APPENDIX 3

HANNUKAINEN OY PILOT PLANT

Mineralogical Studies

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1 WET LIMS CONCENTRARE BEFORE RE-GRINDING

18.9.2017/Jukka Laukkanen (chemical formulae added 21.3.2018 by Sonja Lavikko)

MLA-measurement pilot product LIMS M4 (WLC4)_13.9_18-18:45

Table 1. Mineral contents sample LIMS M4_13.9_18-18:45

Mineral	Chemical formula (ideal)	Wt%	Grain Count
Quartz	SiO_2	0.00	2
Plagioclase	$Na_{0.5}Ca_{0.5}Si_3AlO_8$	0.14	58
K_feldspar	$KAlSi_3O_8$	0.01	13
Clinopyroxene	$(Ca,Mg,Fe,Al)_2(Si,Al)_20_6$	6.61	1233
Ferrotschermakite	$(Ca,Fe)_2(Al_2Si_6O_{22})(OH)_2$	1.12	661
Actinolite	$Ca2Mg3Fe^{2+}{}_2Si_8O_{22}(OH)_2$	0.32	120
Tremolite	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	0.00	0
Andradite	$Ca_3Fe^{2+}{}_2(SiO_4)_3$	0.01	10
Marialite	$Na_4Al_3Si_9O_{24}Cl$	1.60	627
Epidote	$Ca_2Al_2(Fe^{3+},Al)(SiO_4)(Si_2O_7)O(OH)$	0.21	73
Chlorite	$(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2\cdot(Mg,Fe)_3(OH)_6$	0.02	37
Biotite	$K(Mg,Fe)_3(OH,F)_2(AlSi_3O_{10})$	0.01	4
Titanite	$CaTiSiO_5$	0.10	161
Clay	-	0.03	96
Berthierine	$(Fe^{2+},Fe^{3+},Al,Mg)_{2-3}(Si,Al)_2O_5(OH)_4$	0.12	211
Apatite	$Ca_5(PO_4)(F,Cl,OH)$	0.04	26
Allanite	$(Ce,Ca,Y)_2(Al,Fe^{3+})_3(SiO_4)_3(OH)$	0.00	16
Calcite	$CaCO_3$	0.00	0
Pyrite	Fe_2S_2	0.00	4
Pyrrhotite	$Fe^{2+}{}_{0.95}S$	0.17	89
Alteration of Pyrrhotite	-	0.00	4
Chalcopyrite	$CuFe^{2+}S_2$	0.00	3
Sphalerite	ZnS	0.00	1
Magnetite	$Fe^{3+}{}_2Fe^{2+}O_4$	88.95	22071
Uraninite	UO_2	0.00	0
Goethite	$Fe^{3+}O(OH)$	0.48	1355
Process_metal	-	0.00	1
Unknown	-	0.04	223
Total		100.00	27099

- The main sulphur carrier is pyrite, amount of what was measured to be 0.17 wt-%. Both pure particles were detected and associated with magnetite as mixed grains. The liberation for pyrite was ca. 60%
- The silicate content in the sample was 10.3 wt-%, mostly as mixed grains with magnetite. Silicate liberation was only 30%.
- The magnetite content was 89 wt-%, and the liberation was ca. 93%.

Measurements were done for a thin polished section.

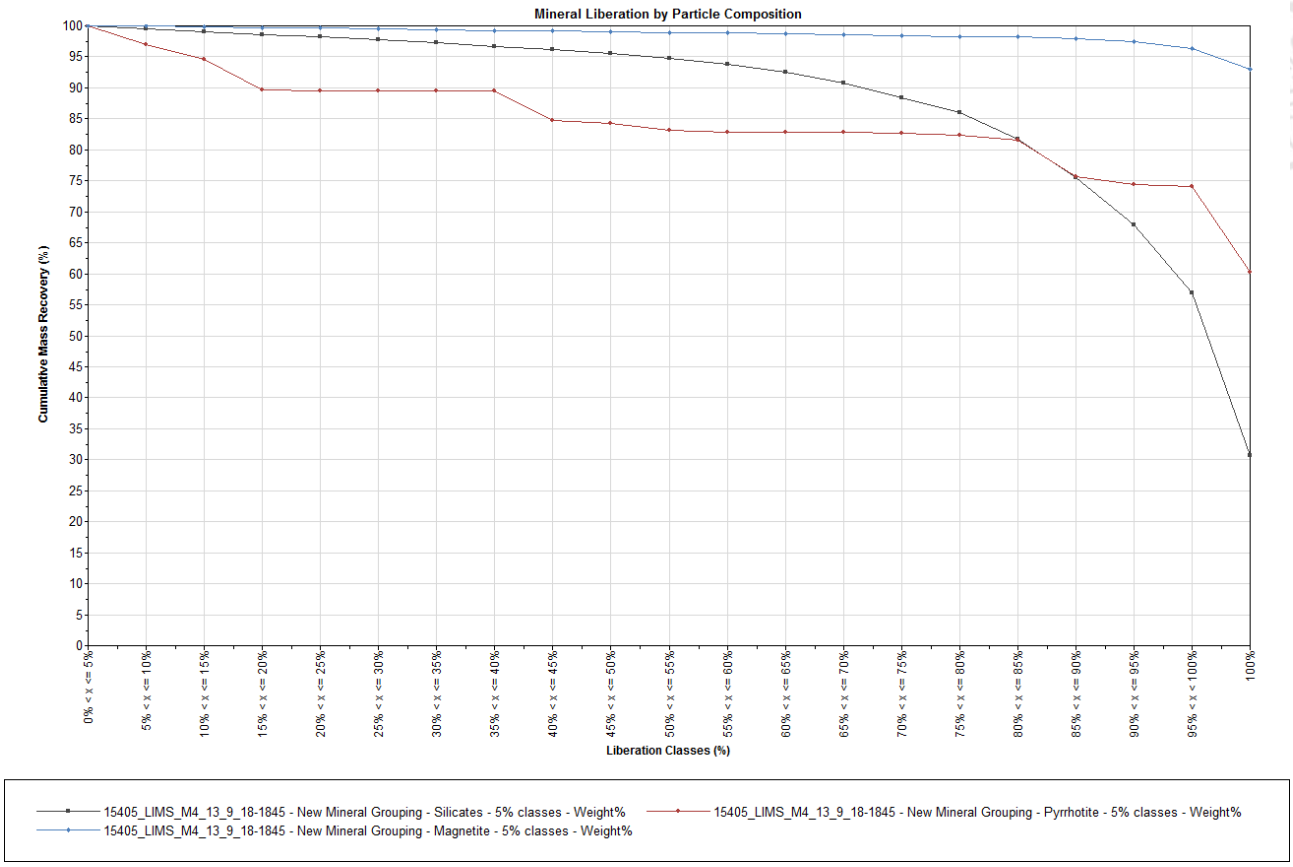

Figure 1. Liberations for Magnetite, Silicates and Pyrite.

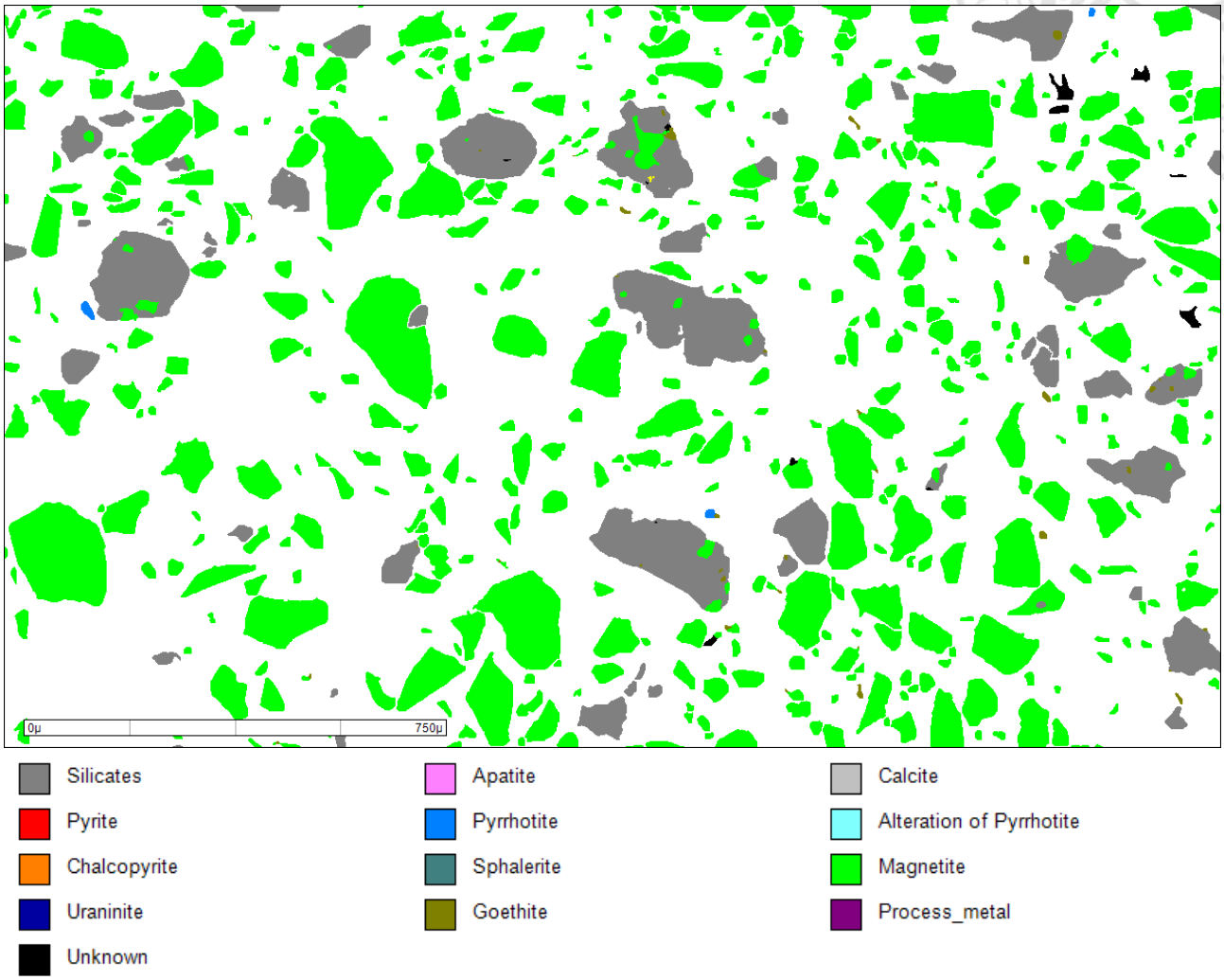

Figure 2. MLA-picture from magnetite product.

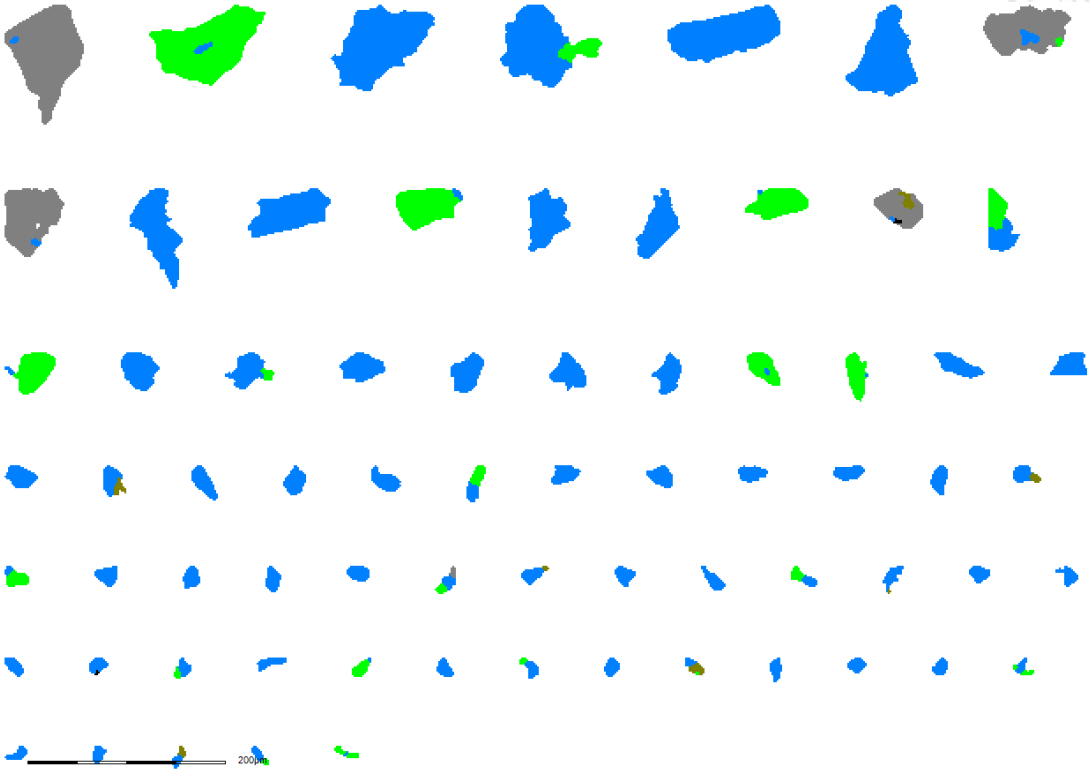

Figure 3. Pyrite particles.

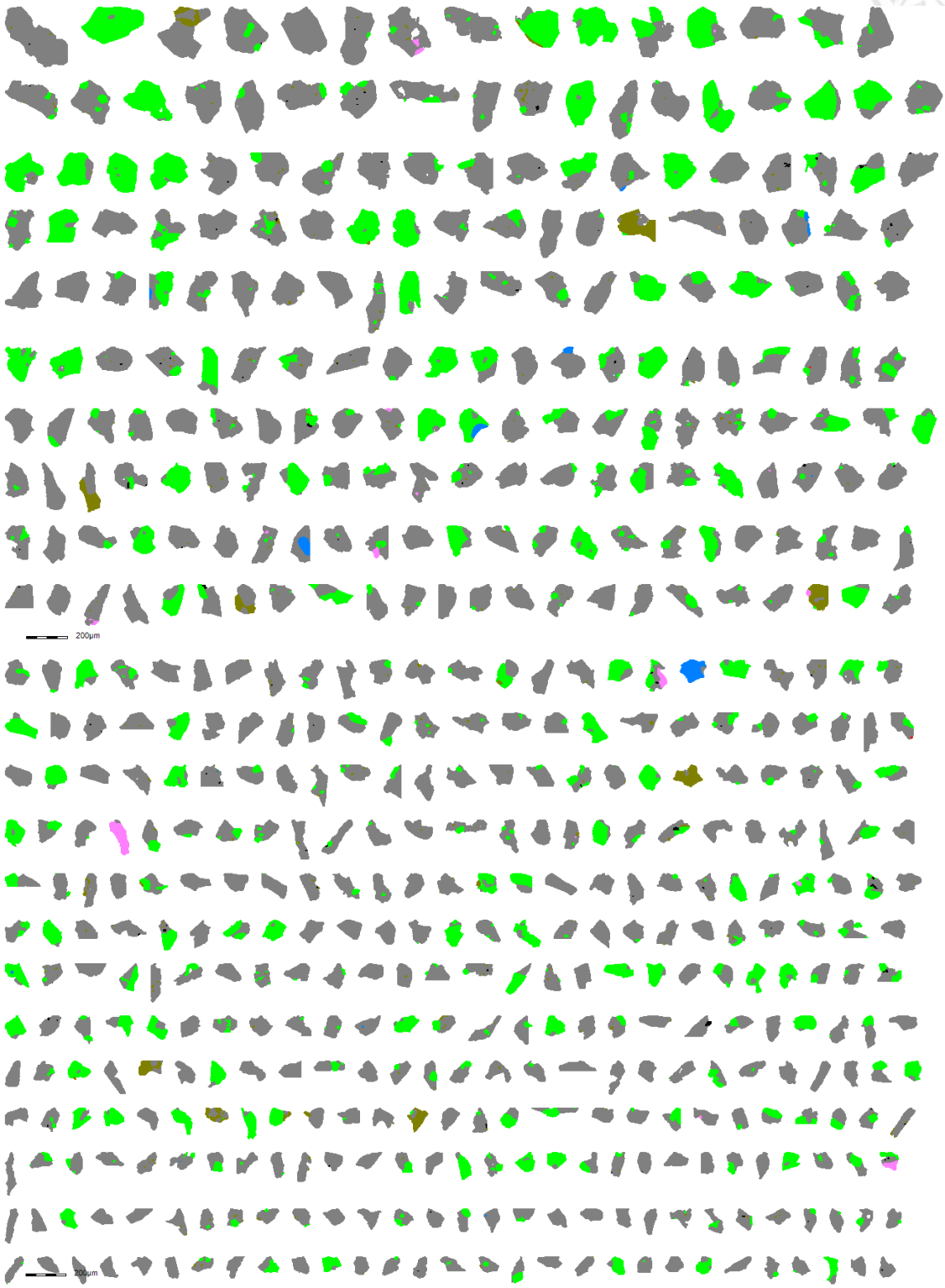

Figure 4. Silicates.

2 MAIN PROCESS SAMPLES, VE-2 ORE 28.9.2017

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November 24th 2017

CuCC3	OK15518	CuKR3	280917, 10 am	VE2
Cy o/f	OK15519	2SY	280917, 10 am	VE2
PyCC	OK15520	PYKR1	280917, 10 am	VE2
PyCT	OK15521	PYKJ1	280917, 10 am	VE2
PyRT	OK15522	PYEJ	280917, 10 am	VE2
PoCC	OK15523	POKR	280917, 10 am	VE2
PoCT	OK15524	POKJ	280917, 10 am	VE2
WLC4	OK15525	LIMS_M4	280917, 10 am	VE2
WLT4	OK15526	LIMS_EM4	280917, 10 am	VE2

Method: XBSE

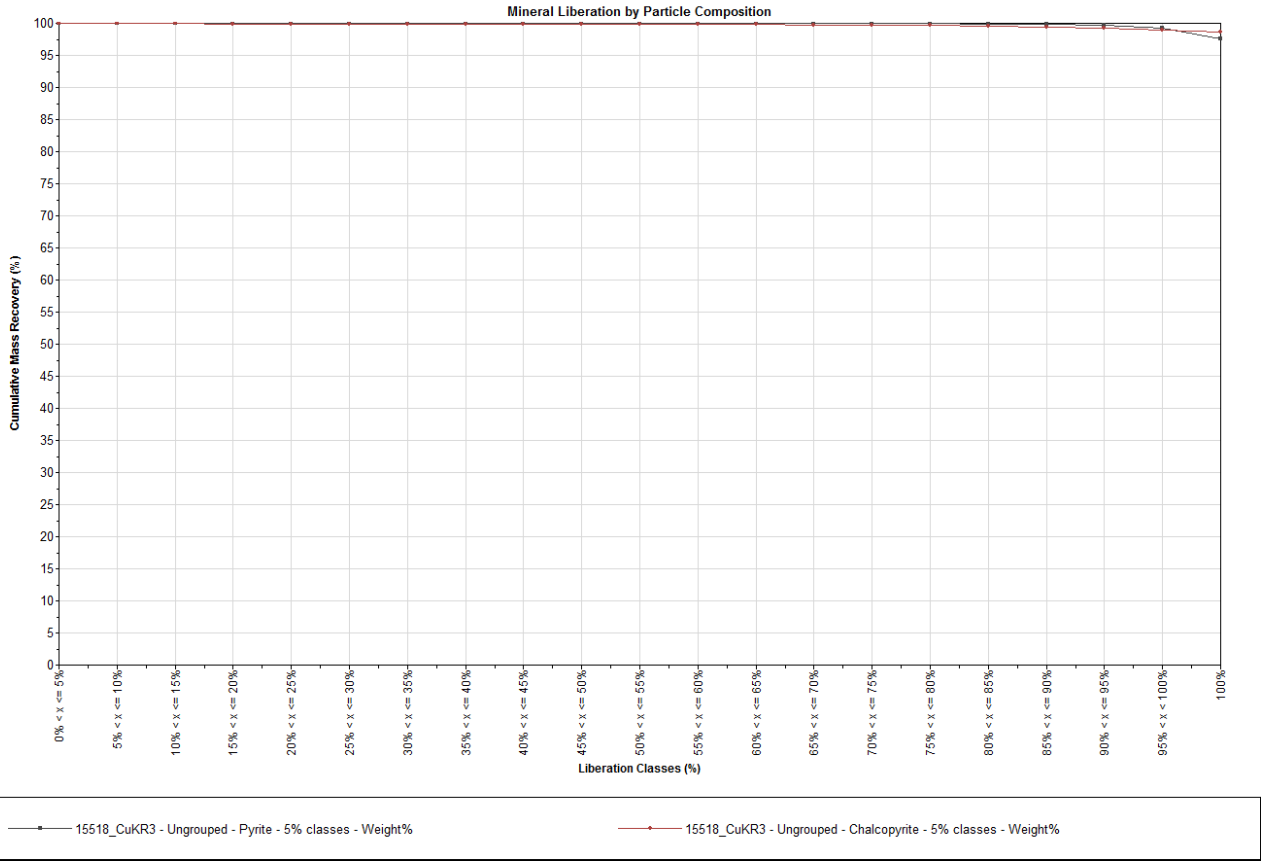
Mineral liberations and associations of main minerals in each sample
Sulphides, oxides and fibrous minerals

Liberations of the main/other relevant minerals p. 8
Mineral associations of the main minerals p. 17
Sulphides and their grain size distribution p. 21
Distribution of pyrite, pyrrhotite, Fe-oxides and goethite in samples p. 30
Fibrous minerals and their habitus in samples p. 31

LIBERATIONS OF THE MAIN/OTHER RELEVANT MINERALS

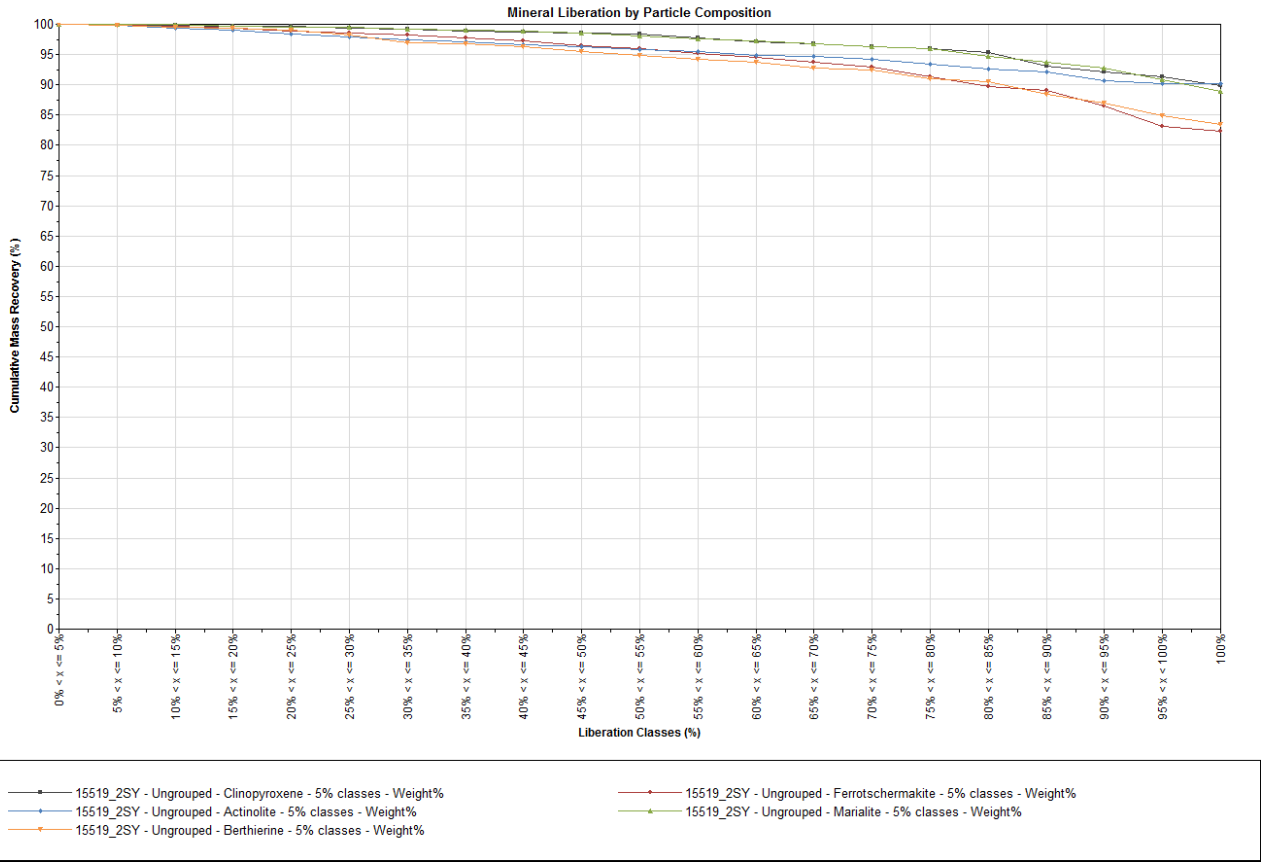
OK15518 CuKR3
Main minerals are chalcopyrite and pyrite.

Liberations for both minerals are very high, liberation being > ~98 % throughout.

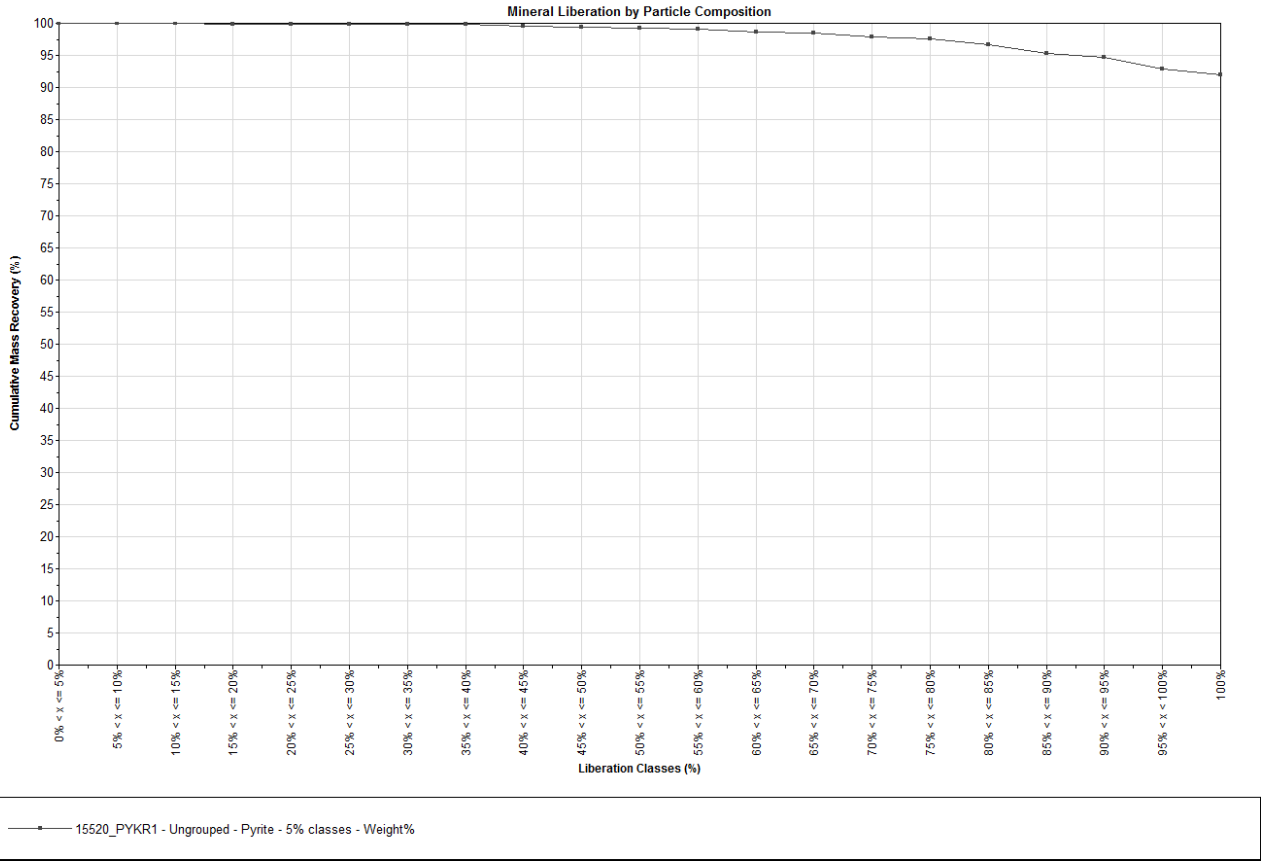


OK15519 2SY
Main minerals are ferrotschermakite, marialite, clinopyroxene, berthierine and actinolite.

Ferrotschermakite liberation is > 95 % at LC 65 % and > 80 % at LC 100 %.
Marialite liberation is > 95 % at LC 85 % and > 90 % at LC 100 %.
Clinopyroxene liberation is > 95 % at LC 85 % and > 90 % at LC 100 %.
Berthierine liberation is > 95 % at LC 55 % and > 85 % at LC 100 %.
Actinolite liberation is > 95 % at LC 70 % and > 90 % at LC 100 %.

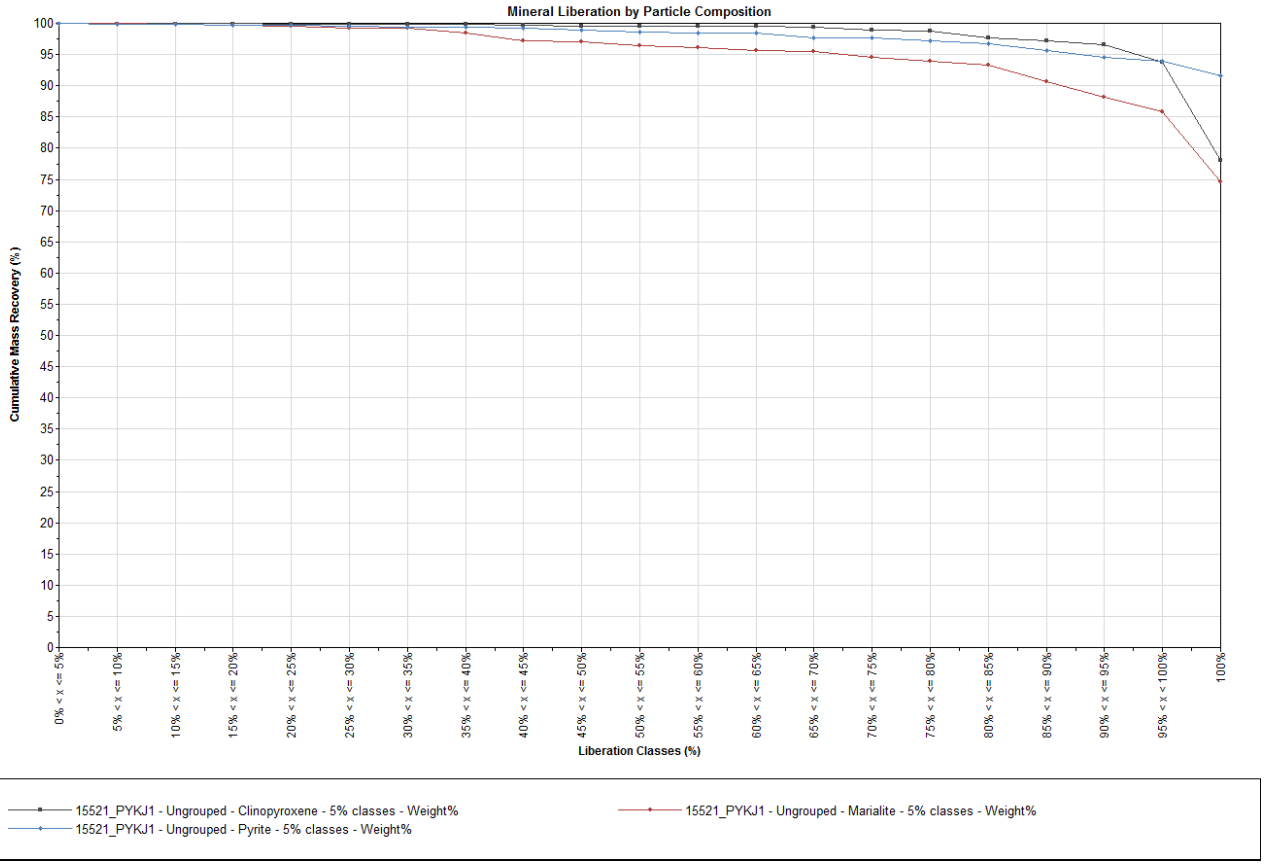


OK15520 PYKR1
Main mineral is pyrite and its liberation is > 95 % at LC 95 % and > 90 % at LC 100 %.



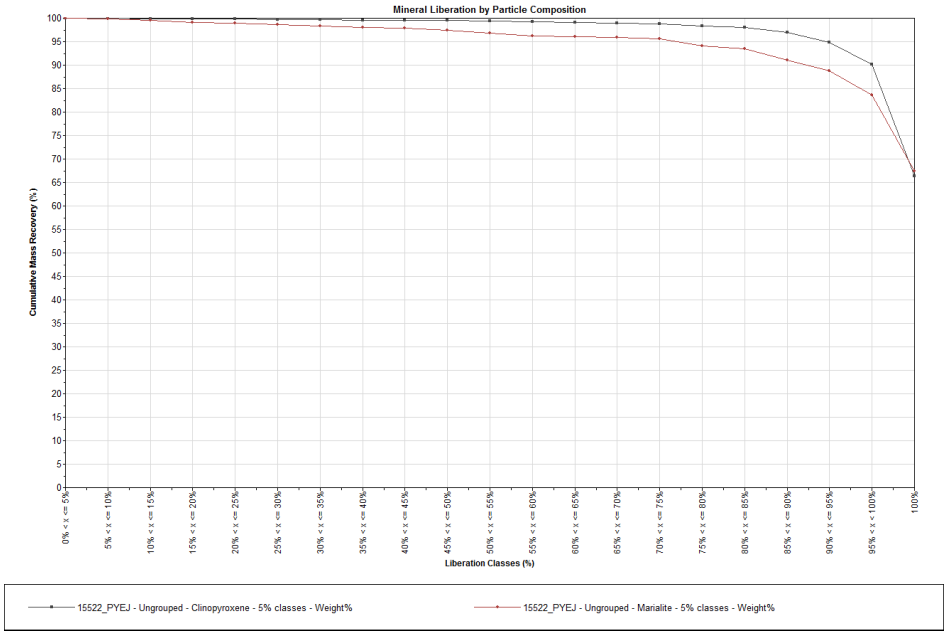
OK15521 PYKJ1
Main minerals are pyrite, clinopyroxene and marialite.

Pyrite liberation is > 95 % at LC 90 % and > 90 % at LC 100 %.
Clinopyroxene liberation is > 95 % at LC 95 % and > 90 % (~94 %) at LC 100 %.
Marialite liberation is > 95 % at LC 70 % and > 85 % at LC 100 %.



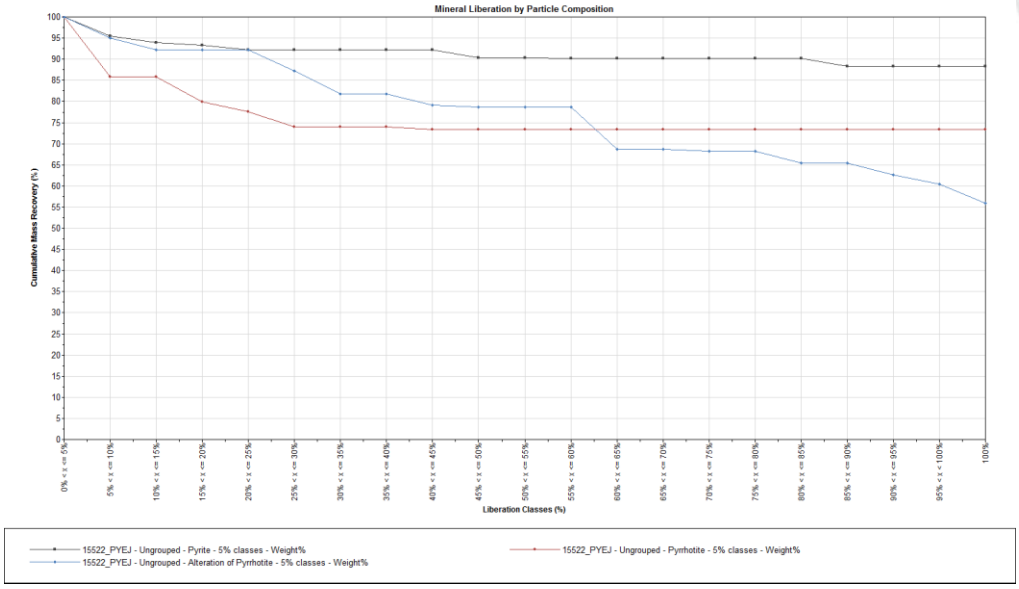
OK15522 PYEJ
Main minerals are clinopyroxene and marialite.

Clinopyroxene liberation is > 95 % at LC 95 % and > 90 % at LC 100 %.
Marialite liberation is > 95 % at LC 75 % and > 80 % (~84 %) at LC 100 %.



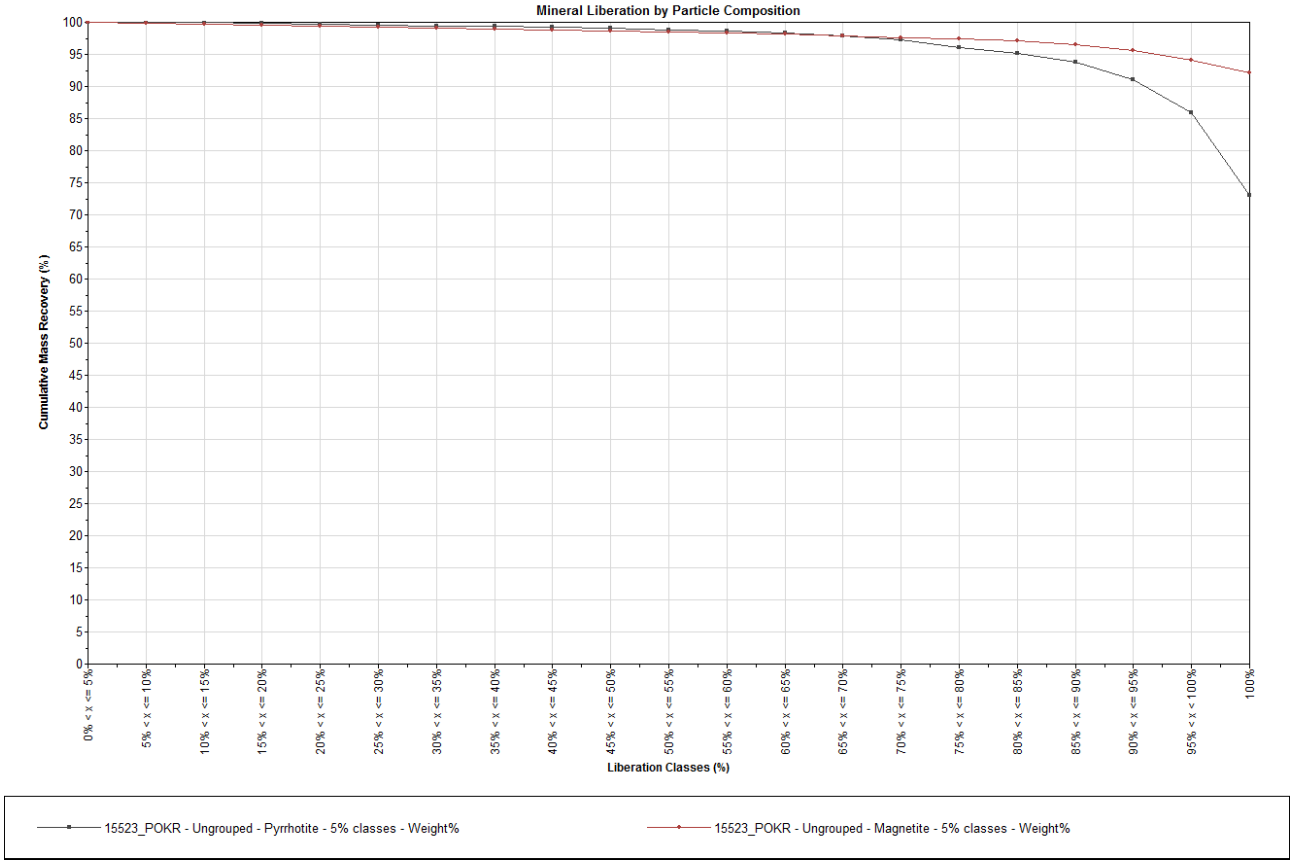
Sulfur in sample is found in pyrite, pyrrhotite and alteration of pyrrhotite. (Their liberations should be interpreted with caution due to their low percentages in the sample.)

Pyrite liberation is > 95 % at LC 10 %, > 90 % at LC 85 % and > 85 % at LC 100 %.
Pyrrhotite liberation is > 85 % at LC 15 %, > 75 % at LC 25 % and stays at > 70 % from LC 30 % until LC 100 %.
Alteration of pyrrhotite liberation is > 90 % at LC 25 %, > 80 % at LC 35 %, > 75 % at LC 60 % and > 60 % at LC 100 %.



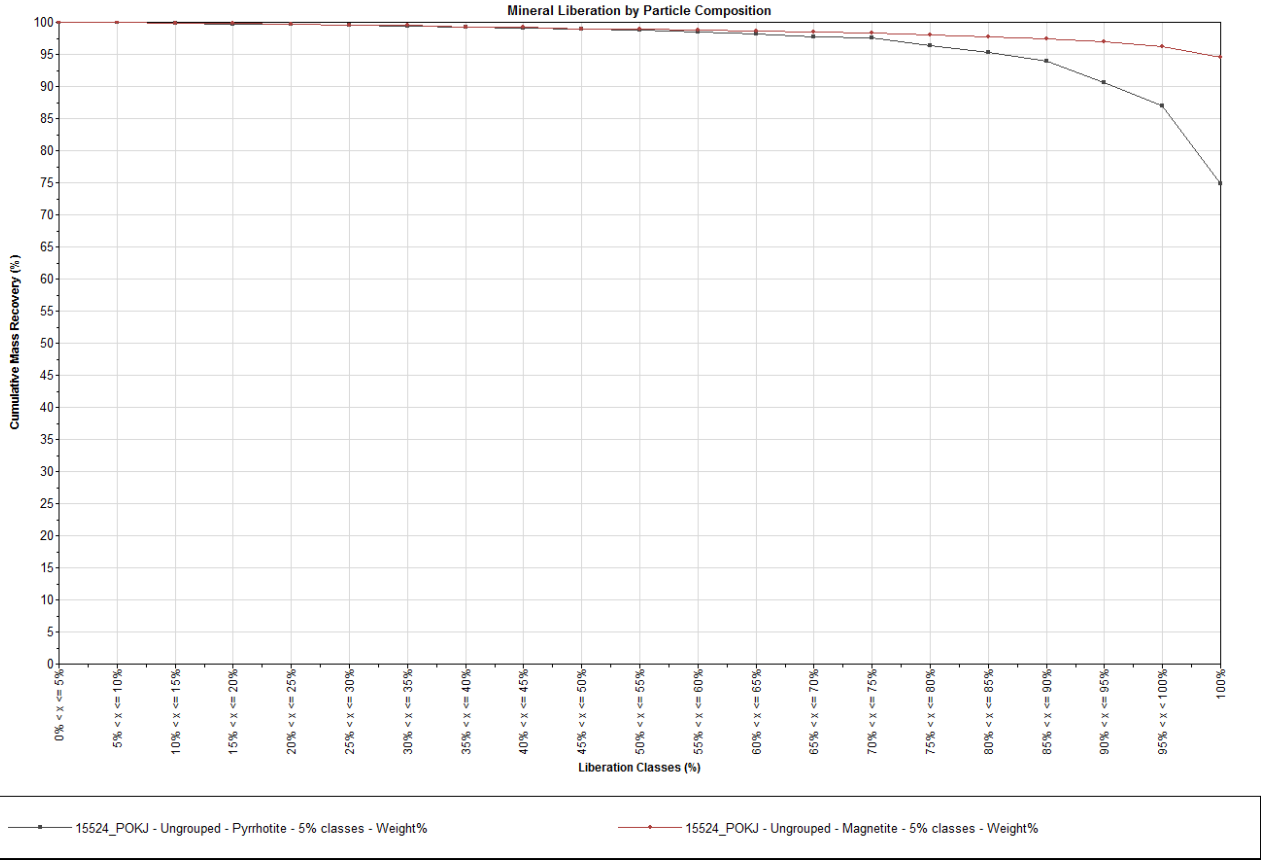
OK15523 POKR
Main minerals are pyrrhotite and magnetite.

Pyrrhotite liberation is > 95 % at LC 85 % and > 85 % at LC 100 %.
Magnetite liberation is > 95 % at LC 95 % and > 90 % (~94 %) at LC 100 %.



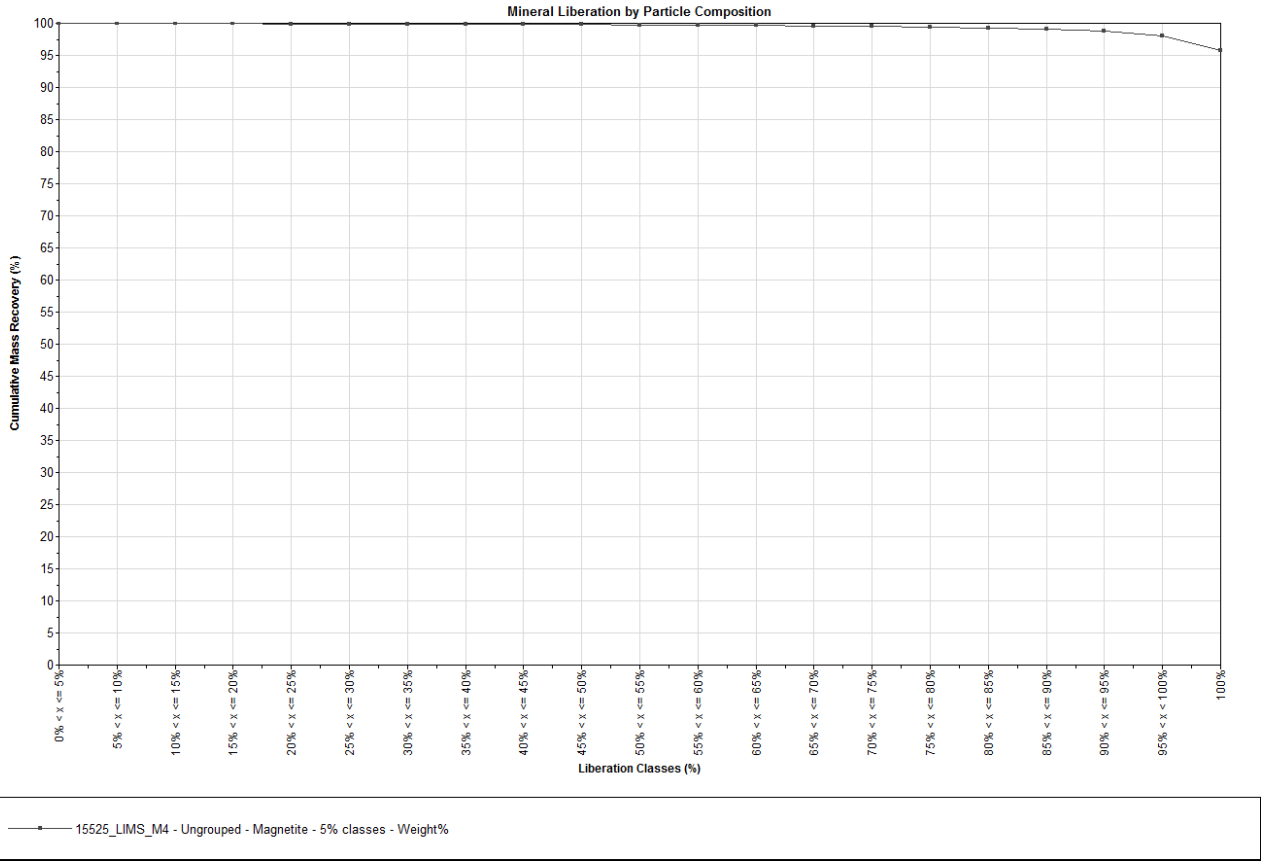
OK15524 POKJ
Main minerals are magnetite and pyrrhotite.

Magnetite liberation is > 95 % at LC 100 %.
Pyrrhotite liberation is > 95 % at LC 85 % and > 85 % at LC 100 %.



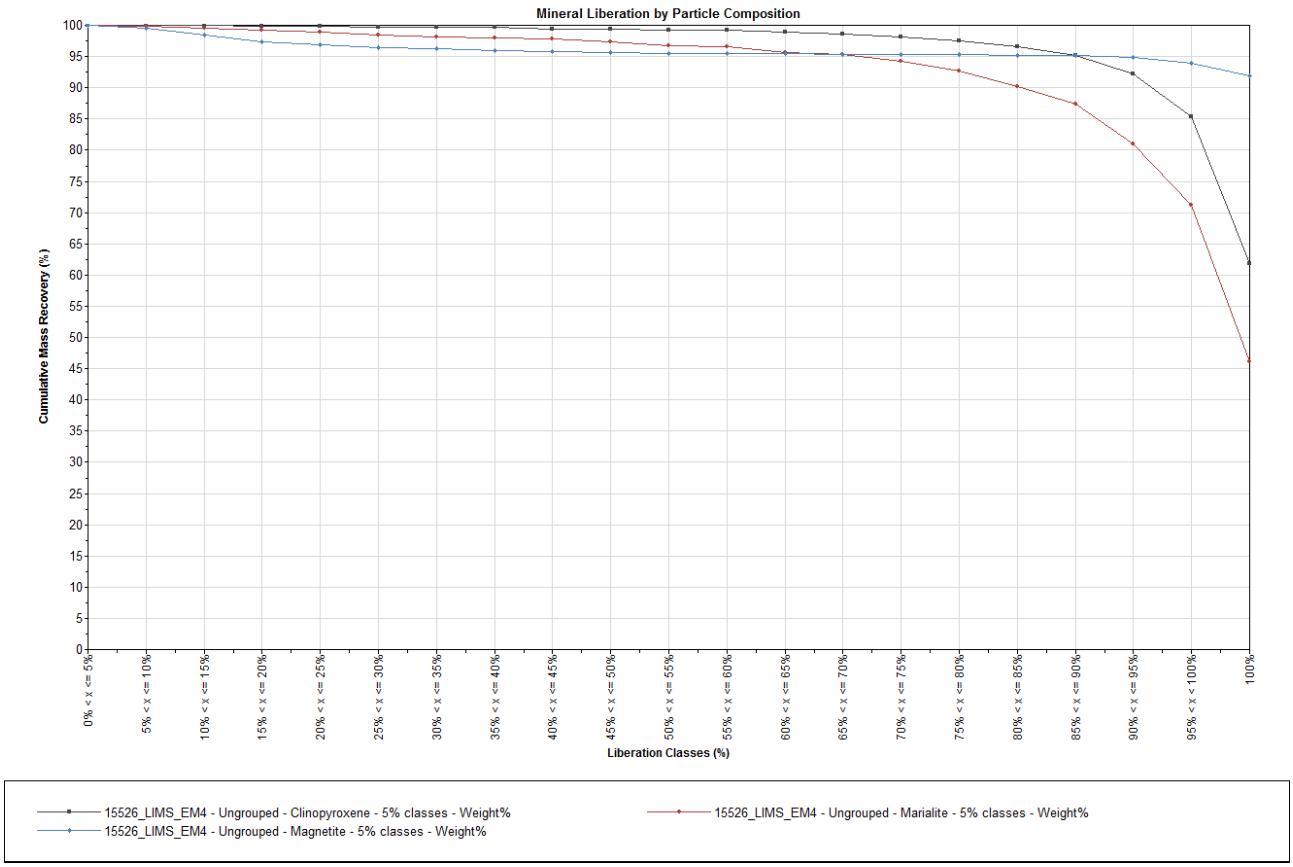
OK15525 LIMS_M4
Main mineral is magnetite.

Magnetite liberation is > 95 % (~98 %) at LC 100 %.



OK15526 LIMS_EM4
Main minerals are clinopyroxene, magnetite and marialite.

Clinopyroxene liberation is > 95 % at LC 90 % and > 85 % at LC 100 %.
Magnetite liberation is > 95 % at LC 95 % and > 90 % (~94 %) at LC 100 %.
Marialite liberation is > 95 % at LC 70 % and > 70 % at LC 100 %.



MINERAL ASSOCIATIONS OF THE MAIN MINERALS
Values > 1% (or the highest value if smaller than 1) are marked with yellow.

OK15518 CuKR3

Mineral	Pyrite	Chalcopyrite
Pyrite	0.00	0.10
Pyrrhotite	0.01	0.03
Covellite	0.00	0.07
Chalcopyrite	0.24	0.00
Unknown	0.00	0.02
Free Surface	99.74	99.71

OK15519 2SY

Mineral	Clinopyroxene	Ferrotschermakite	Actinolite	Marialite	Berthierine
Quartz	0.00	0.00	0.03	0.00	0.00
Plagioclase	0.00	0.04	0.03	0.06	0.05
K_feldspar	0.04	0.06	0.00	0.02	0.03
Clinopyroxene	0.00	0.80	0.58	0.14	0.15
Ferrotschermakite	1.33	0.00	1.55	0.57	1.32
Actinolite	0.47	0.75	0.00	0.14	0.24
Epidote	0.02	0.14	0.02	0.03	0.03
Vesuvianite	0.03	0.00	0.00	0.00	0.00
Marialite	0.23	0.58	0.30	0.00	0.58
Chlorite	0.00	0.02	0.00	0.00	0.13
Biotite	0.00	0.00	0.00	0.03	0.01
Titanite	0.00	0.04	0.01	0.03	0.01
Clay	0.05	0.26	0.04	0.15	0.27
Berthierine	0.16	0.84	0.31	0.37	0.00
Allanite	0.02	0.20	0.02	0.06	0.14
Pyrite	0.10	0.08	0.08	0.11	0.11
Alteration of Pyrrhotite	0.05	0.22	0.11	0.08	0.31
Goethite	0.03	0.08	0.05	0.05	0.59
Unknown	0.08	0.12	0.09	0.06	0.06
Free Surface	97.40	95.76	96.76	98.08	95.96

OK15520 PYKR1

Mineral	Pyrite
Plagioclase	0.11
Clinopyroxene	0.05
Ferrotschermakite	0.07
Actinolite	0.03
Marialite	0.34
Chlorite	0.07
Berthierine	0.29
Pyrrhotite	0.36
Alteration of Pyrrhotite	0.57
Chalcopyrite	0.07
Goethite	0.03
Unknown	0.10
Free Surface	97.84

OK15521 PYKJ1

Mineral	Clinopyroxene	Marialite	Pyrite
Quartz	0.01	0.03	0.00
Plagioclase	0.05	0.55	0.06
K_feldspar	0.01	0.03	0.01
Clinopyroxene	0.00	0.36	0.19
Ferrotschermakite	0.49	0.19	0.10
Actinolite	0.24	0.19	0.11
Epidote	0.00	0.14	0.01
Marialite	0.24	0.00	0.41
Chlorite	0.05	0.08	0.01
Titanite	0.14	0.27	0.01
Clay	0.01	0.39	0.04
Berthierine	0.05	0.74	0.18
Allanite	0.02	0.03	0.00
Pyrite	0.16	0.53	0.00
Pyrrhotite	0.04	0.07	0.42
Alteration of Pyrrhotite	0.02	0.13	0.48
Chalcopyrite	0.05	0.02	0.06
Magnetite	0.04	0.07	0.00
Goethite	0.10	0.12	0.05
Unknown	0.05	0.04	0.05
Free Surface	98.22	96.03	97.79

OK15522 PYEJ

Mineral	Clinopyroxene	Marialite
Quartz	0.03	0.06
Plagioclase	0.08	0.86
K_feldspar	0.00	0.05
Clinopyroxene	0.00	0.93
Ferrotschermakite	1.35	0.31
Actinolite	0.29	0.06
Epidote	0.05	0.17
Marialite	0.52	0.00
Chlorite	0.04	0.20
Biotite	0.00	0.03
Titanite	0.31	0.37
Clay	0.03	1.54
Berthierine	0.14	0.80
Apatite	0.03	0.02
Pyrite	0.04	0.02
Magnetite	0.35	0.23
Goethite	0.29	0.13
Unknown	0.04	0.03
Free Surface	96.35	94.11

OK15523 POKR

Mineral	Pyrrhotite	Magnetite
Clinopyroxene	0.05	0.04
Ferrotschermakite	0.04	0.04
Marialite	0.00	0.03
Chlorite	0.03	0.00
Berthierine	0.07	0.02
Pyrite	0.25	0.04
Pyrrhotite	0.00	0.76
Alteration of Pyrrhotite	2.53	0.40
Magnetite	0.93	0.00
Goethite	0.36	0.58
Process_metal	0.01	0.04
Unknown	0.00	0.00
Free Surface	95.67	98.00

OK15524 POKJ

Mineral	Pyrrhotite	Magnetite
Clinopyroxene	0.07	0.09
Ferrotschermakite	0.05	0.07
Actinolite	0.01	0.05
Marialite	0.04	0.14
Titanite	0.07	0.02
Berthierine	0.17	0.06
Pyrite	0.12	0.00
Pyrrhotite	0.00	0.28
Alteration of Pyrrhotite	2.13	0.18
Magnetite	1.19	0.00
Goethite	0.42	0.53
Process_metal	0.03	0.05
Unknown	0.01	0.01
Free Surface	95.70	98.46

OK15525 LIMS_M4

Mineral	Magnetite
Clinopyroxene	0.13
Ferrotschermakite	0.06
Marialite	0.10
Titanite	0.05
Berthierine	0.04
Goethite	0.29
Process_metal	0.05
Unknown	0.00
Free Surface	99.22

OK15526 LIMS_EM4

Mineral	Clinopyroxene	Marialite	Magnetite
Plagioclase	0.06	1.25	0.06
K_feldspar	0.00	0.04	0.00
Clinopyroxene	0.00	1.90	2.78
Ferrotschermakite	1.86	0.53	0.34
Actinolite	0.43	0.04	0.44
Epidote	0.09	0.37	0.11
Marialite	0.79	0.00	2.07
Chlorite	0.03	0.05	0.05
Titanite	0.42	0.82	0.06
Clay	0.02	1.15	0.02
Berthierine	0.11	1.48	0.08
Apatite	0.04	0.07	0.00
Allanite	0.02	0.11	0.01
Pyrrhotite	0.02	0.02	0.09
Alteration of Pyrrhotite	0.02	0.04	0.03
Ilmenite	0.01	0.04	0.00
Magnetite	1.17	2.08	0.00
Goethite	1.01	1.65	0.34
Unknown	0.04	0.14	0.01
Free Surface	93.76	88.14	93.51

SULPHIDES AND THEIR GRAIN SIZE DISTRIBUTION

Table 1. Sulphide mineral distribution in samples.

Mineral	15518 Wt%	15519 Wt%	15520 Wt%	15521 Wt%	15522 Wt%	15523 Wt%	15524 Wt%	15525 Wt%	15526 Wt%
Pyrite	46.21	5.77	73.39	30.91	0.33	1.21	0.21	0.02	0.01
Pyrrhotite	0.37	0.29	8.52	4.32	0.02	47.58	18.40	0.11	0.56
Alt. of Pyrrhotite	0.05	2.78	1.86	1.57	0.08	4.83	2.59	0.01	0.07
Covellite	0.26	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00
Chalcopyrite	52.88	0.15	4.19	0.51	0.00	0.07	0.00	0.00	0.00
Unknown	0.05	0.89	0.21	0.32	0.09	0.04	0.06	0.01	0.04
Other	0.18	90.12	11.80	62.36	99.49	46.28	78.74	99.85	99.32
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

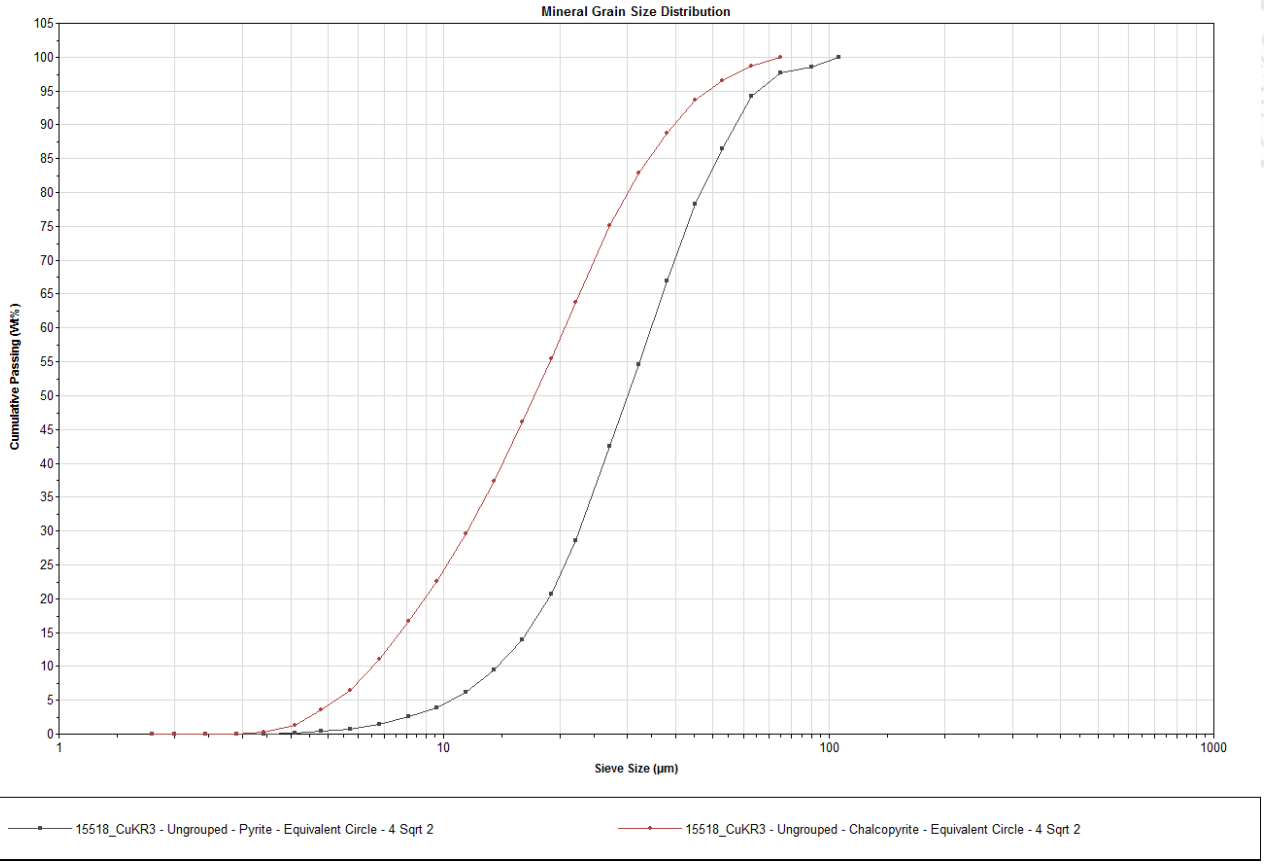


Figure 1. OK15518 CuKR3

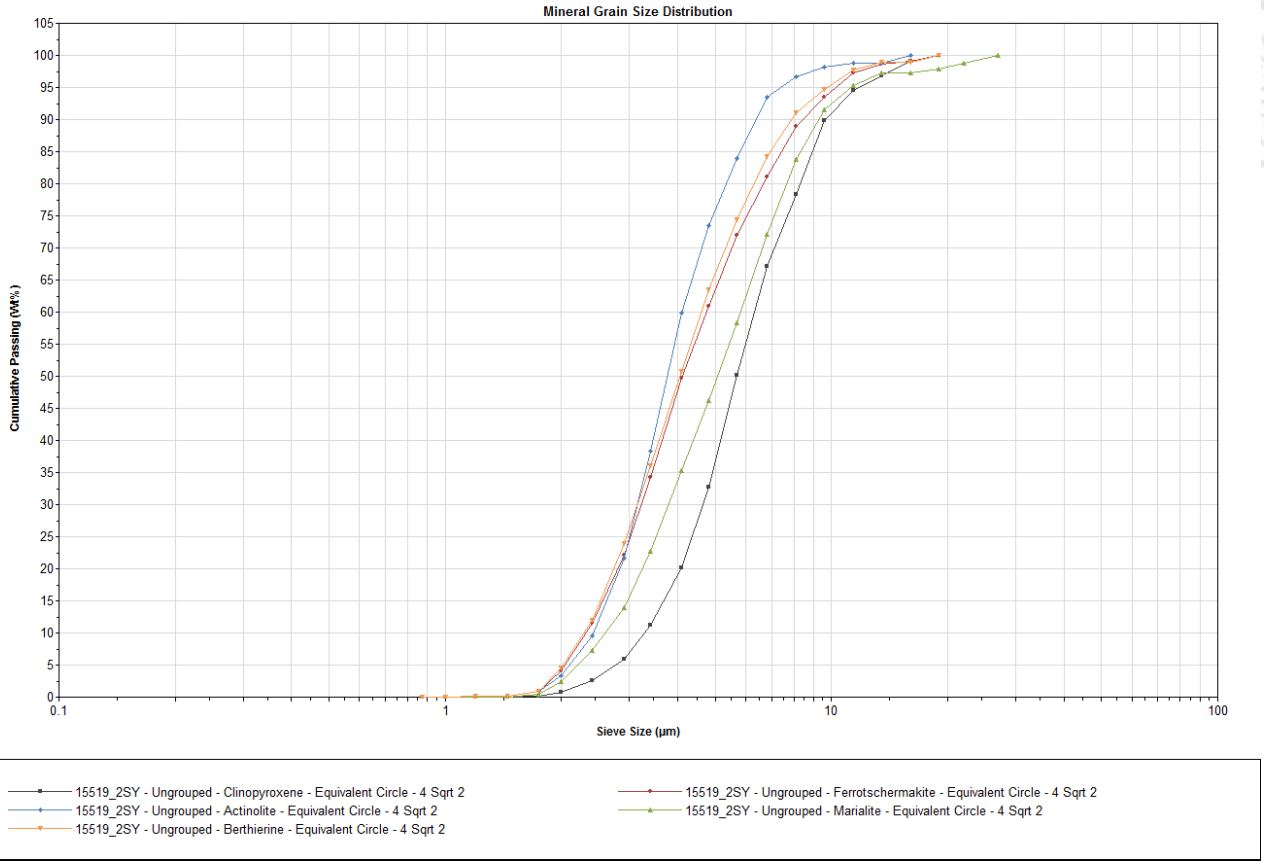


Figure 2. OK15519 2SY

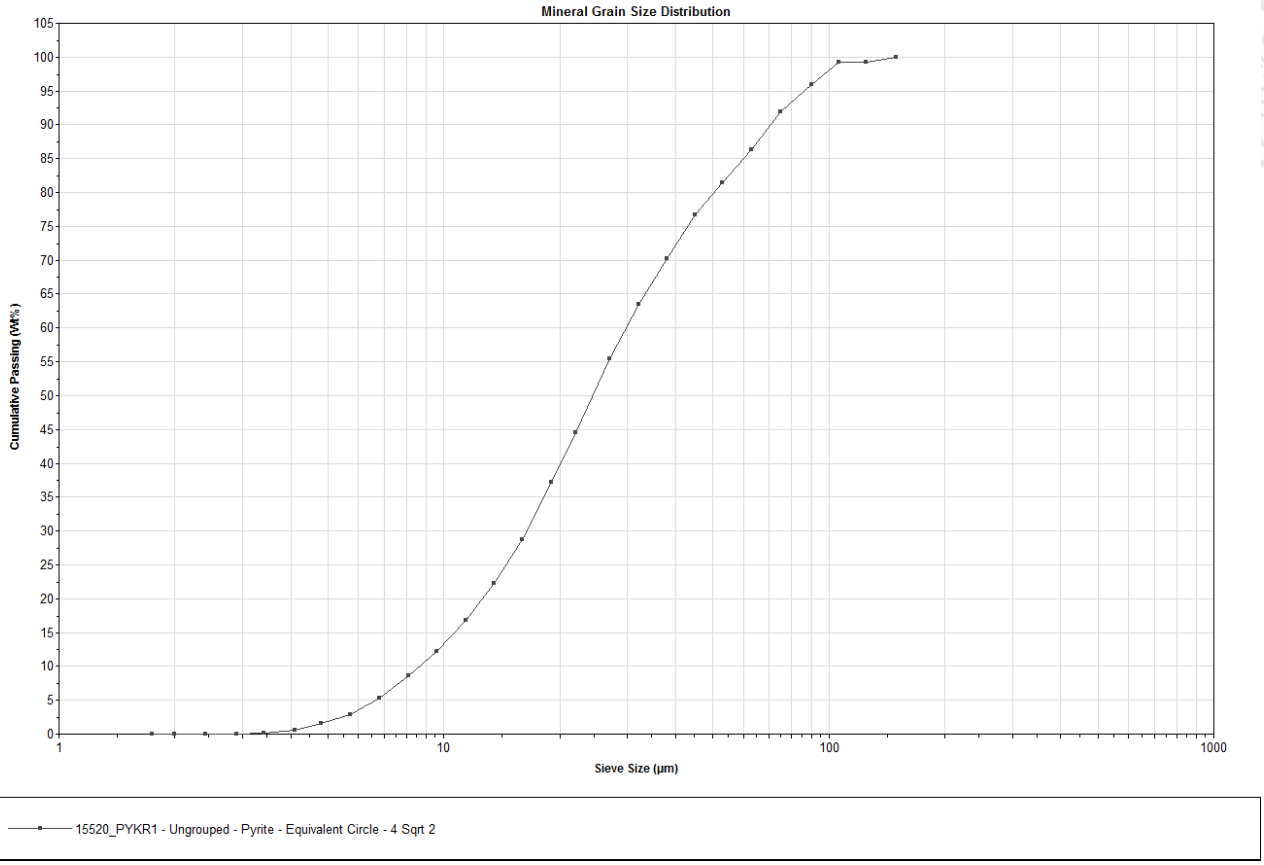


Figure 3. OK15520 PYKR1

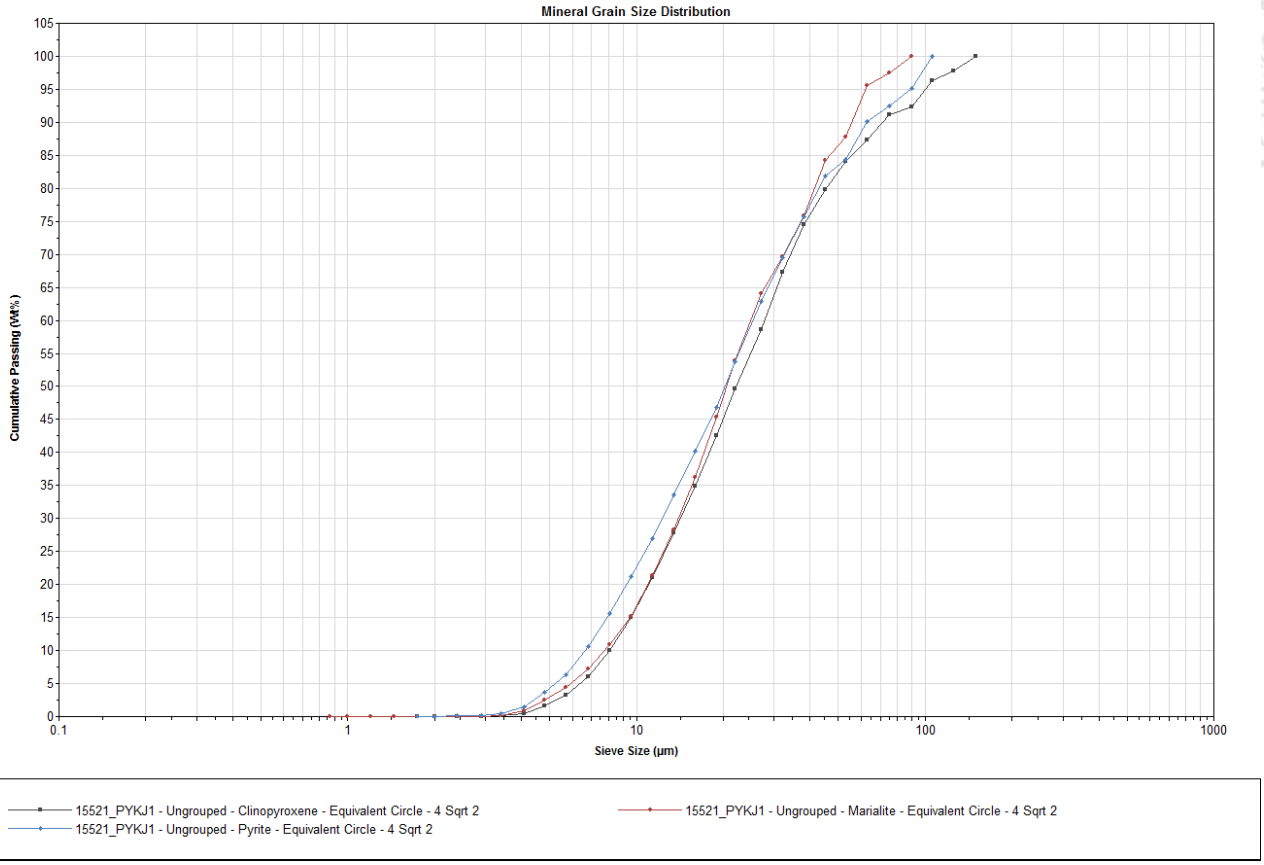


Figure 4. OK15521 PYKJ1

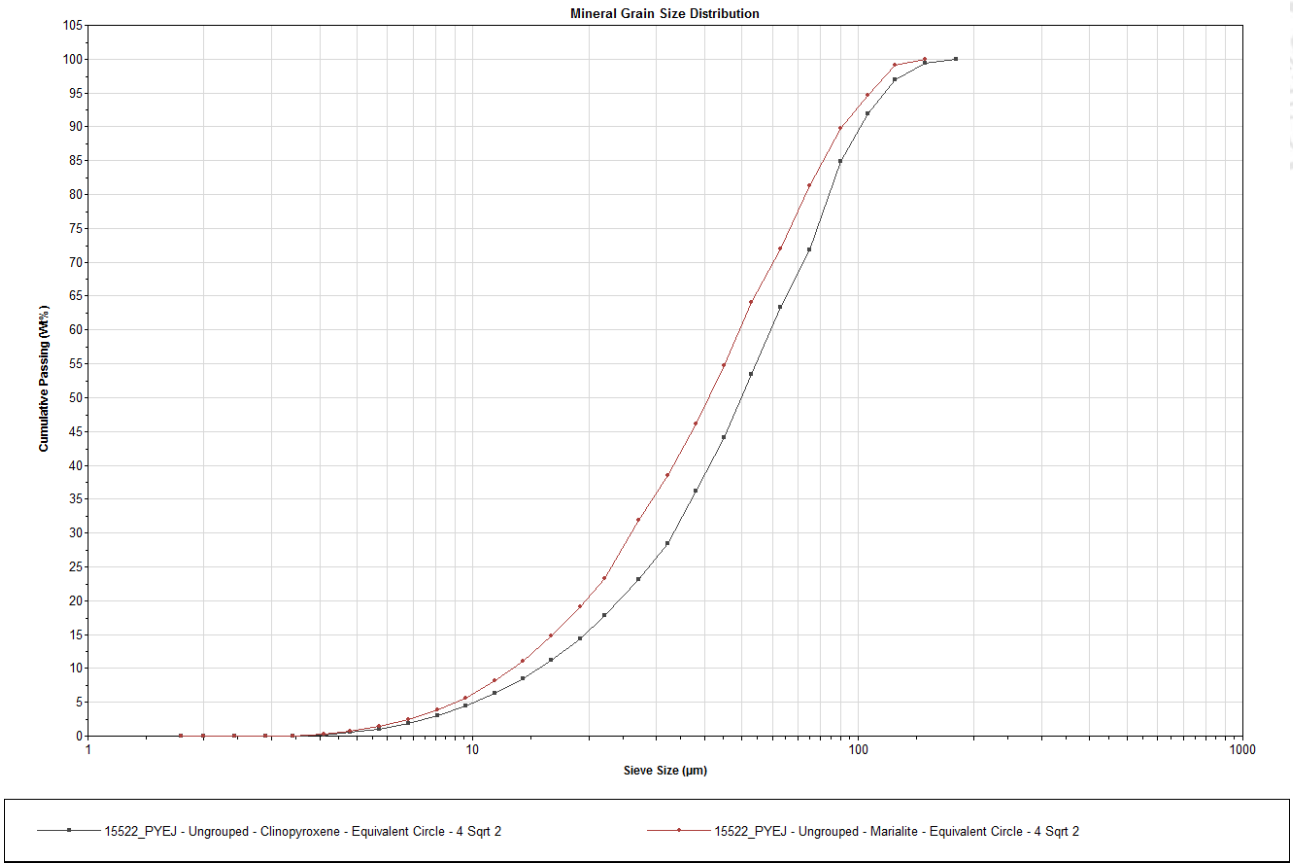


Figure 5. OK15522 PYEJ

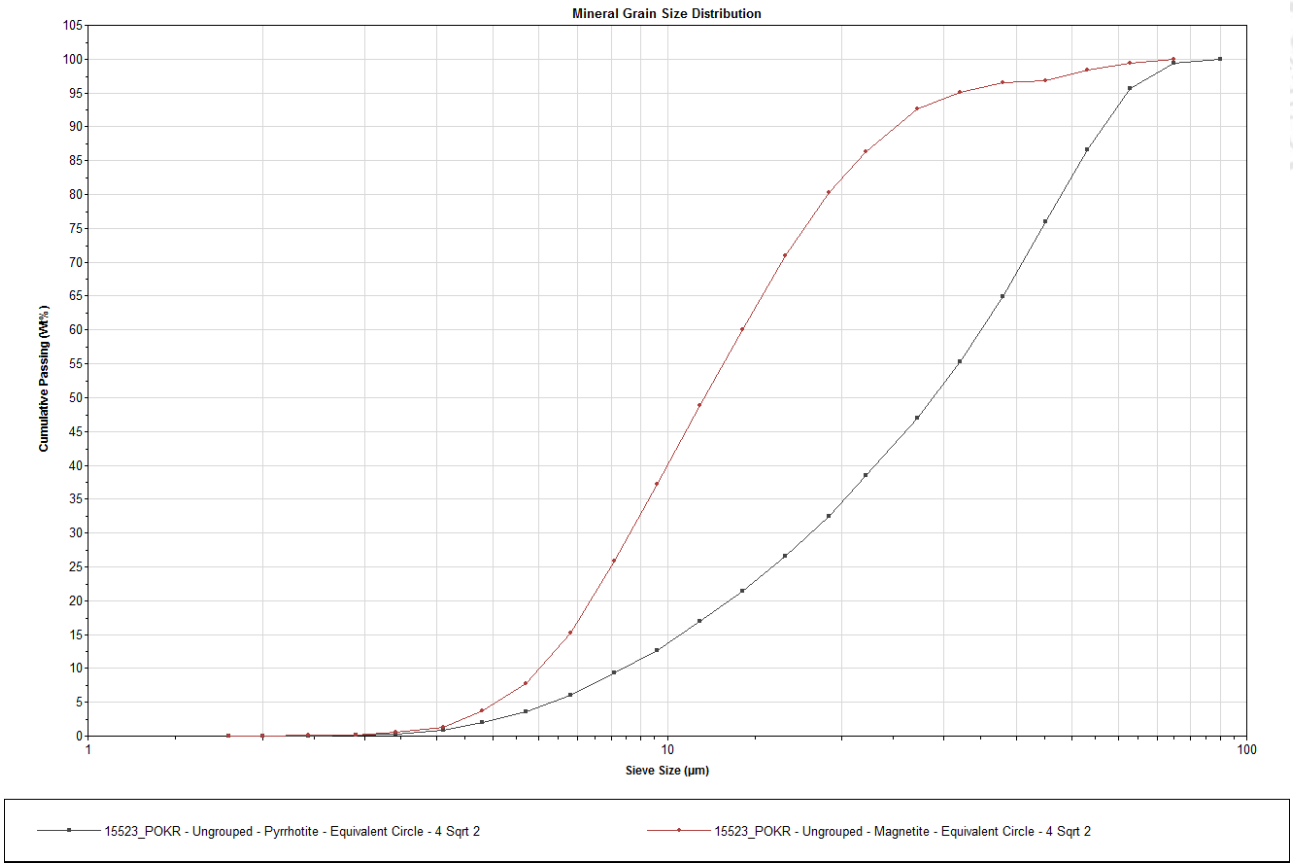


Figure 6. OK15523 POKR

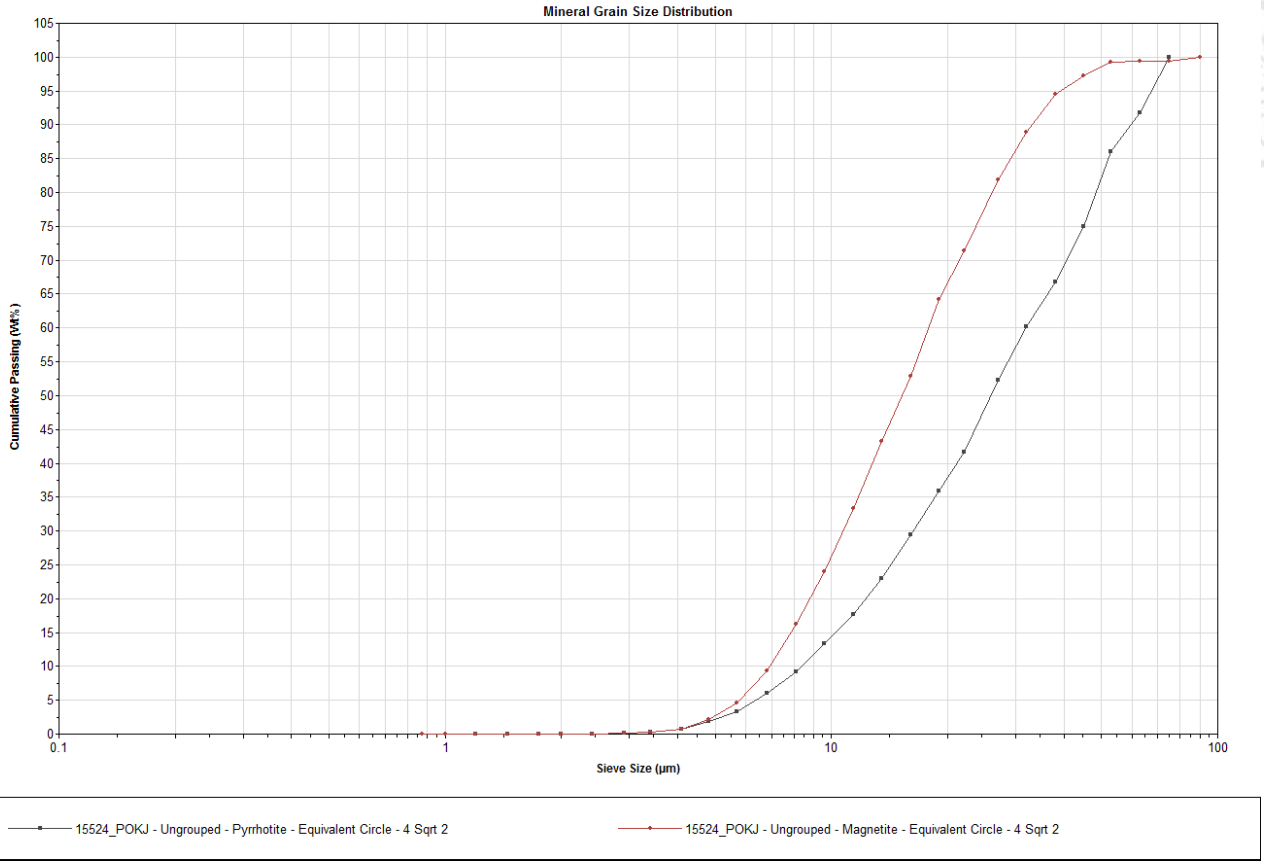


Figure 7. OK15524 POKJ

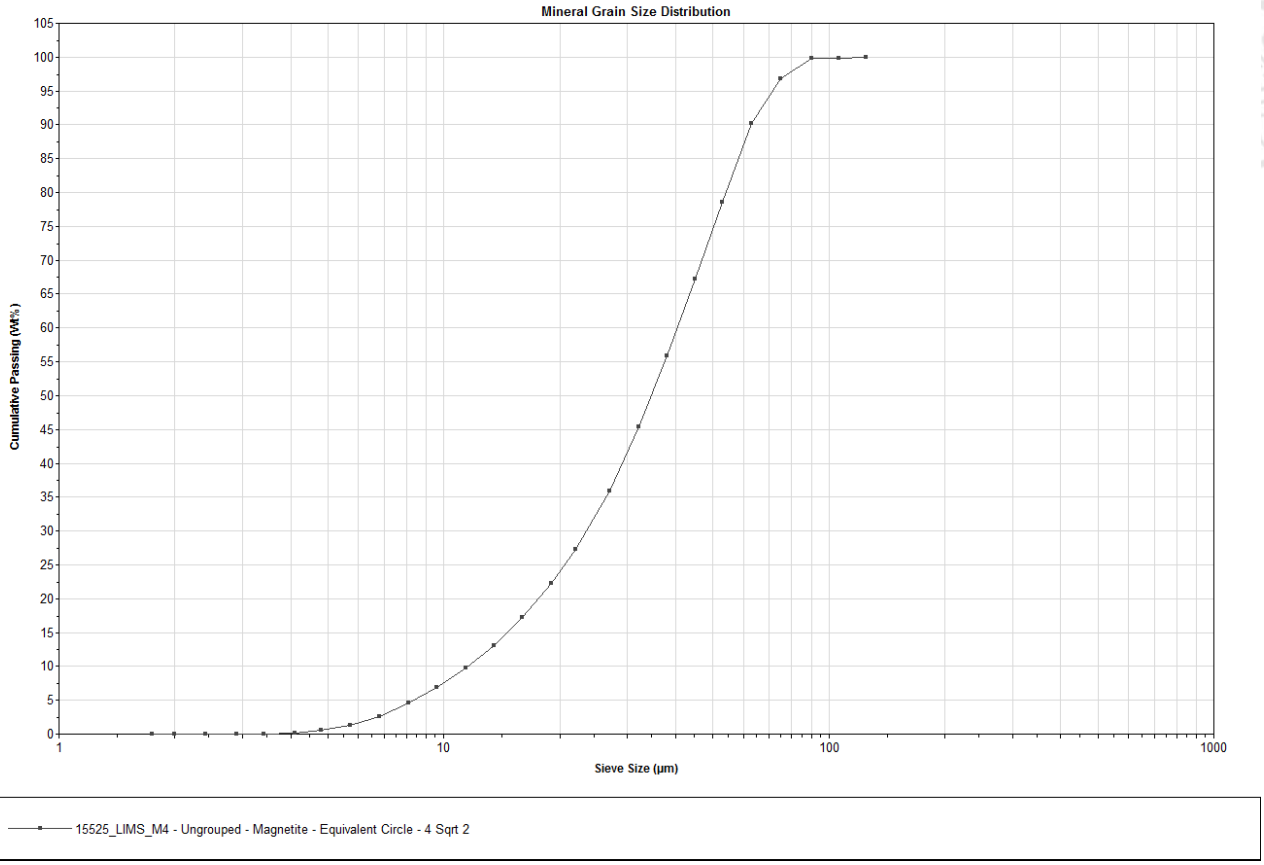


Figure 8. OK15525 LIMS_M4

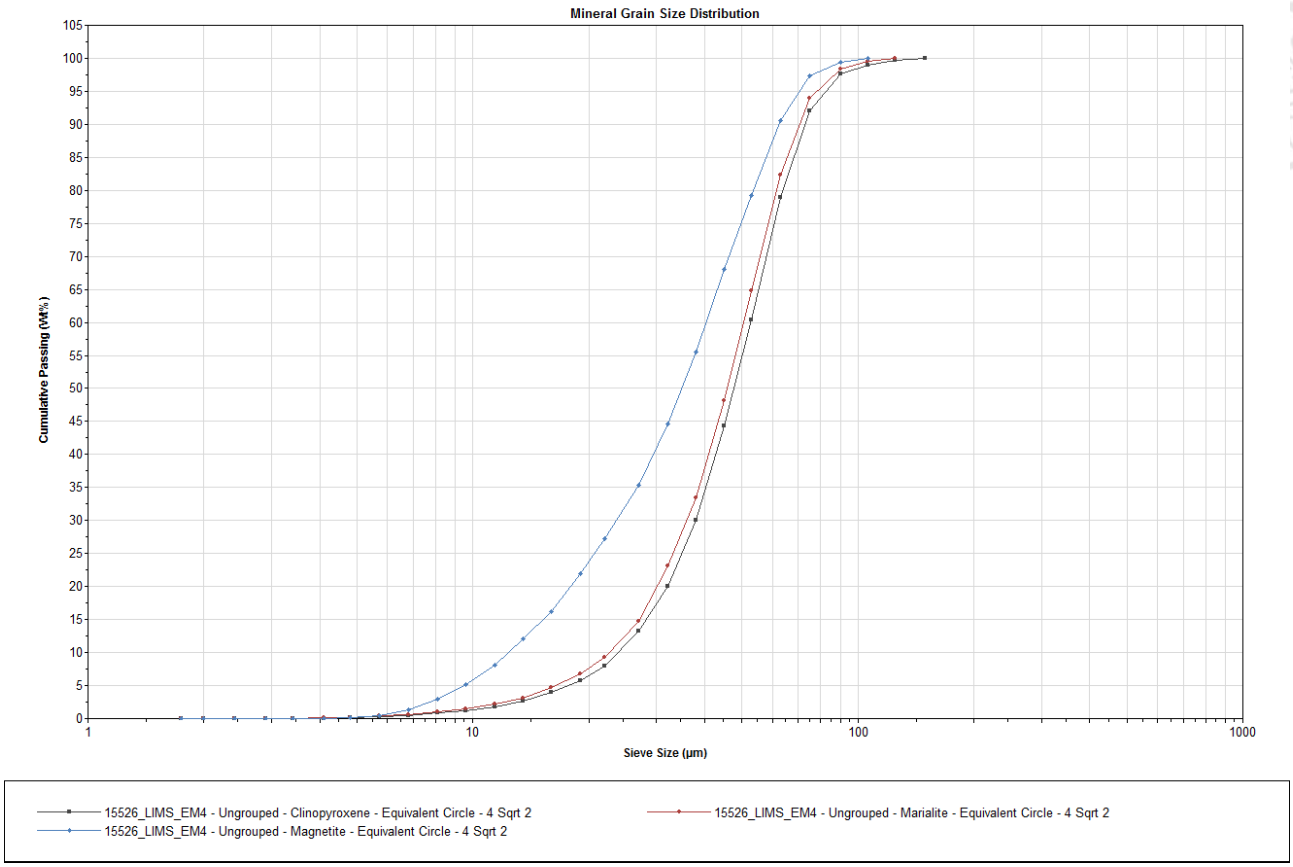


Figure 9. OK15526 LIMS_EM4

DISTRIBUTION OF PYRITE, PYRRHOTITE, FE-OXIDES AND GOETHITE IN SAMPLES

Table 2. Mineral distribution of pyrite, pyrrhotite, Fe-oxides and goethite in samples.

Mineral	15518 Wt%	15519 Wt%	15520 Wt%	15521 Wt%	15522 Wt%	15523 Wt%	15524 Wt%	15525 Wt%	15526 Wt%
Pyrite	46.21	5.77	73.39	30.91	0.33	1.21	0.21	0.02	0.01
Pyrrhotite	0.37	0.29	8.52	4.32	0.02	47.58	18.40	0.11	0.56
Ilmenite	0.00	0.05	0.00	0.03	0.02	0.01	0.01	0.01	0.04
Magnetite	0.01	0.28	0.69	1.59	0.61	37.95	63.23	94.71	22.07
Goethite	0.02	2.55	0.55	1.78	2.07	4.07	4.34	0.97	1.16
Unknown	0.05	0.89	0.21	0.32	0.09	0.04	0.06	0.01	0.04
Other	53.35	90.17	16.65	61.05	96.86	9.15	13.74	4.18	76.13
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

FIBROUS MINERALS AND THEIR HABITUS IN SAMPLES

Potential fibrous mineral present in samples is actinolite (0.01-8.36 %). Actinolite habitus in samples does not present visible fibrous forms, however, due to the small particle size, additional studies with other methods are suggested. The actinolite grains that are visible separately, display a rounded shape (Figure 10a). However, most of the actinolite is found in agglomerates (Figure 10b) and their general habitus is not certain.
Based on MLA analysis, the general habitus of actinolite in samples does not fill the requirements for fibrous asbestos minerals (length/width ratio of >= 3:1).

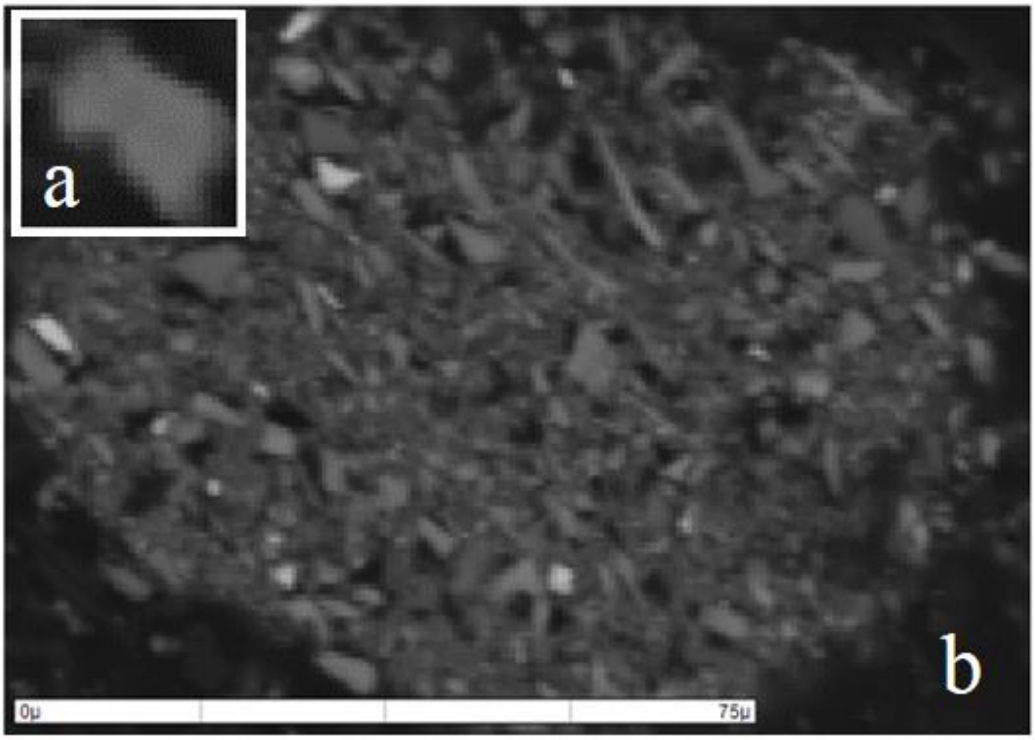


Figure 10. Actinolite grain (a) and agglomerate (b) in sample 15519 2SY.

3 MAIN PROCESS SAMPLES, VE-3 ORE, 25.9.2017

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November 24th 2017

Derrick u/s	OK15529	DA	280917, 10.00 am	VE2
PoRC	OK15530	PoER	250917, 13.40 pm	VE3
WLT4	OK15531	LIMS EM4	250917, 13.40 pm	VE3
WLC4	OK15532	LIMS M4	250917, 13.40 pm	VE3
PyRC	OK15533	PyER	250917, 13.40 pm	VE3
CuCC3	OK15534	CuKR3	250917, 13.40 pm	VE3
Derrick u/s	OK15535	DA	250917, 13.40 pm	VE3
WLT 1-3	OK15536	LIMS EM 1-3	250917, 10.30 am	VE3

Method: XBSE

Mineral liberations and associations of main minerals in each sample
Sulphides, oxides and fibrous minerals

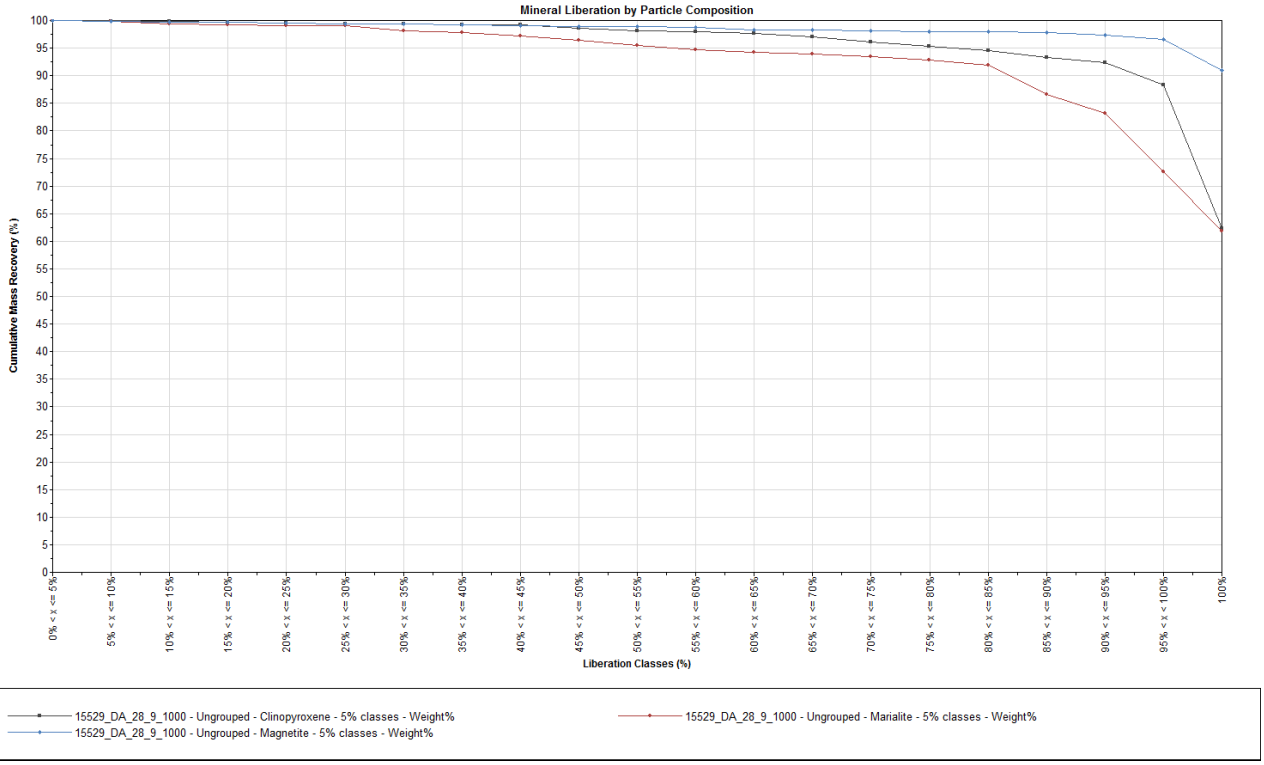
Liberations of the main/other relevant minerals p. 33
Mineral associations of the main minerals p. 41
Sulphides and their grain size distribution p. 45
Distribution of pyrite, pyrrhotite, Fe-oxides and goethite in samples p. 50
Fibrous minerals and their habit in samples p. 51

LIBERATIONS OF THE MAIN/OTHER RELEVANT MINERALS

OK15529 DA

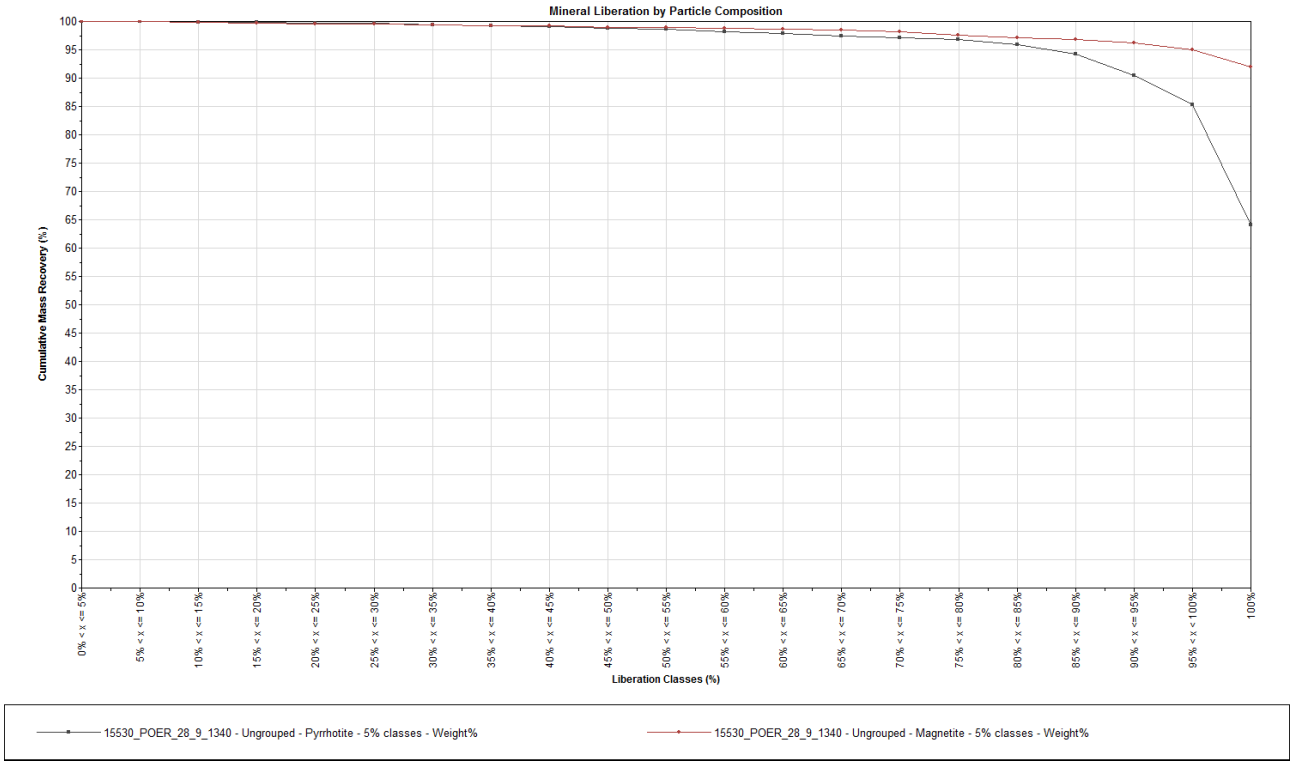
Main minerals are clinopyroxene, marialite and magnetite.

Magnetite liberation is > 95 % at LC 100 %.
Clinopyroxene liberation is > 95 % until LC 85 % and descending evenly. At LC 100 % the liberation is > 85 %.
Marialite liberation is > 95 % until LC 55 % and descending evenly until LC 85 % (> 90 %). At LC 100 % the liberation is > 70 %.



OK15530 PoER
Main minerals are pyrrhotite and magnetite.

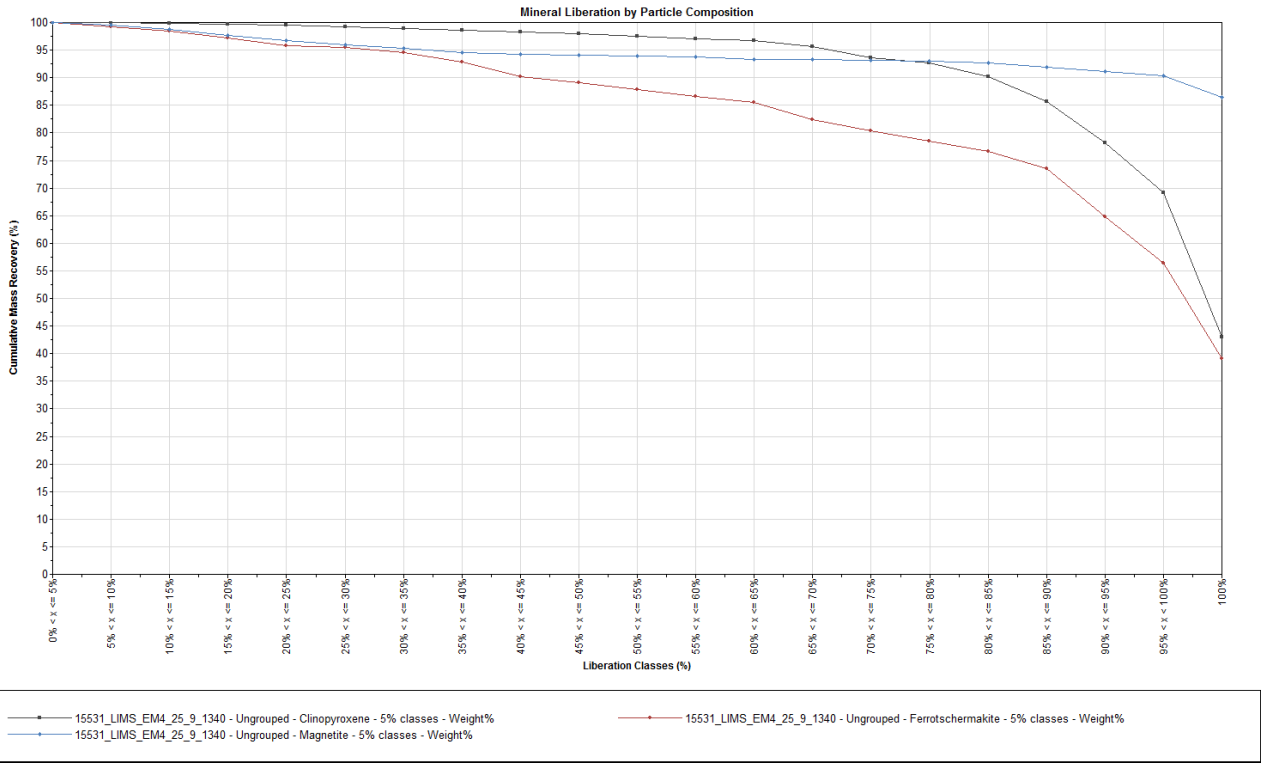
Magnetite liberation is > 95 % at LC 100 %.
Pyrrhotite liberation is > 95 % until LC 85 % and descending evenly. At LC 100 % the liberation is > 85 %.



OK15531 LIMS EM4

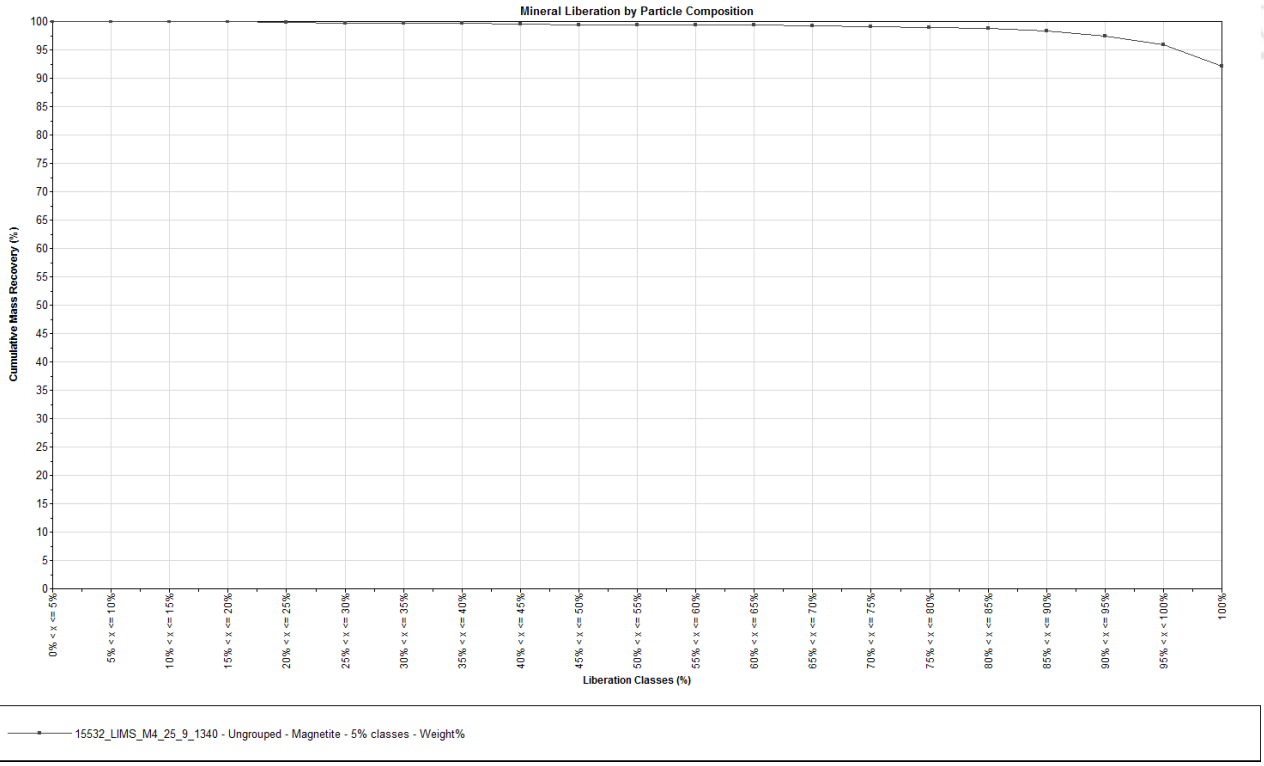
Main minerals are clinopyroxene, ferrotschermakite and magnetite.

Magnetite liberation is > 90 % at LC 100 %.
Clinopyroxene liberation is > 95 % until LC 70 % and descending evenly. At LC 100 % the liberation is > 70 %.
Ferrotschermakite liberation is > 90 % at LC 45 %, > 80 % at LC 75 % and rapidly descending until LC 100 % where the liberation is > 55 %.



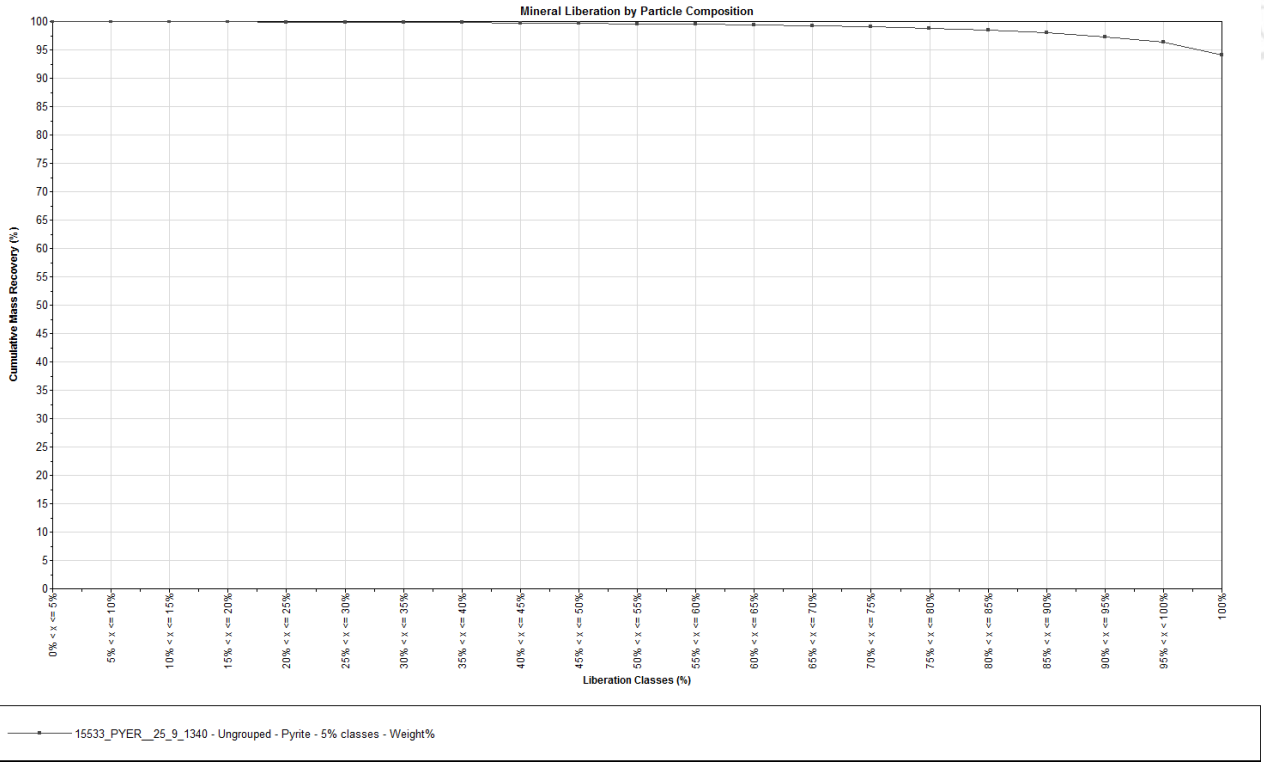
OK15532 LIMS M4

Main mineral is magnetite and its liberation at LC 100 % is > 95 %.



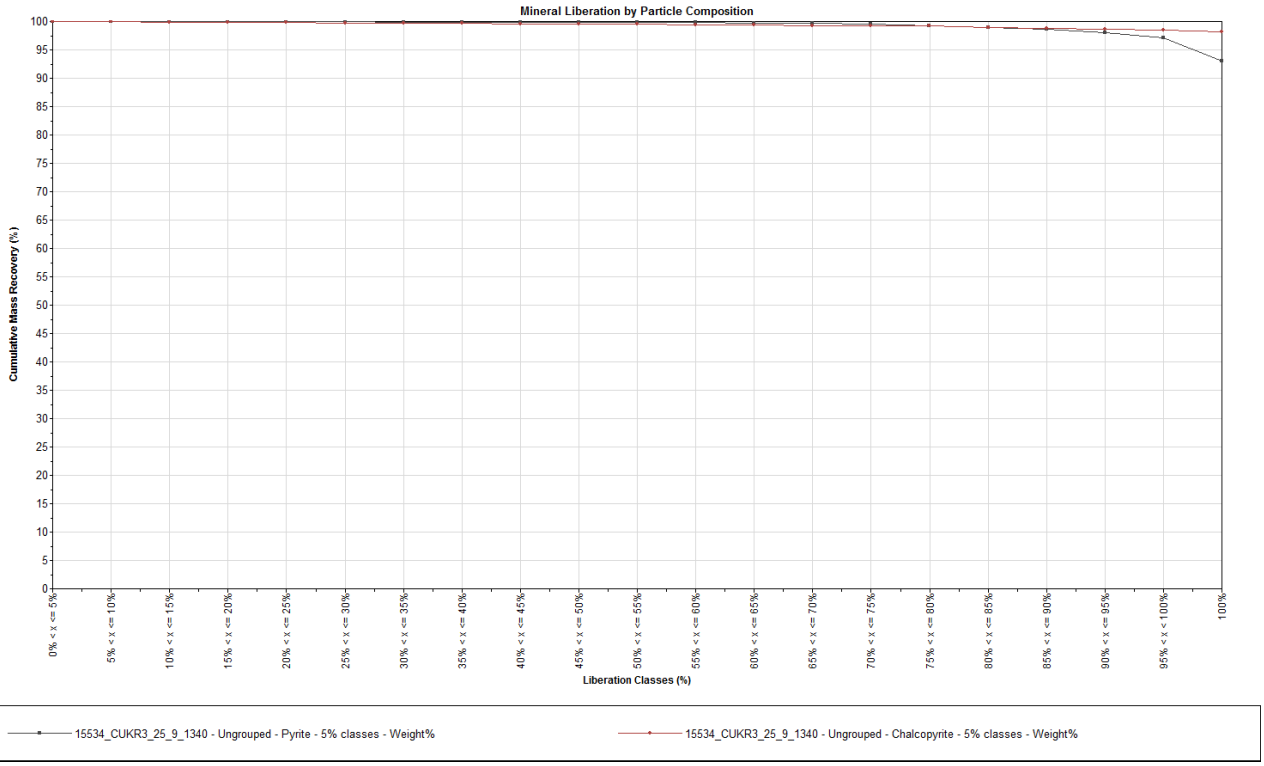
OK15533 PyER

Main mineral is pyrite and its liberation at LC 100 % is > 95 %.



OK15534 CuKR3
Main minerals are pyrite and chalcopyrite.

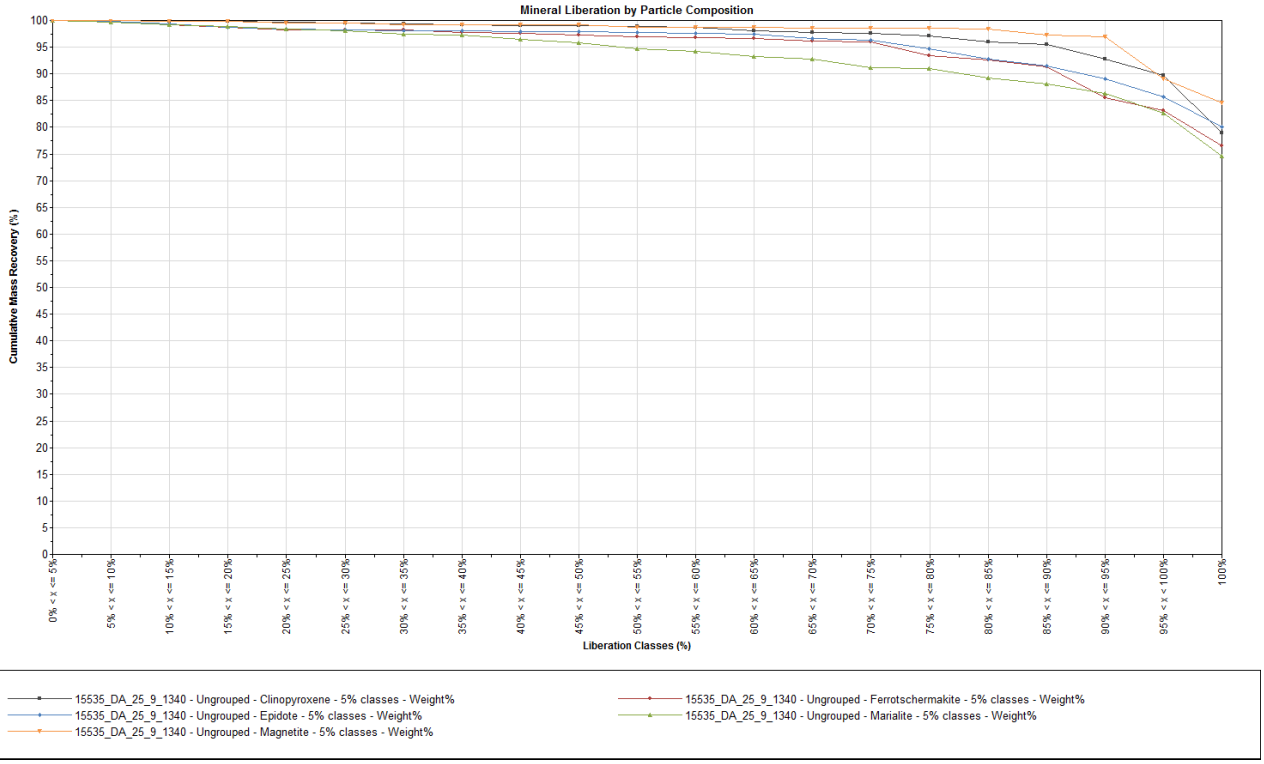
Pyrite liberation is > 95 % at LC 100 %.
Chalcopyrite liberation is > 98 % at LC 100 %.



OK15535 DA

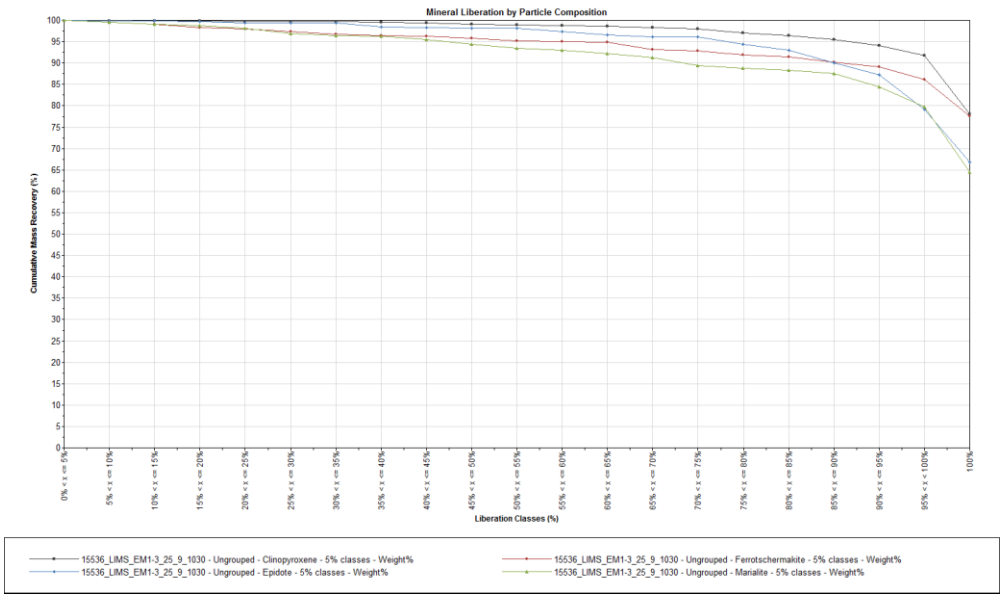
Main minerals are clinopyroxene, ferrotschermakite, epidote, marialite and magnetite.

Clinopyroxene liberation is > 95 % at LC 90 % and > 90 % at LC 100 %.
Ferrotschermakite liberation is > 95 % at LC 75 % and > 80 % at LC 100 %.
Epidote liberation is > 95 % at LC 80 % and > 85 % at LC 100 %.
Marialite liberation is > 95 % at LC 50 % and > 80 % at LC 100 %.
Magnetite liberation is > 95 % at LC 95 % and > 90 % at LC 100 %.



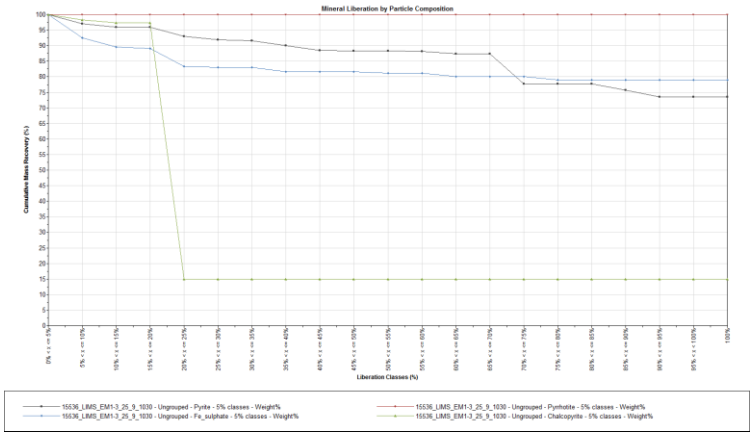
OK15536 LIMS EM 1-3
Main minerals are clinopyroxene, ferrotschermakite, epidote and marialite.

Clinopyroxene liberation is > 95 % at LC 90 % and > 90 % at LC 100 %.
Ferrotschermakite liberation is > 95 % at LC 65 % and > 85 % at LC 100 %.
Epidote liberation is > 95 % at LC 75 % and > 80 % at LC 100 %.
Marialite liberation is > 95 % at LC 45 % and = 80 % at LC 100 %.



Sulfur in sample is found in pyrite, pyrrhotite, Fe-sulphate and chalcopyrite. (Their liberations should be interpreted with caution due to their low percentages in the sample.)

Pyrite liberation is > 95 % at LC 20 %, > 90 % at LC 40 %, > 85 % at LC 70 % and > 70 % at LC 100 %.
Pyrrhotite liberation is > 95 % at LC 100 %.
Fe-sulphate liberation is > 90 % at LC 15 %, > 80 % at LC 75 % and > 75 % (~78 %) at LC 100 %.
Chalcopyrite liberation is > 95 % at LC 20 % and descends to 15 % at LC 25 (15 % at LC 100 %).



MINERAL ASSOCIATIONS OF THE MAIN MINERALS

Values > 1% (or the highest value if smaller than 1) are marked with yellow.

OK15529 DA

Mineral	Clinopyroxene	Marialite	Magnetite
Quartz	0.02	0.02	0.00
Plagioclase	0.08	1.45	0.01
Clinopyroxene	0.00	1.27	0.65
Ferrotschermakite	1.65	0.49	0.36
Actinolite	0.29	0.04	0.08
Epidote	0.07	0.21	0.05
Marialite	0.81	0.00	0.48
Chlorite	0.02	0.08	0.01
Biotite	0.00	0.06	0.00
Titanite	0.29	0.43	0.04
Clay	0.03	0.74	0.02
Berthierine	0.16	1.03	0.08
Allanite	0.01	0.06	0.00
Pyrite	0.07	0.13	0.00
Pyrrhotite	0.05	0.02	0.09
Fe_sulphate	0.06	0.08	0.12
Magnetite	0.60	0.69	0.00
Goethite	0.43	0.68	0.36
Unknown	0.02	0.06	0.01
Free Surface	95.26	92.38	97.57

OK15530 PoER

Mineral	Pyrrhotite	Magnetite
Clinopyroxene	0.01	0.09
Marialite	0.03	0.05
Chlorite	0.00	0.05
Berthierine	0.06	0.26
Pyrite	0.14	0.00
Pyrrhotite	0.00	0.49
Fe_sulphate	2.90	0.25
Magnetite	2.40	0.00
Goethite	0.70	0.69
Process_metal	0.06	0.05
Unknown	0.00	0.01
Free Surface	93.64	97.95

OK15531 LIMS EM4

Mineral	Clinopyroxene	Ferrotschermakite	Magnetite
Plagioclase	0.19	0.64	0.10
Clinopyroxene	0.00	10.32	2.19
Ferrotschermakite	4.36	0.00	1.24
Actinolite	0.62	5.70	0.40
Epidote	0.40	1.51	0.41
Vesuvianite	0.09	0.19	0.02
Andradite	0.25	0.24	0.03
Marialite	1.59	1.39	0.51
Chlorite	0.08	0.79	0.16
Titanite	0.71	0.38	0.11
Clay	0.02	0.22	0.01
Berthierine	0.55	0.69	0.79
Calcite	0.10	0.20	0.01
Pyrrhotite	0.02	0.02	0.09
Fe_sulphate	0.02	0.04	0.04
Magnetite	3.04	4.10	0.00
Goethite	1.18	2.45	0.78
Process_metal	0.00	0.01	0.04
Unknown	0.08	0.19	0.03
Free Surface	86.63	70.78	92.96

OK15532 LIMS M4

Mineral	Magnetite
Clinopyroxene	0.24
Ferrotschermakite	0.09
Epidote	0.04
Marialite	0.06
Chlorite	0.05
Berthierine	0.38
Goethite	0.55
Process_metal	0.06
Unknown	0.01
Free Surface	98.42

OK15533 PyER

Mineral	Pyrite
Ferrotschermakite	0.12
Marialite	0.07
Pyrrhotite	0.13
Fe_sulphate	0.88
Chalcopyrite	0.07
Unknown	0.11
Free Surface	98.46

OK15534 CuKR3

Mineral	Pyrite	Chalcopyrite
Berthierine	0.03	0.05
Pyrite	0.00	0.42
Fe_sulphate	0.16	0.05
Chalcopyrite	0.70	0.00
Unknown	0.01	0.02
Free Surface	98.98	99.26

OK15535 DA

Mineral	Clinopyroxene	Ferrotschermakite	Epidote	Marialite	Magnetite
Plagioclase	0.20	0.07	0.33	1.61	0.03
K_feldspar	0.05	0.09	0.05	0.03	0.00
Clinopyroxene	0.00	3.16	0.59	1.27	0.35
Ferrotschermakite	1.68	0.00	0.95	1.33	0.75
Actinolite	0.34	1.49	0.27	0.07	0.01
Epidote	0.22	0.68	0.00	1.00	0.45
Vesuvianite	0.02	0.05	0.14	0.02	0.00
Andradite	0.21	0.10	0.65	0.10	0.00
Marialite	0.51	1.00	1.06	0.00	0.13
Chlorite	0.03	0.17	0.18	0.03	0.38
Muscovite	0.00	0.10	0.18	0.02	0.00
Titanite	0.23	0.22	0.17	0.22	0.14
Clay	0.01	0.04	0.19	0.48	0.00
Berthierine	0.06	0.15	0.17	0.27	0.71
Apatite	0.01	0.05	0.00	0.00	0.00
Allanite	0.00	0.02	0.04	0.01	0.00
Calcite	0.09	0.05	0.34	0.01	0.00
Pyrite	0.01	0.04	0.02	0.00	0.00
Fe_sulphate	0.02	0.06	0.00	0.01	0.00
Magnetite	0.05	0.19	0.16	0.04	0.00
Goethite	0.09	0.20	0.01	0.02	0.56
Unknown	0.01	0.06	0.06	0.04	0.01
Free Surface	96.13	91.94	94.43	93.41	96.47

OK15536 LIMS EM 1-3

Mineral	Clinopyroxene	Ferrotschermakite	Epidote	Marialite
Plagioclase	0.08	0.06	0.73	2.36
K_feldspar	0.02	0.04	0.11	0.26
Clinopyroxene	0.00	4.50	0.38	1.52
Ferrotschermakite	2.25	0.00	1.22	1.32
Actinolite	0.50	1.76	0.38	0.17
Epidote	0.13	0.85	0.00	1.65
Vesuvianite	0.04	0.02	0.08	0.01
Andradite	0.16	0.05	0.38	0.34
Marialite	0.57	0.99	1.78	0.00
Chlorite	0.18	0.18	0.07	0.16
Muscovite	0.00	0.01	0.08	0.00
Titanite	0.14	0.17	0.08	0.08
Clay	0.00	0.10	0.05	0.80
Berthierine	0.09	0.34	0.15	0.55
Apatite	0.00	0.05	0.00	0.06
Allanite	0.01	0.04	0.13	0.01
Calcite	0.06	0.09	0.28	0.11
Pyrite	0.02	0.03	0.05	0.06
Fe_sulphate	0.01	0.04	0.03	0.02
Goethite	0.06	0.03	0.13	0.07
Unknown	0.01	0.01	0.07	0.04
Free Surface	95.64	90.57	93.80	90.37

SULPHIDES AND THEIR GRAIN SIZE DISTRIBUTION

Table 1. Sulphide mineral distribution in samples.

Mineral	15529 Wt%	15530 Wt%	15531 Wt%	15532 Wt%	15533 Wt%	15534 Wt%	15535 Wt%	15536 Wt%
Pyrite	4.30	0.13	0.07	0.00	77.98	44.05	2.02	0.17
Pyrrhotite	2.98	19.65	1.19	0.10	3.71	0.15	0.28	0.03
Fe_sulphate	0.59	1.86	0.17	0.01	4.79	0.48	0.05	0.04
Covellite	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Chalcopyrite	0.36	0.02	0.01	0.00	2.94	54.15	0.06	0.02
Pentlandite	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Violarite	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Sphalerite	0.00	0.00	0.00	0.00	0.18	0.12	0.00	0.00
Molybdenite	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00
Other	91.77	78.34	98.56	99.88	10.39	0.97	97.58	99.75
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

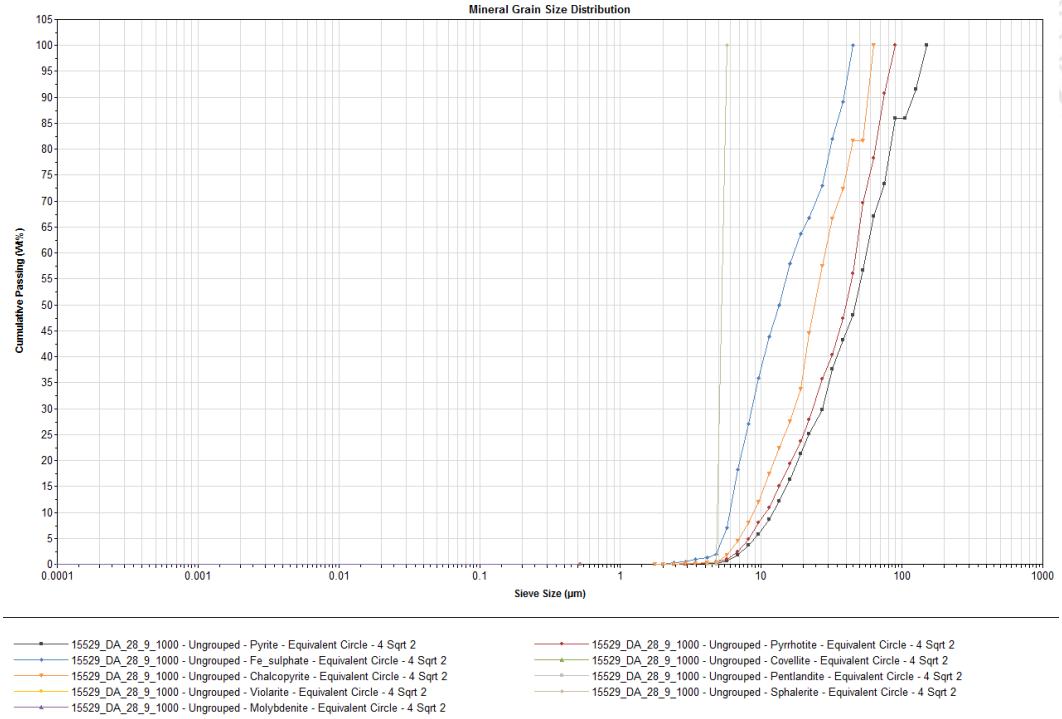


Figure 1. OK15529 DA

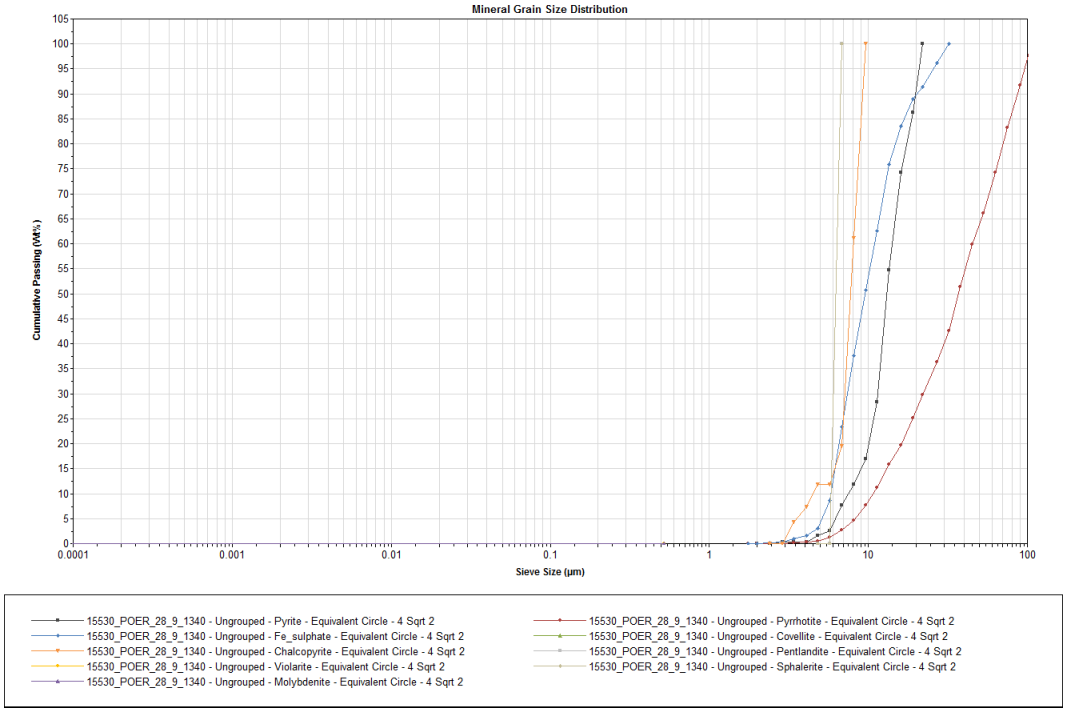


Figure 2. OK15530 PoER.

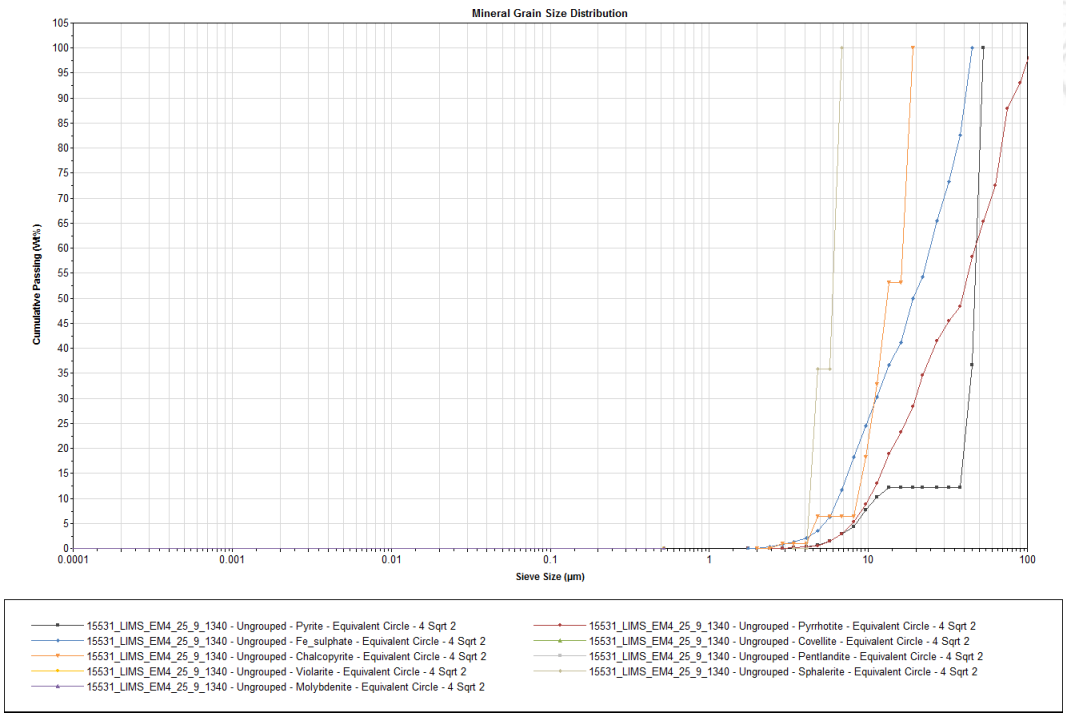


Figure 3. OK15531 LIMS EM4

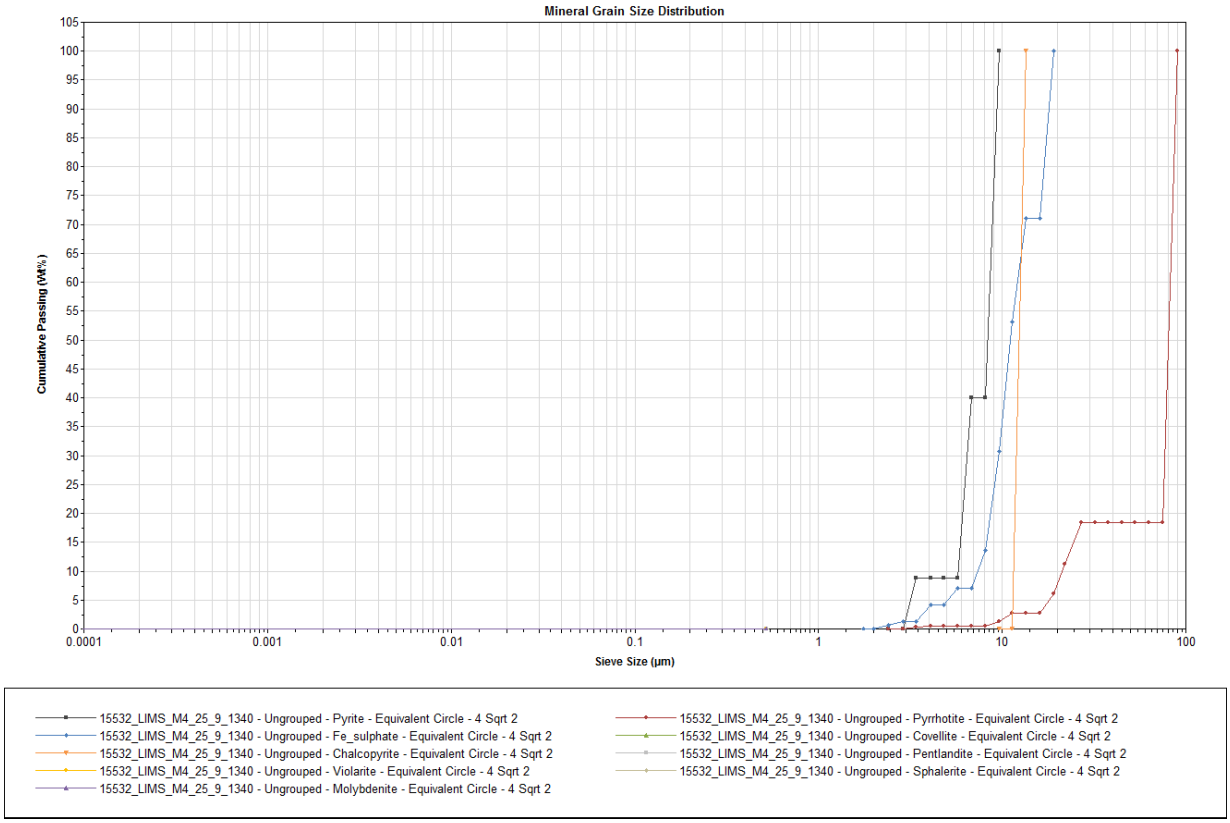


Figure 4. OK15532 LIMS M4.

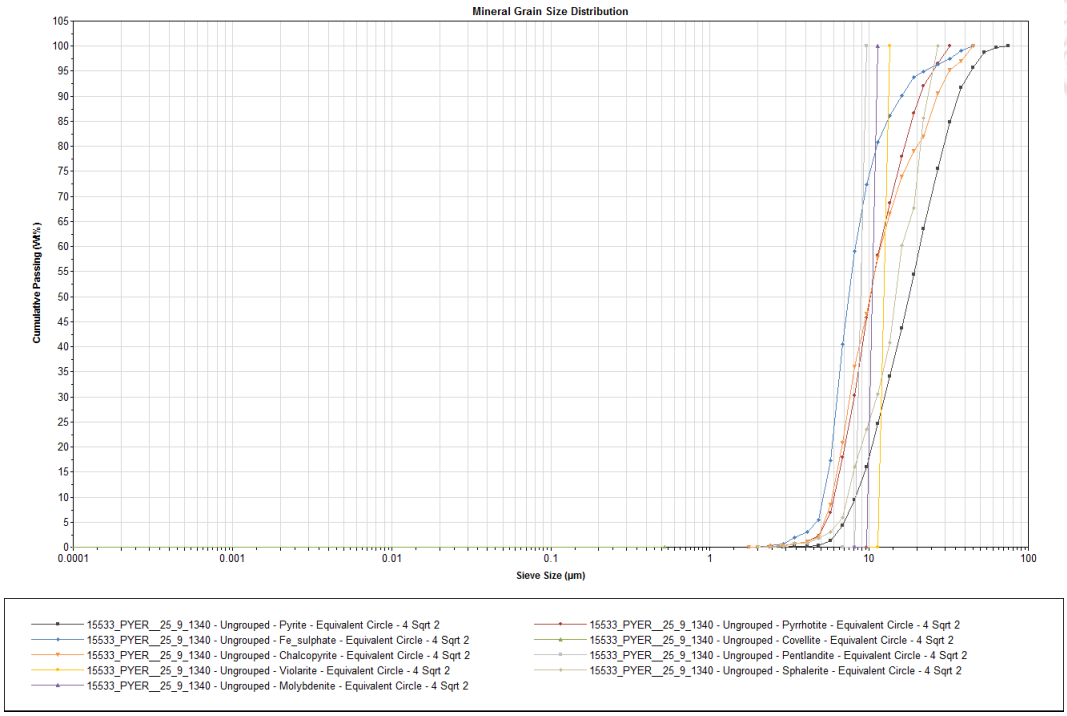


Figure 5. OK15533 PyER.

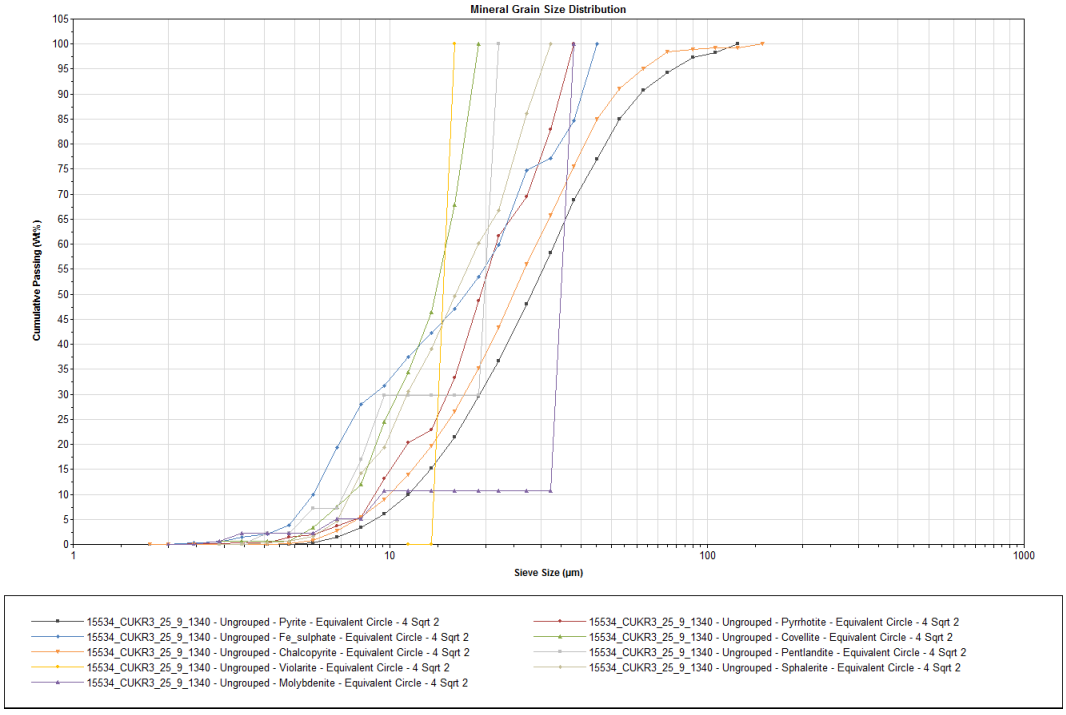


Figure 6. OK15534 CuKR3.

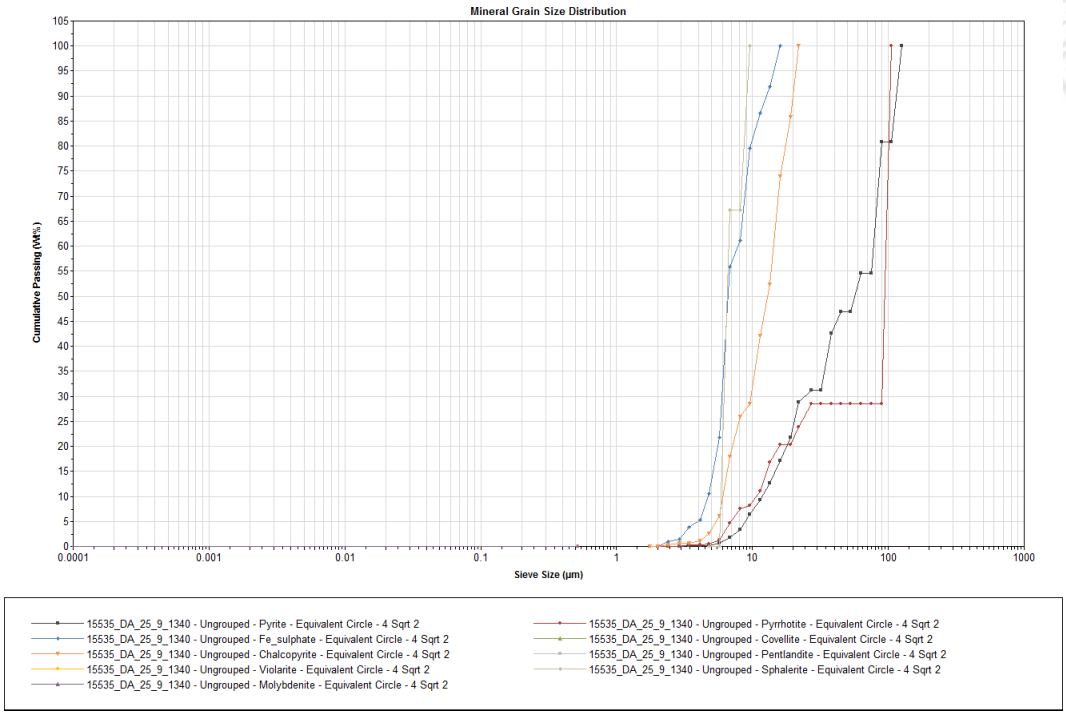


Figure 7. OK15535 DA.

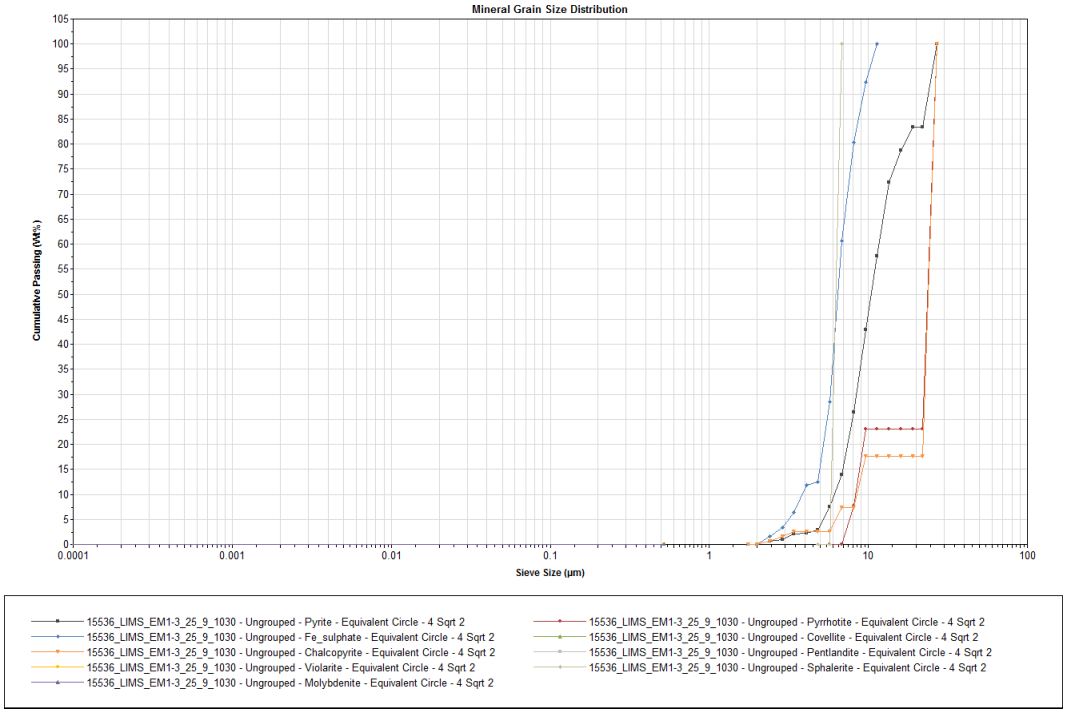


Figure 8. OK15536 LIMS EM 1-3.

DISTRIBUTION OF PYRITE, PYRRHOTITE, FE-OXIDES AND GOETHITE IN SAMPLES

Table 2. Mineral distribution of pyrite, pyrrhotite, Fe-oxides and goethite in samples.

Mineral	15529 Wt%	15530 Wt%	15531 Wt%	15532 Wt%	15533 Wt%	15534 Wt%	15535 Wt%	15536 Wt%
Pyrite	4.30	0.13	0.07	0.00	77.98	44.05	2.02	0.17
Pyrrhotite	2.98	19.65	1.19	0.10	3.71	0.15	0.28	0.03
Ilmenite	0.04	0.00	0.39	0.00	0.00	0.00	0.02	0.02
Magnetite	40.06	69.30	36.00	94.09	0.72	0.00	8.16	0.38
Chromite	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Goethite	1.45	3.38	4.83	0.98	0.20	0.04	0.37	0.30
Other	51.18	7.52	57.51	4.82	17.40	55.76	89.16	99.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

FIBROUS MINERALS AND THEIR HABITUS IN SAMPLES

Potential fibrous minerals present in samples are serpentinite (max. 0.01 %) and actinolite (max. 2.5 %). Their habitus in samples does not present visible fibrous forms, however, due to the small particle size, additional studies with other methods are suggested.
Based on MLA analysis, the general habitus of actinolite and serpentinite in samples do not fill the requirements for fibrous asbestos minerals (length/width ratio of >= 3:1), see Figure 9.

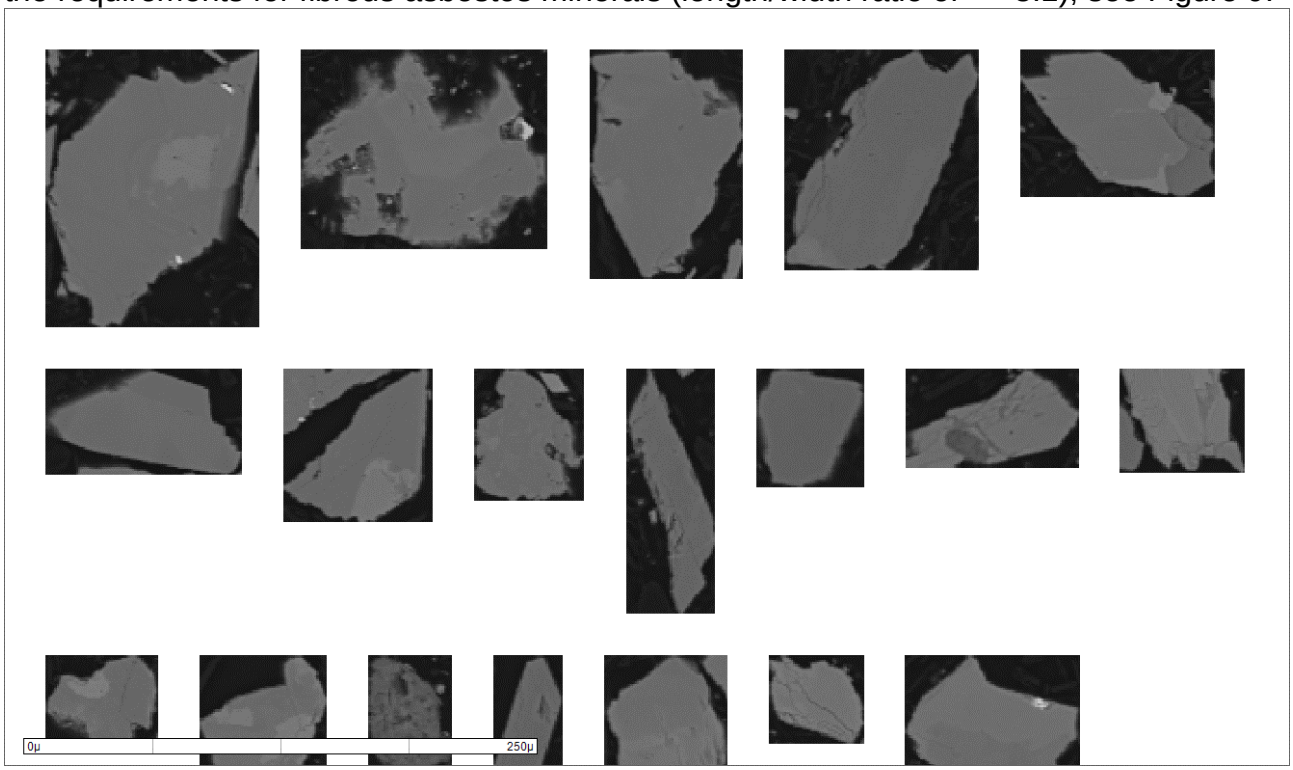


Figure 9. Actinolite grains in sample OK15536 LIMS.