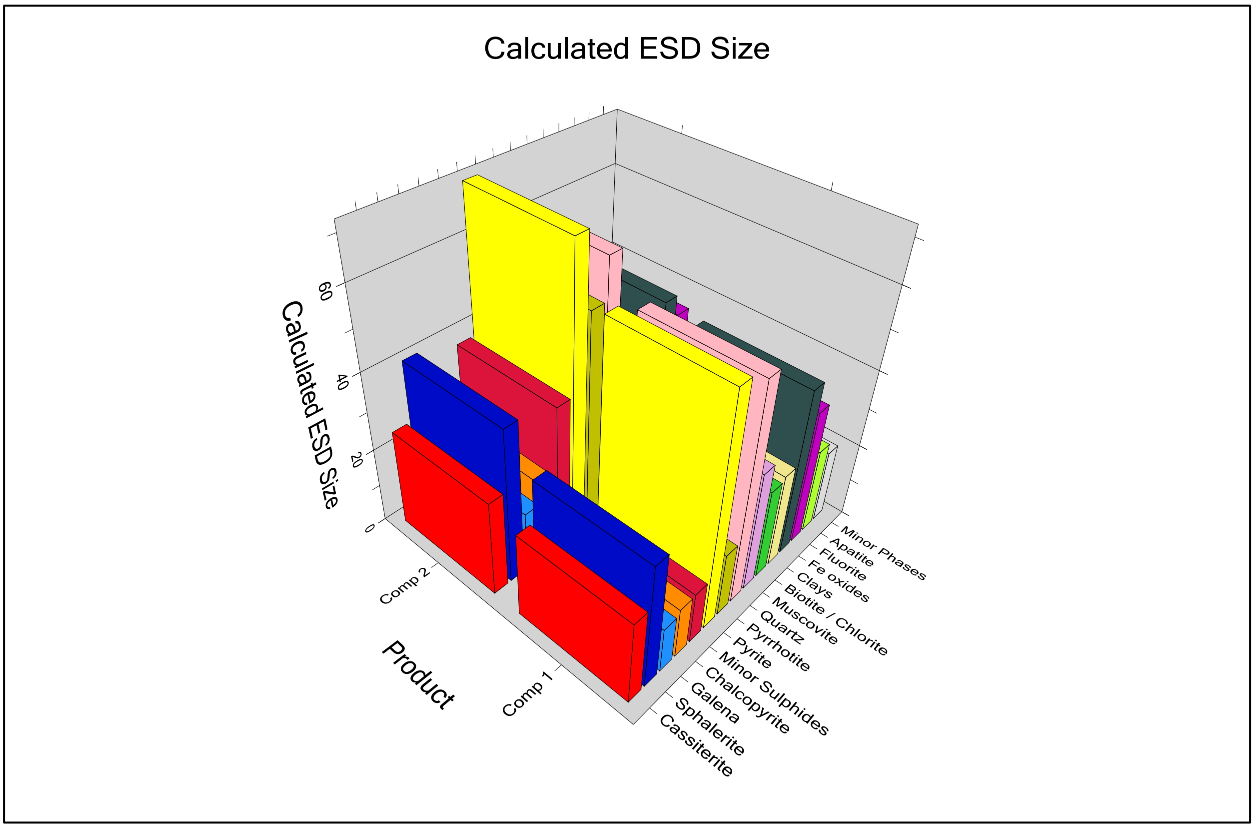
10
20
30
40
50
60
70
80
90
100
Mass (%)
Minerals
Cassiterite
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Quartz
Muscovite
Biotite / Chlorite
Clays
Fe oxides
Fluorite
Apatite
Minor Phases

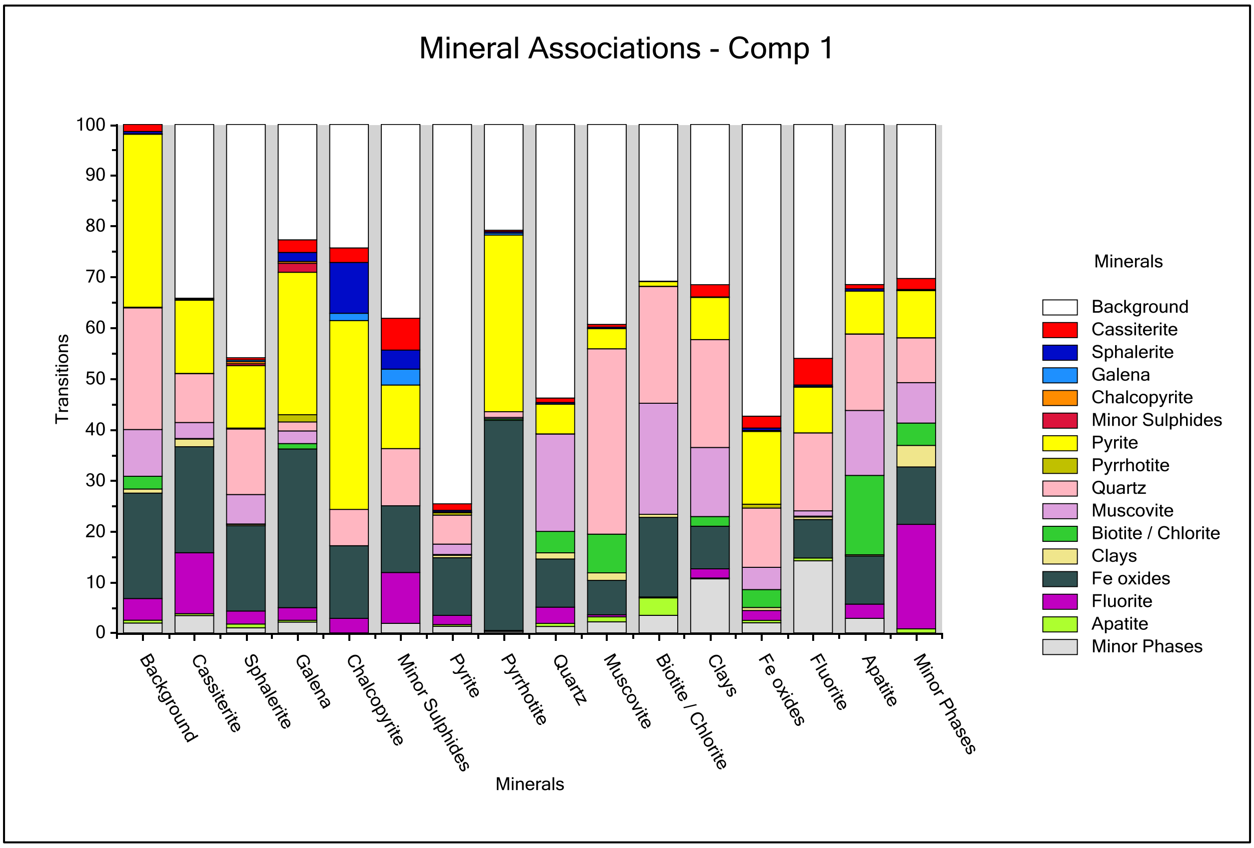
MINERALOGY
APPENDIX II

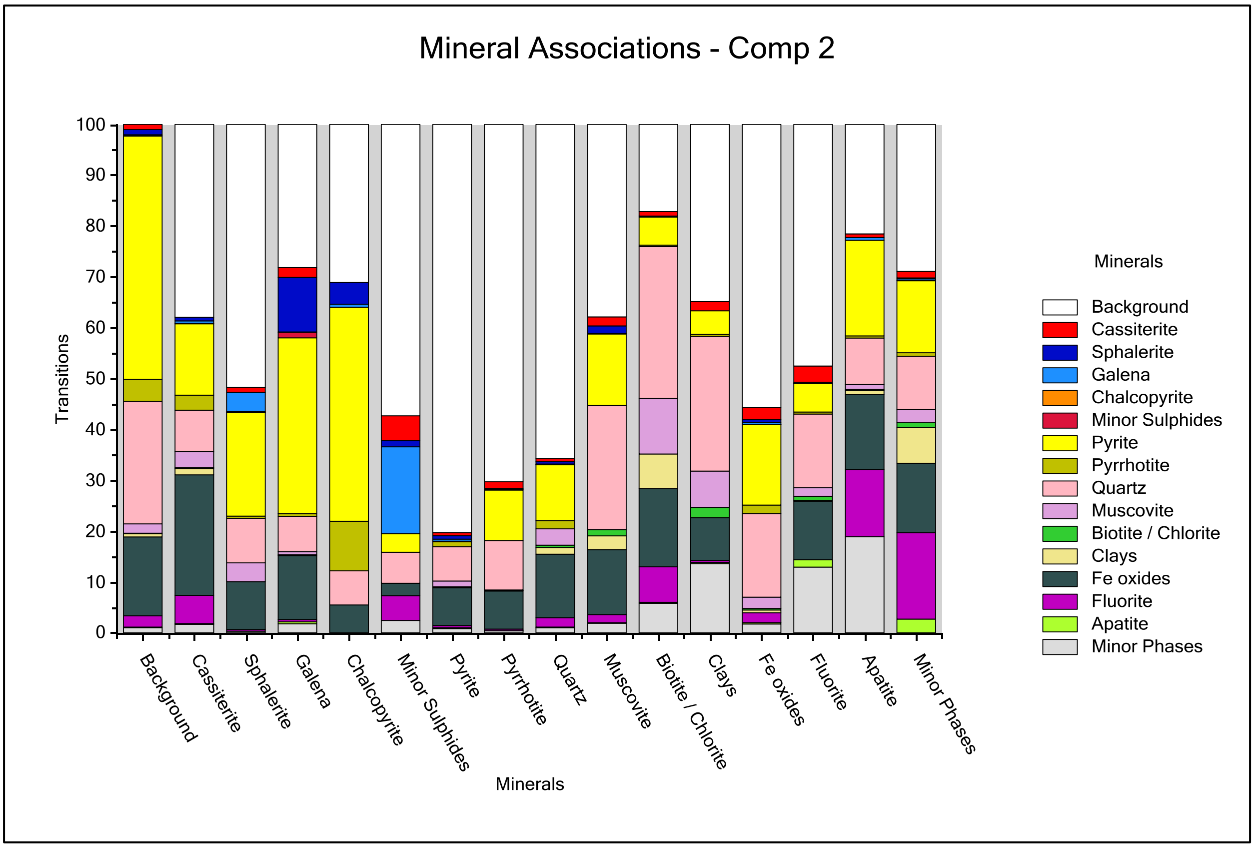
Calculated Grain Size


Calculated ESD Size
Calculated ESD Size
0
20
40
60
Product
Comp 2
Comp 1
Minor Phases
Apatite
Fluorite
Fe oxides
Clays
Biotite / Chlorite
Muscovite
Quartz
Pyrrhotite
Pyrite
Minor Sulphides
Chalcopyrite
Galena
Sphalerite
Cassiterite

MINERALOGY
APPENDIX III

Mineral Associations


Mineral Associations - Comp 1
Transitions
100
90
80
70
60
50
40
30
20
10
0
Background
Cassiterite
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Quartz
Muscovite
Biotite / Chlorite
Clays
Fe oxides
Fluorite
Apatite
Minor Phases
Minerals
Minerals
Background
Cassiterite
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Quartz
Muscovite
Biotite / Chlorite
Clays
Fe oxides
Fluorite
Apatite
Minor Phases


Mineral Associations - Comp 2
Transitions
100
90
80
70
60
50
40
30
20
10
0
Background
Cassiterite
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Quartz
Muscovite
Biotite / Chlorite
Clays
Fe oxides
Fluorite
Apatite
Minor Phases
Minerals
Minerals
Background
Cassiterite
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Quartz
Muscovite
Biotite / Chlorite
Clays
Fe oxides
Fluorite
Apatite
Minor Phases

MINERALOGY
APPENDIX IV

Particle Images

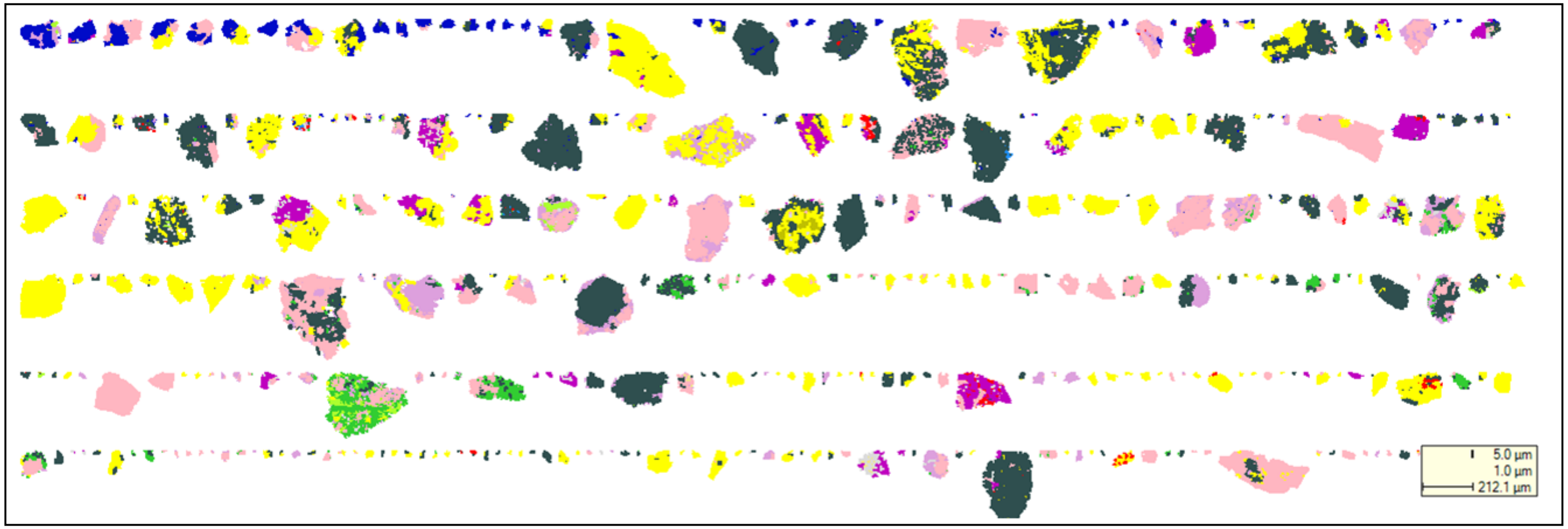
The colour legend is applicable to all particle images presented in this report.

Mineral Name
Background
Cassiterite
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Quartz
Muscovite
Biotite / Chlorite
Clays
Fe oxides
Fluorite
Apatite
Minor Phases

Composite 1 - Particle Mineral Maps Sorted By Decreasing Particle Area

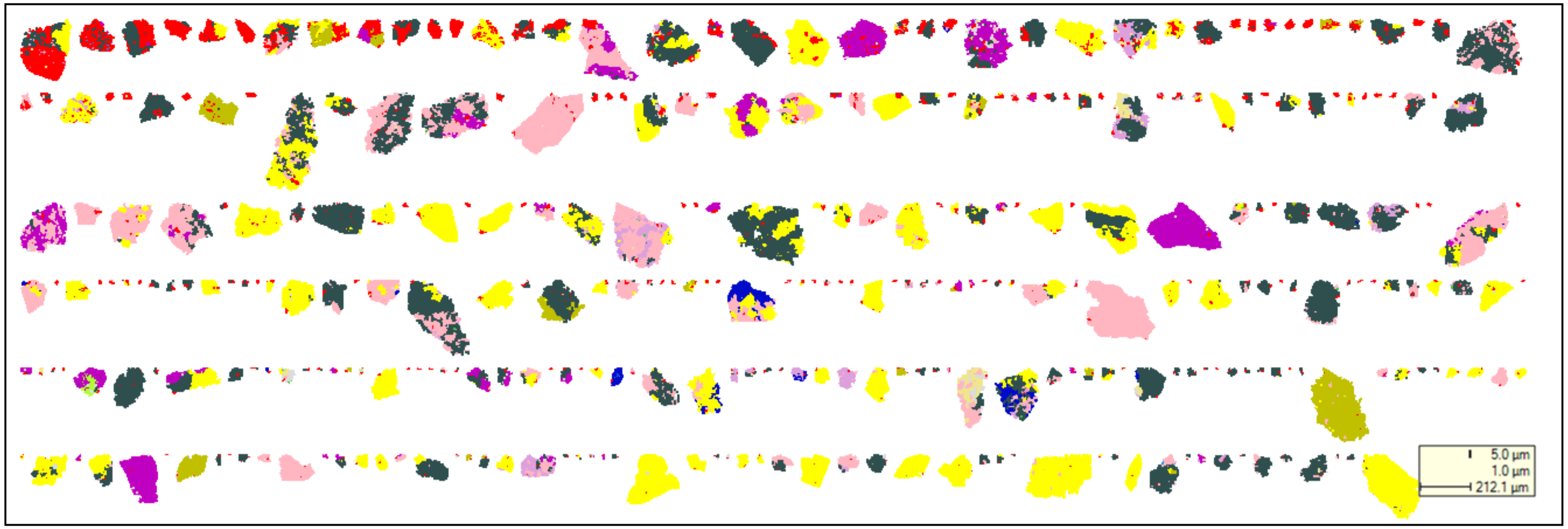
Composite 1 - Particle Mineral Maps Sorted By Decreasing Cassiterite Area

Composite 1 - Particle Mineral Maps Sorted By Decreasing Sphalerite Area

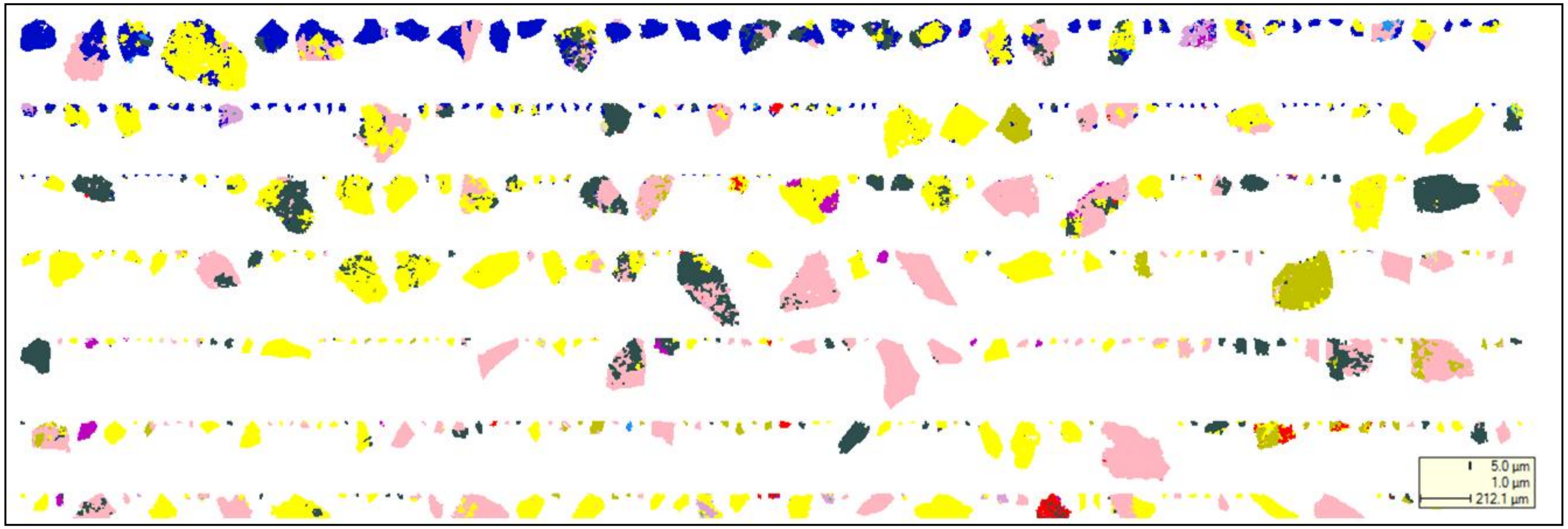


Composite 2 - Particle Mineral Maps Sorted By Decreasing Particle Area

Composite 2 - Particle Mineral Maps Sorted By Decreasing Cassiterite Area

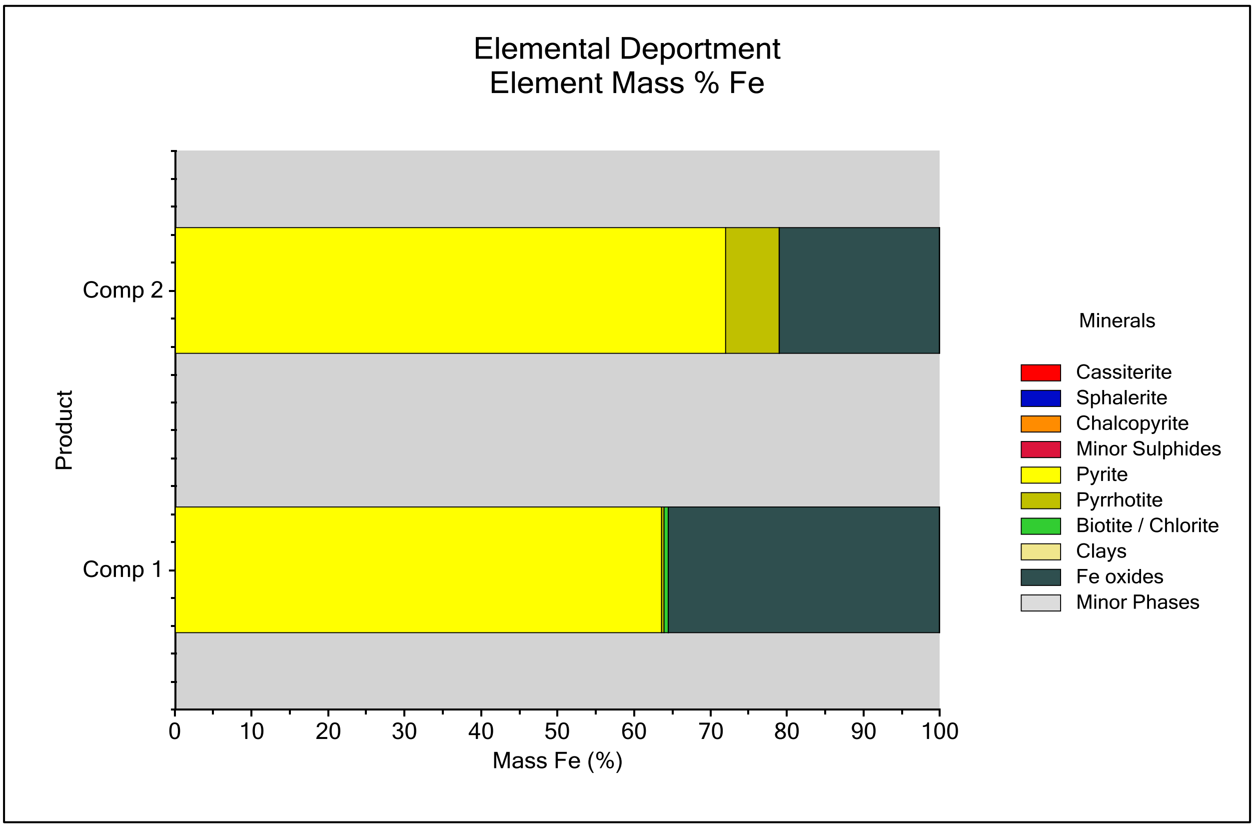


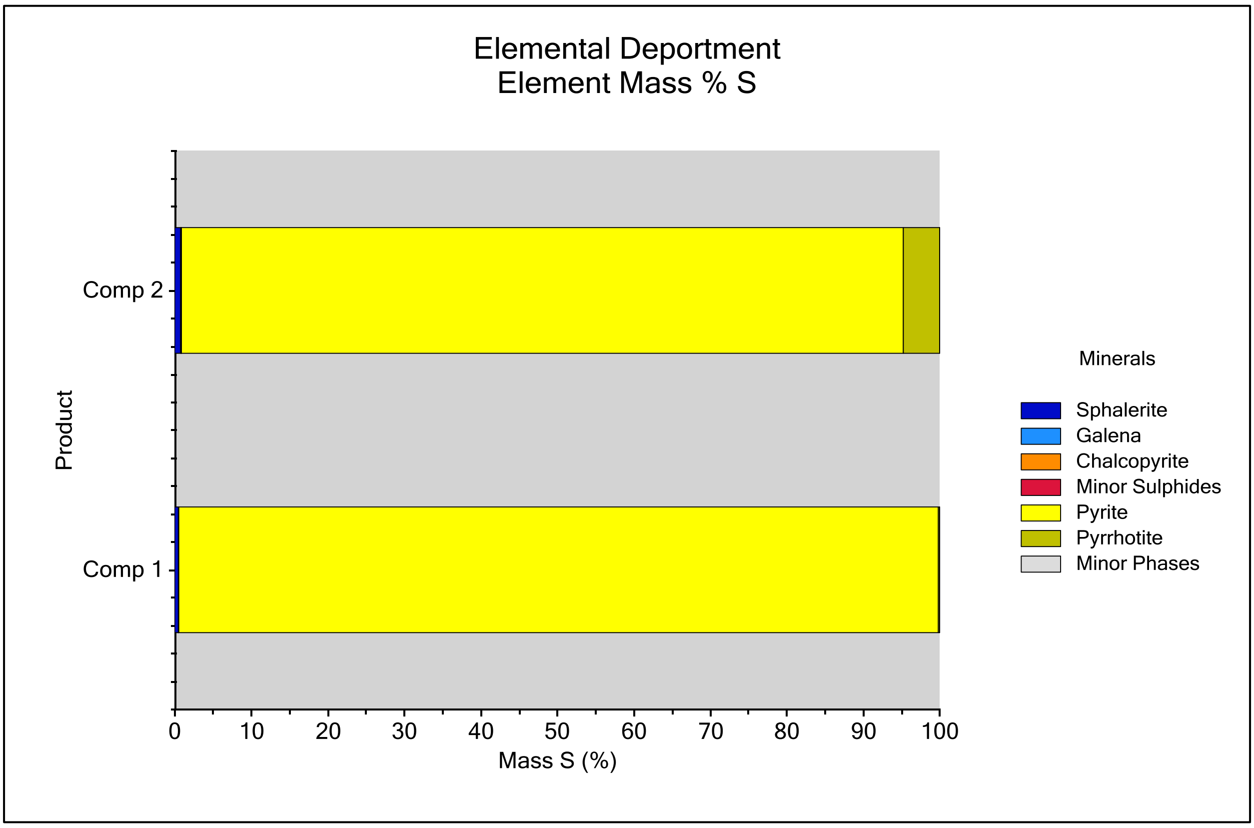
Composite 2 - Particle Mineral Maps Sorted By Decreasing Sphalerite Area



MINERALOGY
APPENDIX V

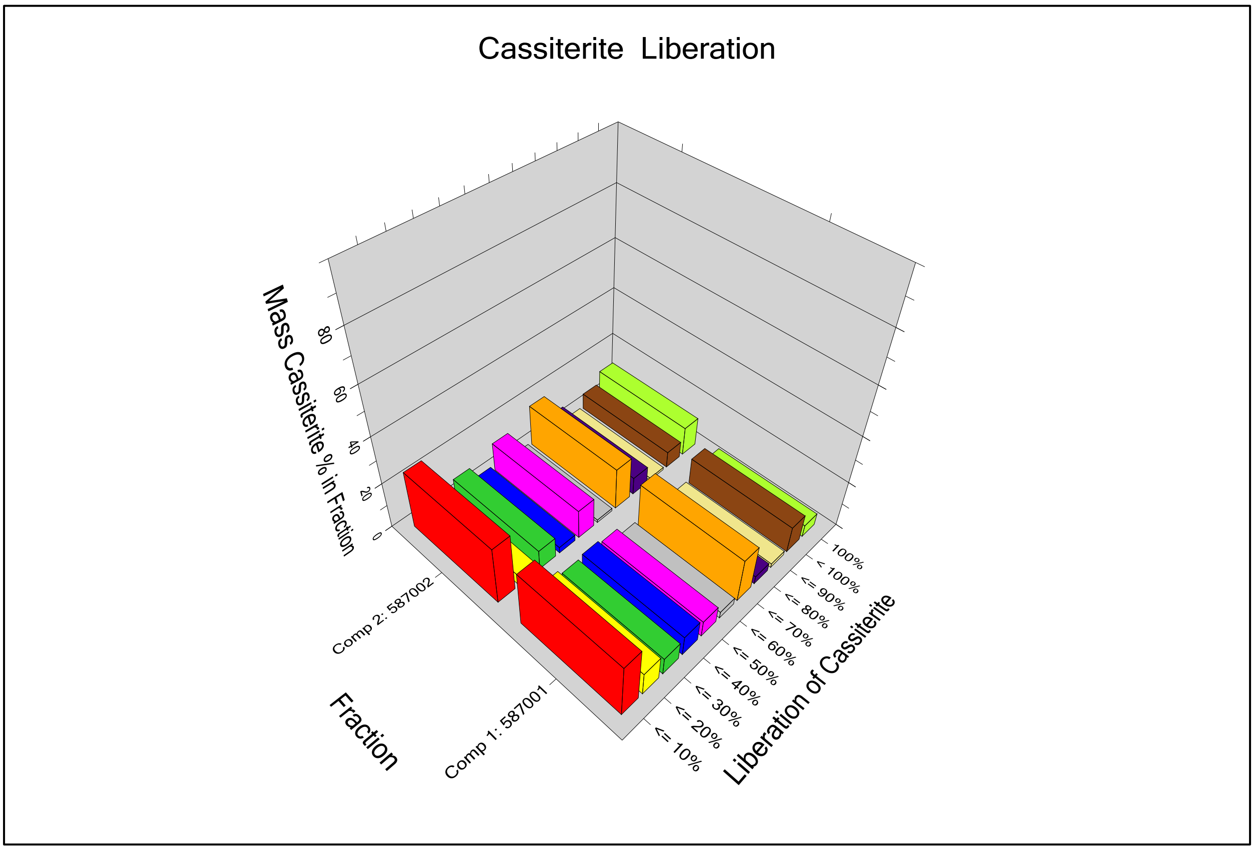
Elemental Deportment
(Fe and S)

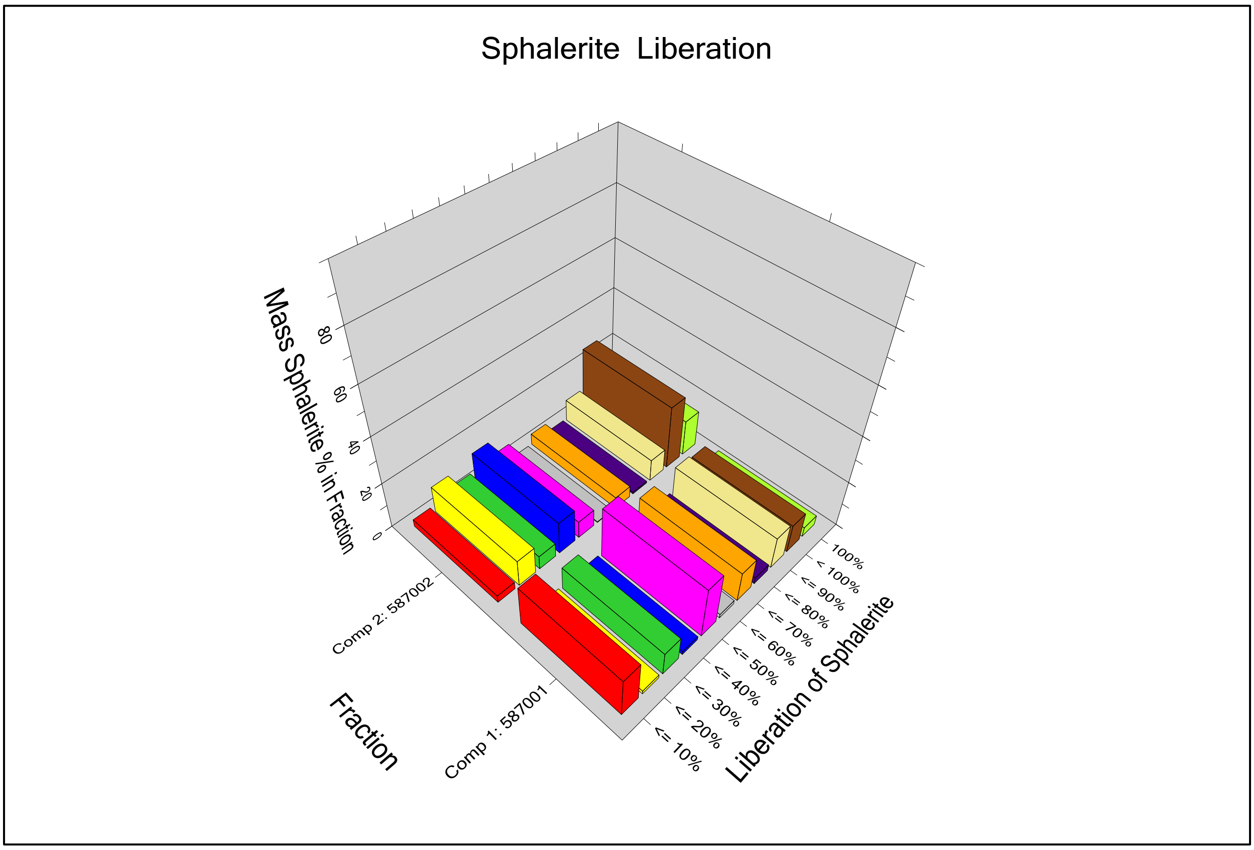

Elemental Deportment
Element Mass % Fe
Product
Comp 2
Comp 1
0
10
20
30
40
50
60
70
80
90
100
Mass Fe (%)
Minerals
Cassiterite
Sphalerite
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Biotite / Chlorite
Clays
Fe oxides
Minor Phases


Elemental Deportment
Element Mass % S
Product
Comp 2
Comp 1
0
10
20
30
40
50
60
70
80
90
100
Mass S (%)
Minerals
Sphalerite
Galena
Chalcopyrite
Minor Sulphides
Pyrite
Pyrrhotite
Minor Phases

MINERALOGY
APPENDIX VI

Liberation of Cassiterite and Sphalerite

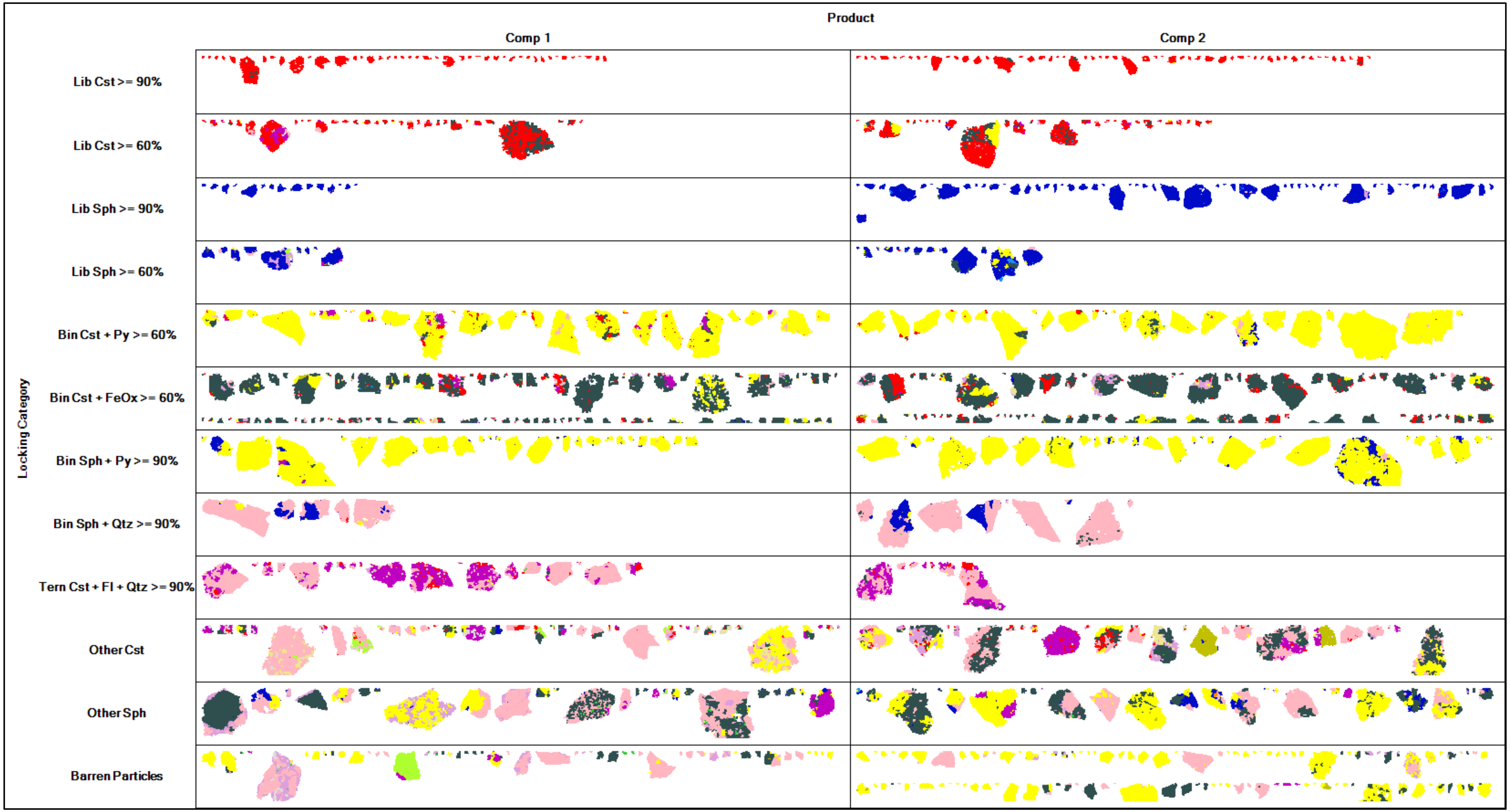

Cassiterite Liberation
Mass Cassiterite % in Fraction
0
20
40
60
80
Fraction
Comp 2: 587002
Comp 1: 587001
Liberation of Cassiterite
<= 10%
<= 20%
<= 30%
<= 40%
<= 50%
<= 60%
<= 70%
<= 80%
<= 90%
< 100%
100%

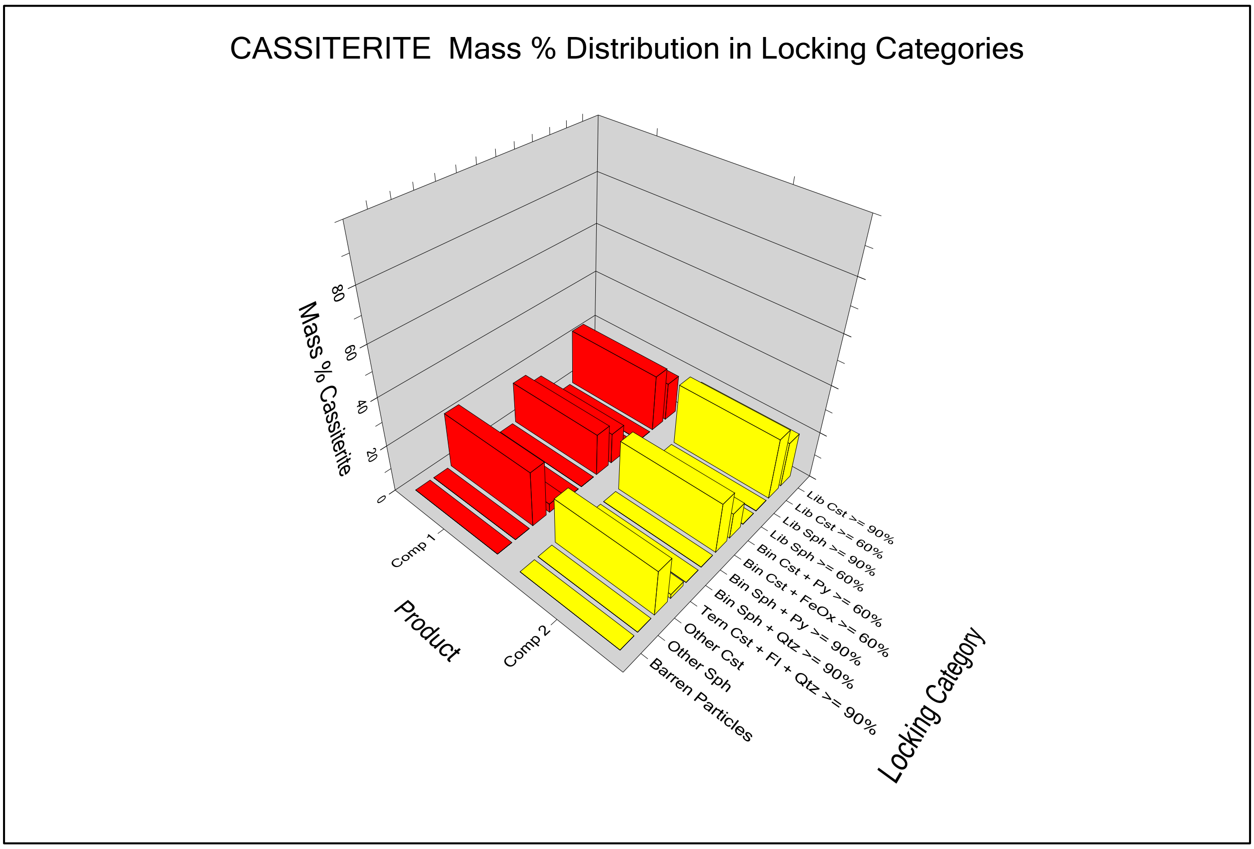

Sphalerite Liberation
Mass Sphalerite % in Fraction
0
20
40
60
80
Fraction
Comp 2: 587002
Comp 1: 587001
Liberation of Sphalerite
<= 10%
<= 20%
<= 30%
<= 40%
<= 50%
<= 60%
<= 70%
<= 80%
<= 90%
< 100%
100%

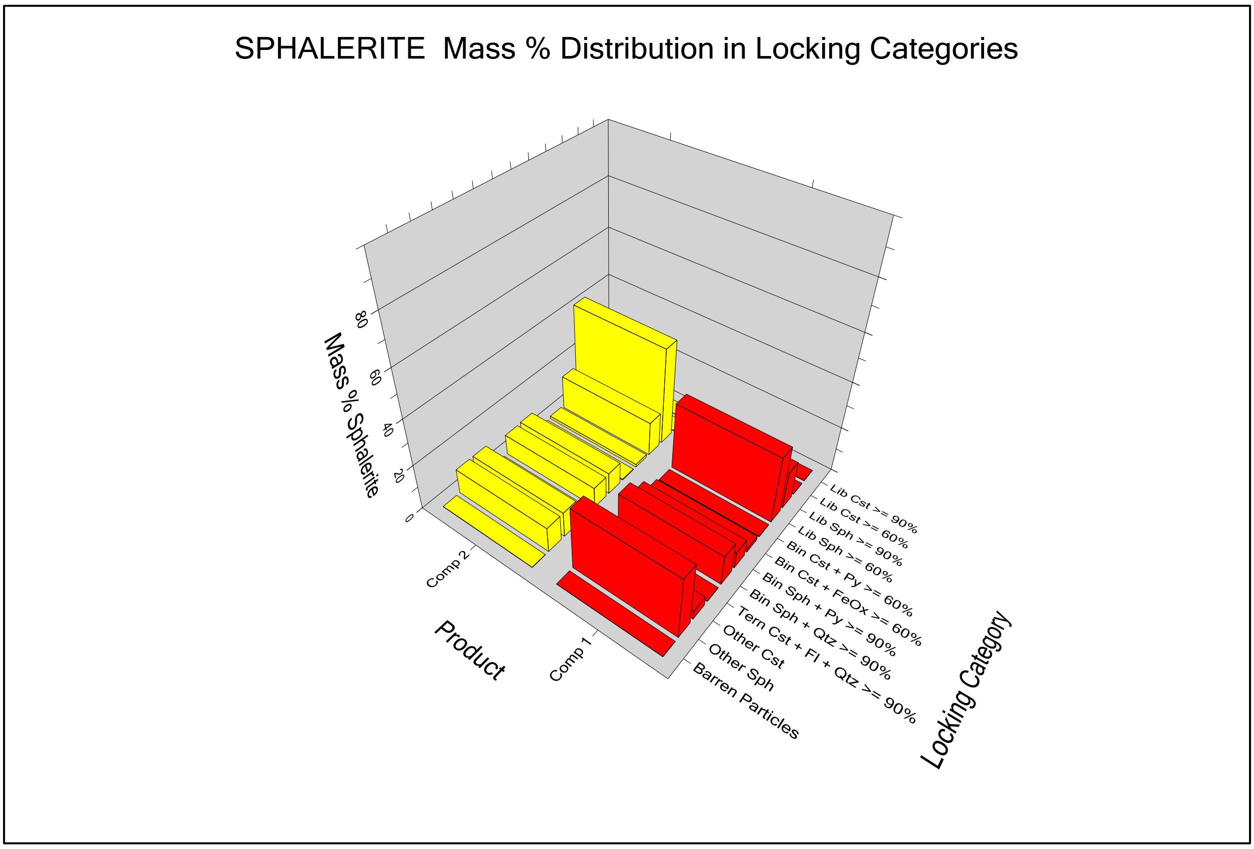
MINERALOGY
APPENDIX VII

Mass % Distribution of Cassiterite and Sphalerite in Particle Locking Categories

Particle Locking Categories Queen Hill Skarn



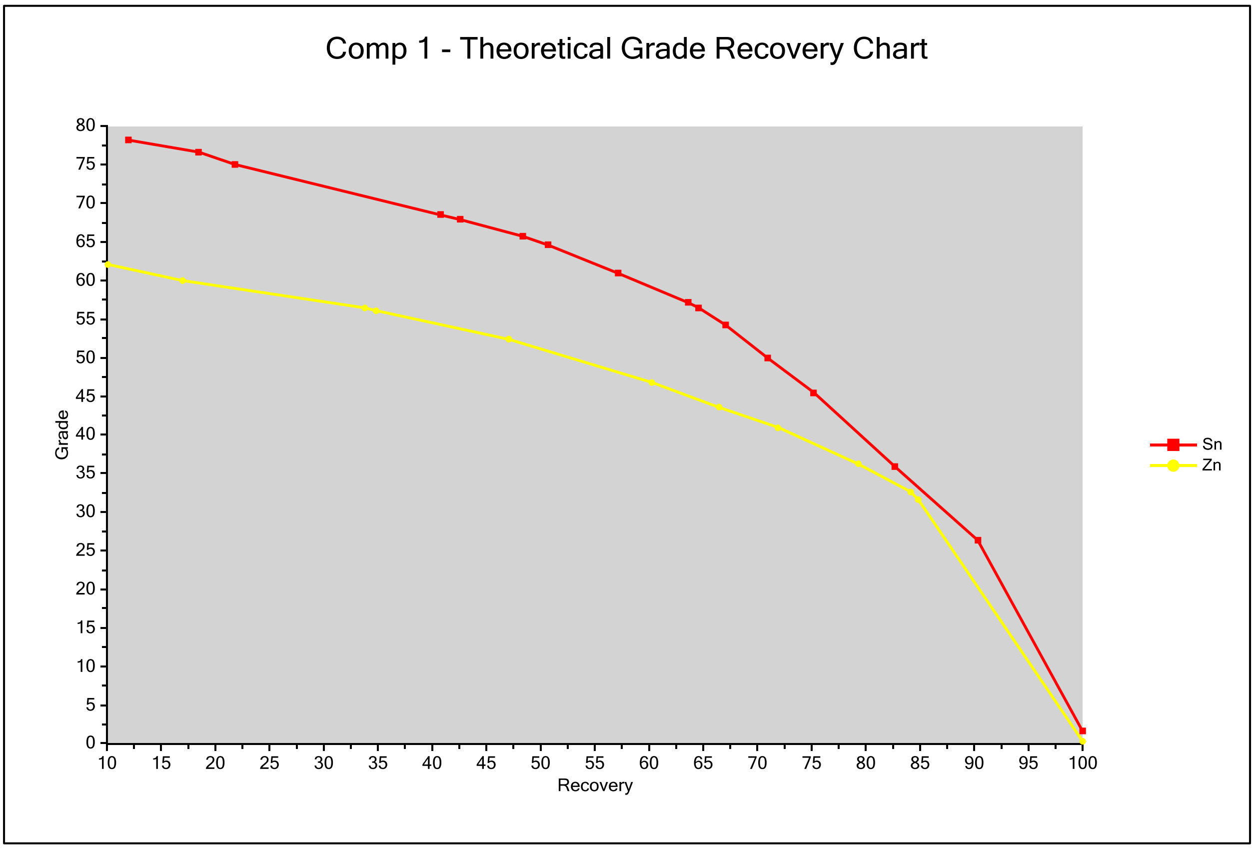

CASSITERITE Mass % Distribution in Locking Categories
Mass % Cassiterite
0
20
40
60
80
Comp 1
Comp 2
Product
Lib Cst >= 90%
Lib Cst >= 60%
Lib Sph >= 90%
Lib Sph >= 60%
Bin Cst + Py >= 60%
Bin Cst + FeOx >= 60%
Bin Sph + Py >= 90%
Bin Sph + Qtz >= 90%
Tern Cst + Fl + Qtz >= 90%
Other Cst
Other Sph
Barren Particles
Locking Category

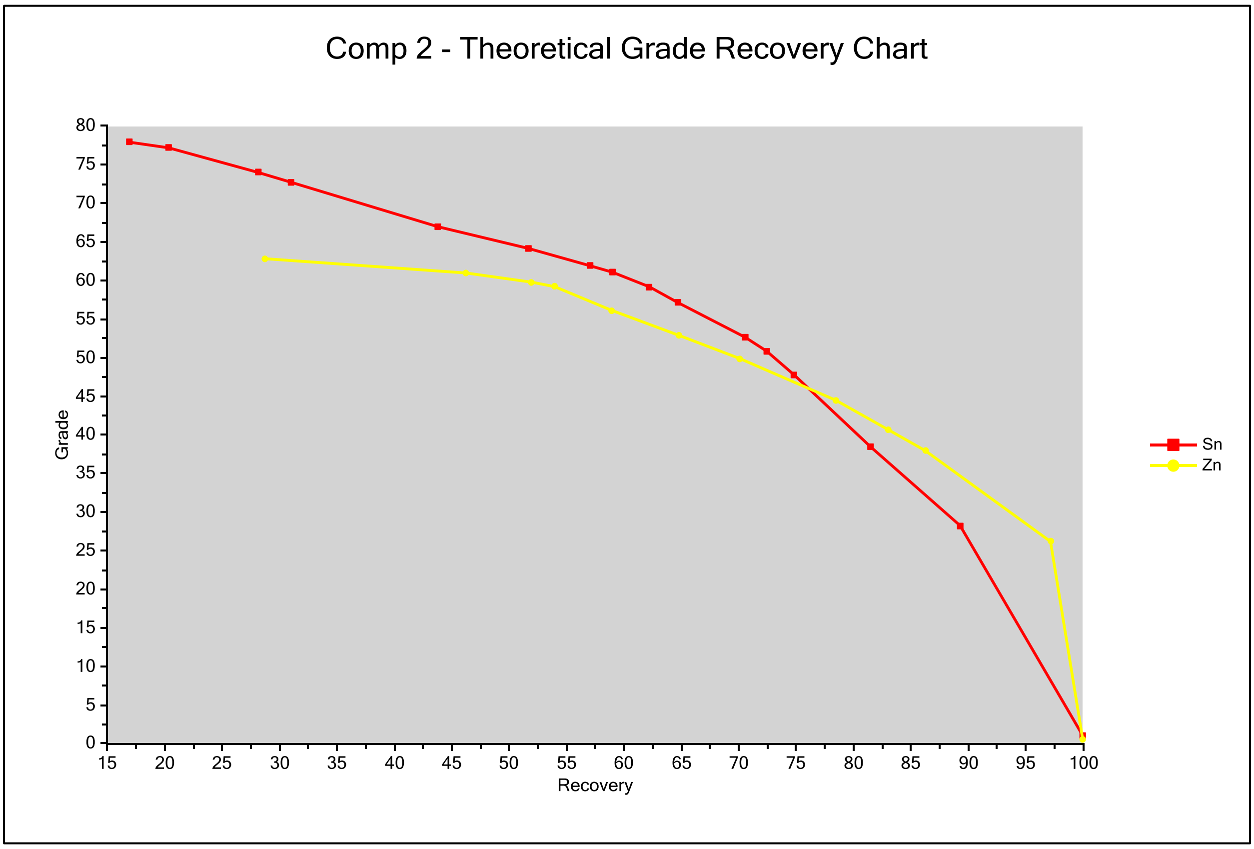

SPHALERITE Mass % Distribution in Locking Categories
Mass % Sphalerite
0
20
40
60
80
Comp 2
Comp 1
Product
Lib Cst >= 90%
Lib Cst >= 60%
Lib Sph >= 90%
Lib Sph >= 60%
Bin Cst + Py >= 60%
Bin Cst + FeOx >= 60%
Bin Sph + Py >= 90%
Bin Sph + Qtz >= 90%
Tern Cst + Fl + Qtz >= 90%
Other Cst
Other Sph
Barren Particles
Locking Category

MINERALOGY
APPENDIX VIII

Theoretical Grade Recovery Charts

Sn and Zn Upgrading Potential


Comp 1 - Theoretical Grade Recovery Chart
Grade
Recovery
Sn
Zn


Comp 2 - Theoretical Grade Recovery Chart
Grade
Recovery
Sn
Zn