HÜNİTEK

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DENEY RAPORU ANALYSIS REPORT	
Müşterinin Adı / Customer Name	AEX Mineral INC.
Adresi / Address	
Evrak Kayıt No / Record No	HNTK22-000024
Numune Bilgileri / Name and Identity of Sample	2 polished epoxy mounts containing mineral separates and lithic fragments
Numunenin Kabul Tarihi / Sample Receipt Date	03.01.2022
Laboratuvar Adı / Name of Laboratory	Electron Microscopy
Deney Metodu / Analysis Method	SEM-EDS
Deneyin Yapıldığı Tarih / Date of Analysis	15.01.2022
Açıklamalar / Remarks	Samples have been investigated using BSE detector and analyzed using EDS
Raporun Sayfa Sayısı / Report Page Number	20

Hacettepe Üniversitesi İleri Teknolojiler Uygulama ve Araştırma Merkezi Laboratuvarı'na gönderilen numune(ler) üzerinde istenilen deneyler yapılmıştır. Deney ve/veya ölçüm sonuçları ve genişletilmiş ölçüm belirsizlikleri (olması halinde) bu raporun takip eden sayfalarında verilmektedir.
The requested analyse(s) were performed on the sample(s) sent to the Hacettepe University Advanced Technologies Application and Research Center laboratory. The test and/or measurement results and the uncertainties (if applicable) with confidence level are given on the following pages which are a part of this report.

Tarih	**Deney Sorumlusu** Person in Charge of Test	**HÜNİTEK Müdürü** Head of HUNITEK
01.02.2022	Doç.Dr. H. Evren Çubukçu	Doç Dr Ömür Çelikbıçak

Hacettepe University

Research and Application Center for Advanced Technologies

(HUNITEK)

PETROGRAPHICAL AND MINERALOGICAL ANALYSIS REPORT

Prepared by
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(Hacettepe University)

AEX METAL INC.

January, 2022

Contents

1. INTRODUCTION

This analytical report aims to characterize the petrographical and mineralogical features of the processed and unprocessed magnetic lithological samples delivered by AEX Metal INC. The characterization of the provided samples includes the identification of the representative and accessory mineral phases using electron microscopy and x-ray spectrometry. Backscattered electron (BSE) signals have been utilized to distinguish modal phases and rock textures. Chemical compositions of modal phases have been acquired using energy dispersive spectrometer. Since the samples are magnetically separated from rock pulps/fragments, the results do not contain information on the geological occurrence and the distribution of ore bodies in the field.

2. ANALYTICAL METHODS

2.1. Sample Definition

Petrographical and mineralogical analyses have been carried on the briefly processed samples delivered by AEX Metal Inc.

Test suite is comprised of 4 major sample sets, each representing different grain sizes and/or different preparation process:

1. Magnetic concentrate with average grain size > 75 μm.
2. Magnetic concentrate with average grain size < 25 μm.
3. Rock fragments with average grain size > 2 mm (collected using hand magnet from RAB fragments).

The results acquired during this study will be presented in 3 main sections: a) Petrographical properties of > 2 mm rock fragments in order to reveal the textural relationships within unprocessed samples b) Systematic mineralogy of the magnetic concentrates.

2.2. Sample Preparation

Representative portions separated from the samples have been dried at 40°C for 24 h. The Scanning Electron Microscopy and Energy Dispersive Spectrometry (SEM-EDS) based mineralogical analyses require samples with polished, flat surfaces such as blocks where samples are mounted with epoxy. The dried samples were embedded in epoxy resin at 50°C under vacuum and left to cure for 16 h. Sample blocks were then lapped on cast-iron disc using 200 µm SiC slurry. Upon coarse grinding, sample blocks were sequentially polished using 9, 6, 3 and 1 µm diamond suspensions on appropriate polishing cloths. Final chemical polishing was realized with 0.05 µm silica. Polished epoxy blocks were ultrasonically cleaned in dilute water for 1 h. Prior to SEM-EDS analyses, sample blocks were coated with graphite.

2.3. Mineralogical Analyses

Mineralogical studies have been carried out using various techniques and instruments. Modal abundances and textural relationships have been identified using SEM-EDS. Furthermore, the verification of modal phases especially for pyrrhotite is realized by XRD analyses.

SEM-EDS analyses were realized at the Electron Microscopy laboratories of Research and Application Center for Advanced Technologies (HUNITEK) of Hacettepe University using TESCAN GAIA 3 field emisson scanning electron microscope (FE-SEM) equipped with Oxford XMAX 150 silicon drift detector energy dispersive spectrometer (EDS). During image and spectral data acquisition, the accelerating voltage was kept at 25 kV with 5 nA beam current under 9 mm of working distance. For point analyses the counting times were between 90 – 120 s, whereas 180 – 300 s for mapping single frame. Backscattered electron (BSE) signals were composited with superimposed spectral data in order to obtain elemental distribution maps. In order to acquire composite elemental maps of representative large areas (> 25 mm^2), sequential mapping and further digital stitching were performed.

BSE images were pseudocolorized based on EDS analyses on modal phases and the greyscale values, a function of mean atomic number, that they represent. This digitally enhanced imagery was used to depict the textural properties of especially the magnetic grains > 2mm.

3. PETROGRAPHY

The petrographical features are determined on unprocessed, > 2mm grains obtained during rotary air blast (RAB) drilling. Magnetic fragments were collected using a hand magnet and then mounted on epoxy blocks for detailed SEM-EDS analyses.

A total of 33 magnetic fragments were analyzed (Figure 3.1).

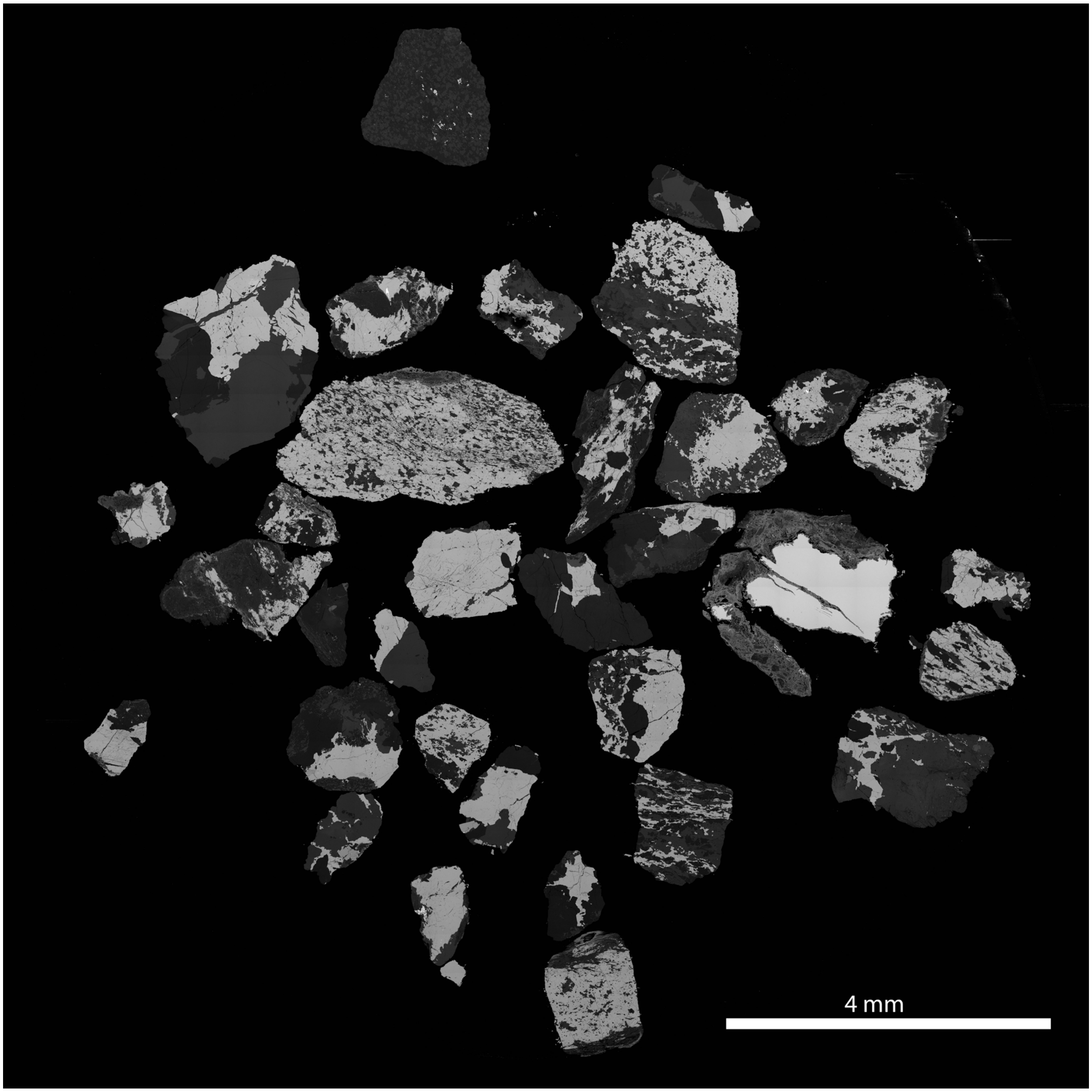


Figure 3-1. Large area Backscattered Electron (BSE) composite image of analyzed 33 magnetic grains.

Although the whole-rock lithology of the host rocks is not clearly known yet, the selected fragments indicate (a) crystalline, metamorphic origin(s) with varying degrees of P/T-induced deformation and/or associated oxidation of Fe/S-bearing phases. The overall petrographical features and modal mineralogical assemblages of selected magnetic grains are summarized in Figure 3.2.

The magnetic grains are dominantly comprised of silicate, carbonate, sulphide, oxide and phosphate groups of minerals with sporadic occurrences of metallic (Fe-Ni-Cr) alloys and rare electrum.

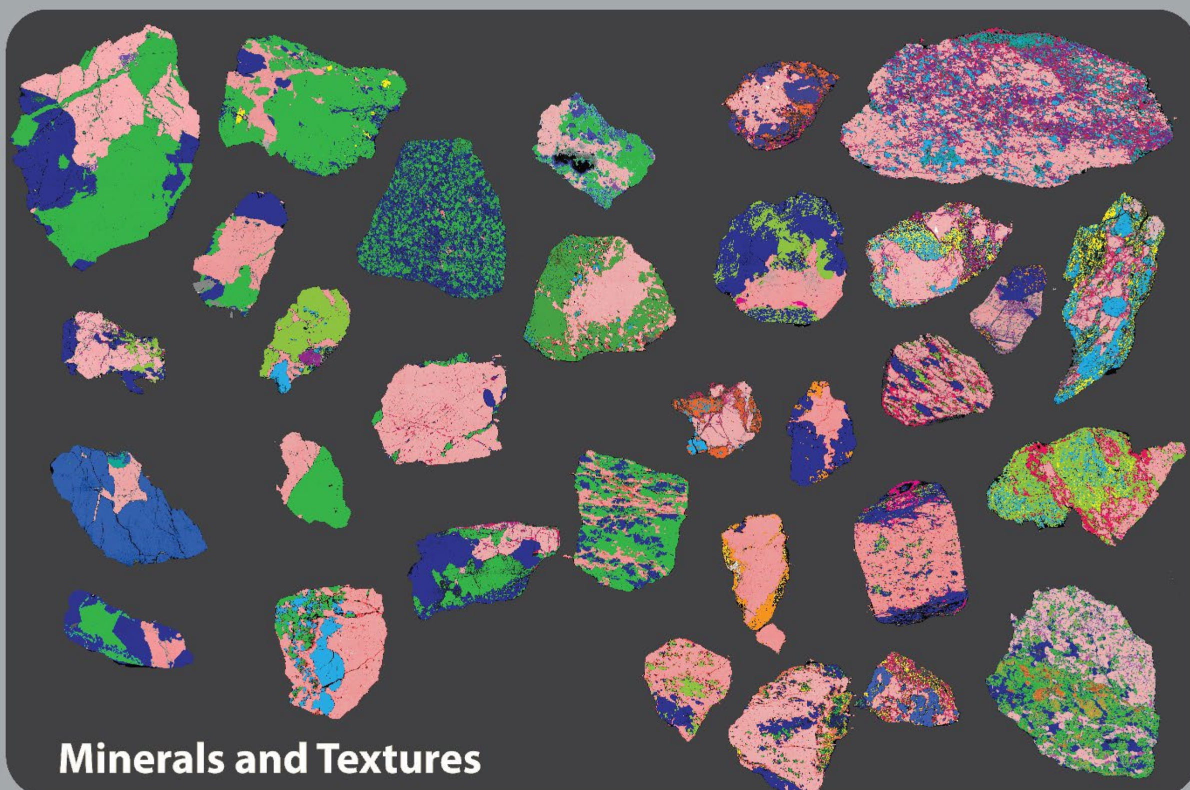
The analyzed crystalline grains exhibit granoblastic and/or post/syn-kinematic textures with usually oriented crystals strengthening a metamorphic origin.

Petrographical Features

Rationale: *Observe (magnetic) pyrrhotite and associated textures, magnetic fragments (> 2mm) are chosen*

increasing oxidation, P/T induced deformation/alteration →

eu/subhedral , intact gangue crystals	usually anhedral crystals
quartz ± albite ± carbonates	**quartz ± albite ± carbonates ± chlorite ± muscovite ± chloritoid**
almost intact pyrrhotite	intense deformation/dissolution of pyrrrhotite
oxidation limited	intense oxidation



Quartz	**Quartz + Albite**	**Muscovite**	**Chlorite**	**Chloritoid**
SiO2 (including polimorphs)	*Tectosilicates, albite and quartz mapped together*	*± phengite - celadonite series*	*Chamosite - clinochlore series*	*Chloritoid group*
Carbonate	**Oxidation**	**pyrite**	**pyrrhotite**	**Zn/Cu/Ni sulphide**
calcite and/or dolomite-ankerite series	*Oxidated amalgamate of Fe ± S*		*Magnetic 4m(c)*	*Pentlandite ± sphalerite ± chalcopyrite*

4. MINERALOGY

4.1. Silicates

4.1.1. Quartz [SiO_2]

Quartz is omnipresent in all the samples exhibiting eu/subhedral crystals in relatively less deformed grains (Figure 4.1a, b). Deformed grains contain sub/anhedral crystals with evident mechanical disintegration (Figure 4.1d, f).

4.1.2. Feldspars [Albite – $Na(AlSi_3O_8)$]

Feldspar group of minerals are represented by relatively sparse albite in carbonate-bearing host rocks with metamorphic origin. Albite is sub/anhedral with microcrysts rarely exceeding 100 µm (Figure 4.1 c, d, e, f).

4.1.3. Muscovite [$KAl_2(AlSi_3O_{10})(OH)_2$]

Muscovite (or species belong to phengite – celadonite series) is observed frequently in rock fragments where deformation is relatively significant. It occurs as deformed/oriented masses or as intergrowths with albite (Figure 4.1e).

4.1.4. Chlorite [$(Mg,Fe)_3(Si,Al)4O_{10}(OH)_2\cdot(Mg,Fe)_3(OH)_6$]

Chlorite (or species belong to clinochlore – chamosite series) is omnipresent in rock fragments with substantial deformation and associated alteration. It is considered to be the alteration products of ferromagnesian phases. Chlorite is observed as oriented/deformed subparallel masses along coarser phases (Figure 4.1d, e).

4.1.5. Chloritoid Group [$(Fe^{2+},Mg,Mn^{2+})Al_2(SiO_4)O(OH)_2$]

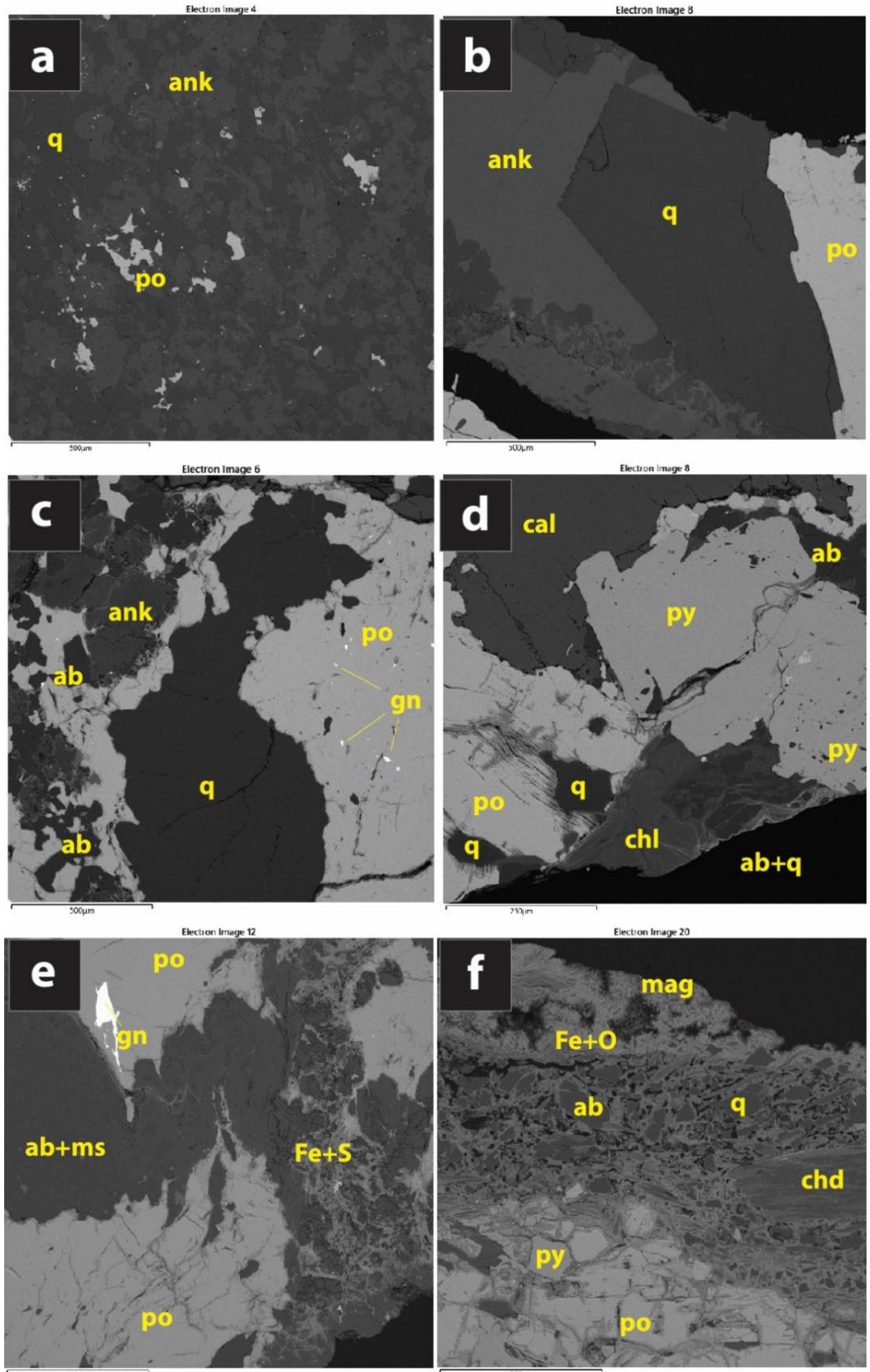
Chlortoid group of minerals are only observed in intensely deformed rock fragments probably affected by pronounced mechanical stress and/or associated elevated temperature. They occur as subhedral crystals having compositionally different lamellar intergrowths (Figure 4.1a).

4.2. Carbonates [$Ca,Mg,Fe(CO_3)_2$]

Carbonates are omnipresent in all the rock fragments investigated since the original host rock(s) is (are) believed to be of metamorphic origin (Figure 4.1a). Carbonates are represented by calcite and ankerite, exhibiting eu/subhedral crystals in relatively less deformed samples (Figure 4.1b, c), whereas their morphology is observed to be modified with increasing degree of deformation (Figure 4.1d).

4.3. Phosphates

Apatite [$Ca_5(PO_4)_3$] is a frequent accessory mineral with eu/subhedral microcrysts <150 µm. Rare occurences of monazite [$(Ce,La,Nd,Th)PO_4$] is observed as anhedral inclusions in either sulfides or silicates. Xenotime [YPO_4] represents a scarce phase observed only as anhedral inclusions in silicates.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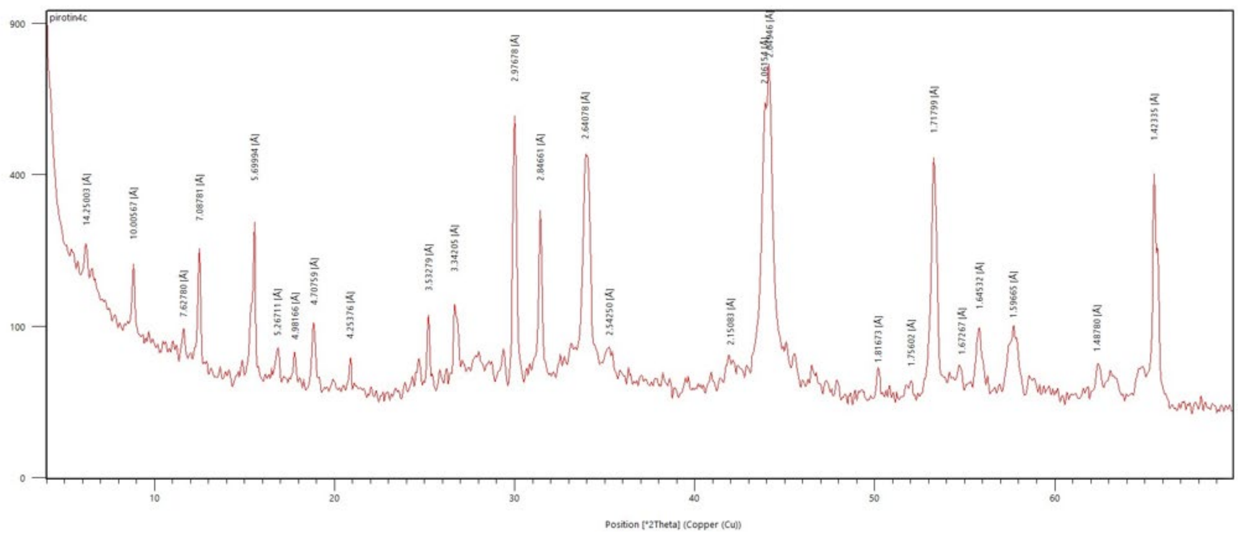
4.4. Sulfides

Sulfide group of minerals represent the majority of modal phases both in magnetically separated crushed/sieved rock pulps and lithic grains from RAB drilling (Figure 3.2). Main sulfide phases observed are Fe-sulfides (pyrrhotite, pyrite), Zn/Cu/Ni-sulfides (chalcopyrite, sphalerite, pentlandite), As-bearing sulfides ([cobaltoan] arsenopyrite) and galena (PbS).

4.4.1. Pyrrhotite (4C) [$Fe_{1-x}S$]

Pyrrhotite represent the most abundant phase in all the samples (Figure 3.2). Due to its magnetic character, pyrrhotite is considered to be 4C/M polymorph. Performed XRD analyses on magnetic fraction verify the existence of pyrrhotite 4C (Figure 4.2).



Pyrrhotite displays variable grain sizes but coarse crystals exceeding 1 mm in length predominate. Relatively smaller pyrrhotite is usually disseminated in quartz+carbonate bearing metamorphic host (Figure 4.1a). Eu/subhedral crystals are abundant in relatively less altered and less deformed host rocks (Figure 4.1b, c, d). However, P/T-induced deformation is observed to modify pre-existing pyrrhotite accompanied with oxidation and alteration along developed fracture network (Figure 4.1 d, e, f). Moreover, composite pyrrhotite grains are omnipresent in all the samples with pentlandite, sphalerite and chalcopyrite. (Figure 4.3 a, b, c, d). Inclusions of arsenopyrite (Figure 4.3 e) are also observed. Rare ullmannite crystals are developed along the rims of pyrrhotite (Figure 4.3 f).

In both processed and unprocessed grains, pyrrhotite contains an average of ~0.6 % Ni (Table 4.1 and 4.2).

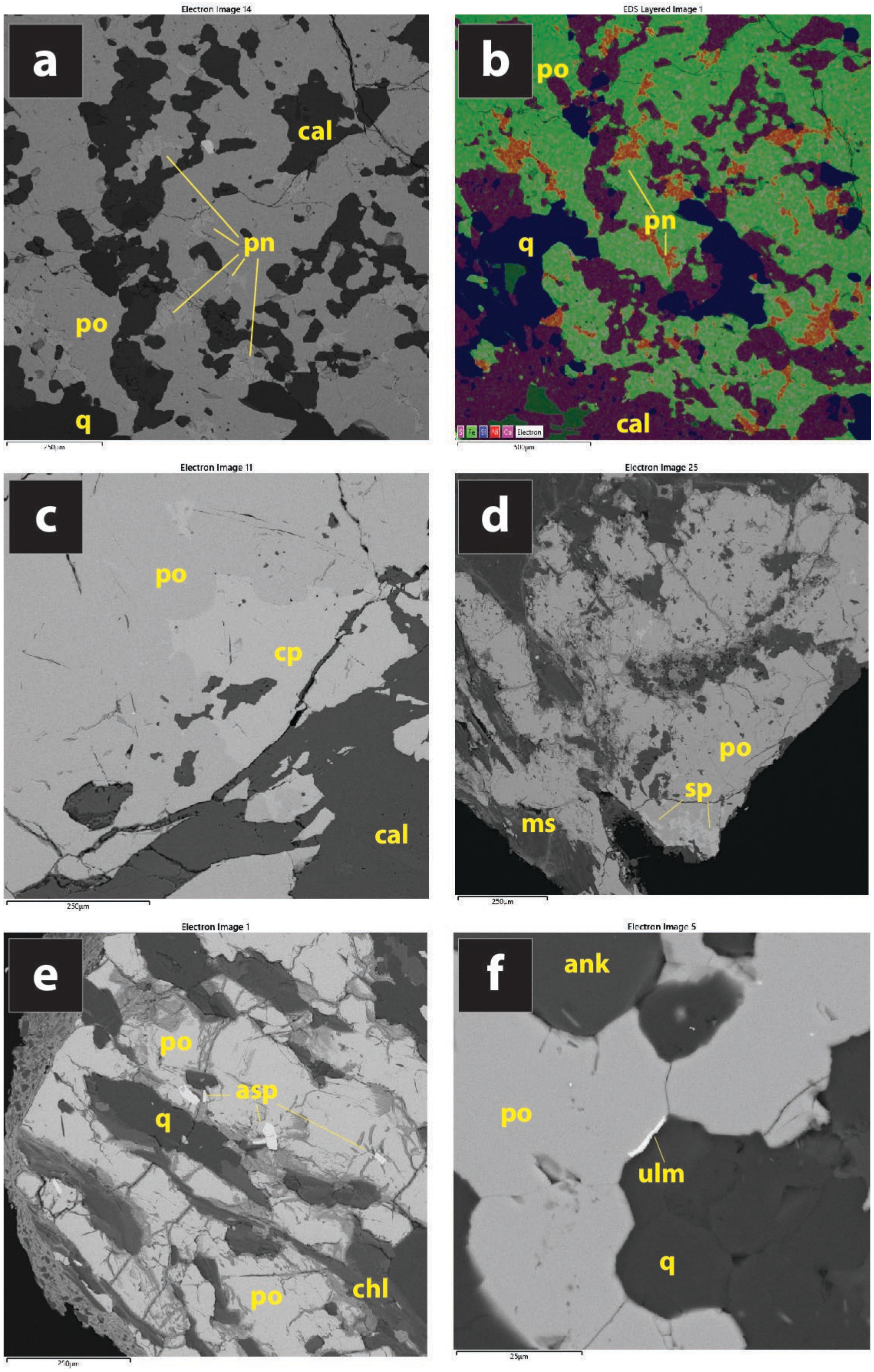
Pyrite is observed as coarse, eu/subhedral crystals (Figure 4.1 d) and anhedral inclusions (?) (or synneusis?) with pyrrhotite (Figure 4.1 f).

Table 4-1. Selected pyrrhotite analyses from processed samples

AnID	Spectrum Label	Sample	mineral	Fe	S	Ni	Total
41	Spectrum 102	2-FeS-Ni	po	58,22	41,17	0,61	100
42	Spectrum 103	2-FeS-Ni	po	58,35	41,05	0,6	100
43	Spectrum 115	2-FeS-Ni	po	58,39	41,19	0,41	99,99
45	Spectrum 128	2-FeS-Ni	po	57,93	41,48	0,58	99,99
18	Spectrum 36	2-FeS-Ni	po	58,05	41,5	0,45	100
19	Spectrum 38	2-FeS-Ni	po	57,77	41,69	0,53	99,99
2	Spectrum 4	2-FeS-Ni	po	57,75	41,67	0,58	100
20	Spectrum 40	2-FeS-Ni	po	57,84	41,53	0,64	100,01
3	Spectrum 5	2-FeS-Ni	po	58	41,5	0,51	100,01
4	Spectrum 6	2-FeS-Ni	po	58	41,58	0,42	100
110	Spectrum 12	FeS-Ni	po	57,14	41,89	0,73	99,76
111	Spectrum 13	FeS-Ni	po	57,23	41,88	0,68	99,79
112	Spectrum 14	FeS-Ni	po	57,03	42,04	0,67	99,74
113	Spectrum 15	FeS-Ni	po	56,9	42,05	0,7	99,65
106	Spectrum 8	FeS-Ni	po	57,44	41,64	0,64	99,72
107	Spectrum 9	FeS-Ni	po	56,85	42,14	0,73	99,72
48	Spectrum 1	FM3-25	po	54,05	45,95		100
58	Spectrum 11	FM3-25	po	53,7	45,7	0,6	100
59	Spectrum 12	FM3-25	po	53,07	46,06	0,87	100
64	Spectrum 22	FM3-25	po	56,78	42,56	0,65	99,99
65	Spectrum 23	FM3-25	po	58,54	40,86	0,6	100
66	Spectrum 24	FM3-25	po	53,13	45,63	1,24	100
67	Spectrum 25	FM3-25	po	55,45	43,79	0,76	100
82	Spectrum 40	FM3-25	po	54,91	44,3	0,79	100
100	Spectrum 58	FM3-25	po	52,76	45,89	1,13	99,78
101	Spectrum 59	FM3-25	po	55,68	43,62	0,7	100
102	Spectrum 60	FM3-25	po	56,35	42,82	0,83	100
54	Spectrum 7	FM3-25	po	53,36	45,65	0,99	100
55	Spectrum 8	FM3-25	po	53,39	45,57	1,04	100
56	Spectrum 9	FM3-25	po	53,22	45,63	1,15	100
137	Spectrum 20	FM3-4	po	57,31	42,12		99,43
144	Spectrum 27	FM3-4	po	55,45	43,99	0,56	100
145	Spectrum 28	FM3-4	po	56,46	42,89	0,65	100
148	Spectrum 31	FM3-4	po	55,92	43,36	0,71	99,99
153	Spectrum 36	FM3-4	po	55,91	43,26	0,83	100
125	Spectrum 7	FM3-4	po	57,43	41,73	0,71	99,87
163	Spectrum 1	FM3-5	po	57,09	42,29	0,62	100
164	Spectrum 2	FM3-5	po	57,19	42,24	0,57	100

Table 4-2. Selected pyrrhotite analyses from unprocessed sample grains

AnID	Spectrum Label	Sample	mineral	Fe	S	Ni	Total
189	Spectrum 27	Grain-02	po	57,87	42,13		100
193	Spectrum 31	Grain-03	po	58	42		100
204	Spectrum 42	Grain-03	po	57,76	42,24		100
205	Spectrum 43	Grain-03	po	58,01	41,99		100
211	Spectrum 49	Grain-04	po	58,73	41,27		100
215	Spectrum 53	Grain-04	po	58,11	41,89		100
220	Spectrum 58	Grain-04	po	56,97	42,89		99,86
231	Spectrum 69	Grain-05	po	57,7	42,3		100
235	Spectrum 73	Grain-06	po	58,42	41,58		100
265	Spectrum 103	Grain-07	po	57,55	41,91	0,55	100,01
266	Spectrum 104	Grain-07	po	57,06	42,28	0,66	100
275	Spectrum 113	Grain-08	po	58,1	41,9		100
339	Spectrum 177	Grain-13	po	58,7	41,3		100
340	Spectrum 178	Grain-13	po	57,91	41,54	0,55	100
344	Spectrum 182	Grain-13	po	58,35	41,65		100
345	Spectrum 183	Grain-13	po	57,64	42,24		99,88
370	Spectrum 208	Grain-16	po	57,76	41,65	0,59	100
372	Spectrum 210	Grain-16	po	57,86	41,58	0,55	99,99
381	Spectrum 219	Grain-17	po	56,84	42,35	0,81	100
383	Spectrum 221	Grain-17	po	57,35	41,99	0,66	100
393	Spectrum 231	Grain-18	po	57,72	42,28		100
518	Spectrum 356	Grain-20	po	57,71	41,56	0,73	100
535	Spectrum 9	Grain-21	po	57,33	42,12	0,55	100
554	Spectrum 28	Grain-23	po	58,94	41,06		100
577	Spectrum 51	Grain-26	po	58,02	41,27	0,71	100
589	Spectrum 63	Grain-27	po	57,44	41,88	0,69	100,01
606	Spectrum 80	Grain-28	po	56,95	42,59	0,46	100
636	Spectrum 110	Grain-30	po	57,2	42,27	0,53	100
640	Spectrum 114	Grain-30	po	58,12	41,51	0,37	100
623	Spectrum 97	Grain-30	po	57,64	41,58	0,55	99,77
648	Spectrum 122	Grain-31	po	57,42	42,05	0,53	100
653	Spectrum 127	Grain-31	po	56,9	42,31	0,79	100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4.4.2. Pentlandite [$(Ni,Fe)_9S_8$]

Pentlandite is observed as mottled, exsolved? anhedral grains in pyrrhotite in an unprocessed magnetic grain with a carbonate-bearing metamorphic origin (Grain # 06) (Figure 4.3 a, b). The main Ni-bearing phase pentlandite contains ~ 35 % Ni (Table 4.3).

Table 4-3. Selected pentlandite analyses from unprocessed sample grain (# 06)

AnID	Spectrum Label	Sample	mineral	Fe	S	Co	Ni	Total
236	Spectrum 74	Grain-06	pn	28.35	35.48	2.37	33.69	100
237	Spectrum 75	Grain-06	pn	28.43	35.64	2.45	33.36	100
239	Spectrum 77	Grain-06	pn	28.17	36.01	2.51	33.3	100
240	Spectrum 78	Grain-06	pn	28.12	35.62	2.74	33.52	100
241	Spectrum 79	Grain-06	pn	28.01	35.34	2.78	33.88	100
242	Spectrum 80	Grain-06	pn	27.88	35.96	2.53	33.63	100
243	Spectrum 81	Grain-06	pn	27.96	35.94	2.55	33.55	100
244	Spectrum 82	Grain-06	pn	28.25	35.71	2.47	33.57	100
245	Spectrum 83	Grain-06	pn	28.13	35.96	2.56	33.35	100
246	Spectrum 84	Grain-06	pn	27.98	35.89	2.7	33.3	100
258	Spectrum 96	Grain-06	pn	28.56	35.95	2.54	32.94	100

4.4.3. Chalcopyrite [$CuFeS_2$]

Chalcopyrite is observed on the rims/periphery of pyrrhotite forming composite grains (Figure 4.3c). Selected chemical analyses of chalcopyrite is presented in Table 4.4.

Table 4-4. Selected chalcopyrite analyses from unprocessed and processed samples

AnID	Spectrum Label	Sample	mineral	Fe	S	Ni	Cu	Total
69	Spectrum 27	FM3-25	cp	29.32	40.5	0.45	29.73	100
146	Spectrum 29	FM3-4	cp	30.35	38.12		31.53	100
147	Spectrum 30	FM3-4	cp	29.87	38.56	0.28	31.29	100
194	Spectrum 32	Grain-03	cp	30.03	37.66		32.32	100
195	Spectrum 33	Grain-03	cp	29.98	37.77		32.25	100
206	Spectrum 44	Grain-03	cp	30.12	37.63		32.25	100
207	Spectrum 45	Grain-03	cp	29.79	37.6		32.61	100
208	Spectrum 46	Grain-03	cp	29.83	37.65		32.52	100
209	Spectrum 47	Grain-03	cp	29.77	37.84		32.39	100
229	Spectrum 67	Grain-05	cp	29.84	37.64		32.52	100
230	Spectrum 68	Grain-05	cp	30.15	37.41		32.44	100
270	Spectrum 108	Grain-07	cp	29.7	37.9	0.38	32.02	100
271	Spectrum 109	Grain-07	cp	29.86	37.76	0.41	31.97	100
660	Spectrum 134	Grain-32	cp	29.42	38.46	0.45	31.67	100
661	Spectrum 135	Grain-32	cp	29.76	38.3	0.15	31.79	100
662	Spectrum 136	Grain-32	cp	29.8	37.72	0.26	32.22	100

4.4.4. Sphalerite [$(Zn,Fe)S$]

Sphalerite, similar to chalcopyrite, forms composite crystals with pyrrhotite. Sphalerite is observed on the rims of pyrrhotite (Figure 4.3d). Selected chemical analyses of sphalerite is presented in Table 4.5.

Table 4-5. Selected sphalerite analyses from unprocessed and processed samples

AnID	Spectrum Label	Sample	mineral	Fe	S	Ni	Cu	Zn	Total
49	Spectrum 2	FM3-25	sp	7.74	40.84	0.64		50.78	100
75	Spectrum 33	FM3-25	sp	10.62	40.12	0.82		48.44	100
269	Spectrum 107	Grain-07	sp	6.58	35.75	0.59	0.54	54.39	100
355	Spectrum 193	Grain-14	sp	7.24	35.82	0.47		56.47	100
356	Spectrum 194	Grain-14	sp	8.71	37.01	0.5		53.78	100
358	Spectrum 196	Grain-14	sp	5.72	36.2	0.39		57.7	100
359	Spectrum 197	Grain-14	sp	5.5	35.64	0.35		56.67	100
360	Spectrum 198	Grain-14	sp	5.13	36.9	0.3		57.68	100
361	Spectrum 199	Grain-14	sp	6.3	36.1	0.37		55.66	100

4.4.5. Galena [PbS]

Galena is ubiquitous in all the samples represented by inclusions major sulfide phases, namely pyrrhotite. (Figure 4.1c, e). The Ni content of galena is noteworthy, sometimes exceeding 1 % (Table 4.6).

Table 4-6. Selected galena analyses from unprocessed and processed samples

AnID	Spectrum Label	Sample	mineral	Fe	S	Ni	Pb	Total
197	Spectrum 35	Grain-03	gn	2.94	12.76	0.75	83.55	100
212	Spectrum 50	Grain-04	gn	0.28	12.27	0.95	86.14	100
227	Spectrum 65	Grain-05	gn	4.8	11.87	0.79	72.95	100
234	Spectrum 72	Grain-05	gn	7.5	13.73	0.93	75.17	100
322	Spectrum 160	Grain-11	gn	3.15	12.47	0.75	80.92	100
323	Spectrum 161	Grain-11	gn	8.36	15.39	0.7	72.53	100
337	Spectrum 175	Grain-12	gn	0.44	12.69	0.72	85.91	100
338	Spectrum 176	Grain-12	gn	0.55	12.41	0.89	85.92	100
545	Spectrum 19	Grain-22	gn	15.04	18.41	1.16	65.39	100
556	Spectrum 30	Grain-23	gn	3.71	12.68	0.55	83.06	100
561	Spectrum 35	Grain-24	gn	5.79	12.51	1.25	77.55	100
570	Spectrum 44	Grain-25	gn	1.91	12.56	0.9	84.63	100
572	Spectrum 46	Grain-25	gn	2.02	12.87	0.95	84.17	100
616	Spectrum 90	Grain-29	gn	2.3	12.21	0.84	84.64	100
641	Spectrum 115	Grain-30	gn	2.55	12.62	0.89	83.94	100
622	Spectrum 96	Grain-30	gn	0.58	12.88	0.94	84.77	100

Arsenopyrite is observed as euhedral inclusions in pyrrhotite (Figure 4.3e). Co content of arsenopyrite is usually > 2% (Table 4.7). Therefore, cobaltoan- prefix is suggested for the grains with elevated Co content. In one analysis Co is measured to be greater than 20 % (Table 4.7).

Table 4-7. Selected cobaltoan arsenopyrite analyses from unprocessed and processed samples

AnID	Spectrum Label	Sample	mineral	Fe	S	Co	Ni	As	Total
39	Spectrum 100	2-FeS-Ni	asp	31.56	21.04	0	0.33	47.08	100
40	Spectrum 101	2-FeS-Ni	asp	31.75	21.18		0.48	46.48	100
46	Spectrum 129	2-FeS-Ni	asp	28.26	21.19	3.58	0.51	46.46	100
47	Spectrum 130	2-FeS-Ni	asp	25.36	20.63	6.2	0.77	46.94	100
14	Spectrum 31	2-FeS-Ni	asp	30.19	21.13	0.82	0.83	47.02	100
15	Spectrum 32	2-FeS-Ni	asp	30.09	21.67	1.02	0.61	46.6	100
27	Spectrum 78	2-FeS-Ni	asp	23.94	20.78	6.81	1.56	46.91	100
28	Spectrum 79	2-FeS-Ni	asp	24.1	20.82	6.48	1.34	47.26	100
29	Spectrum 80	2-FeS-Ni	asp	26.74	21.24	4.26	1.04	46.63	100
165	Spectrum 3	FM3-5	asp	30.24	23.46	4.86	0.87	40.44	100
166	Spectrum 4	FM3-5	asp	29.48	23.58	5.26	0.93	40.61	100
167	Spectrum 5	FM3-5	asp	30.54	23.34	4.04	1.04	40.9	100
238	Spectrum 76	Grain-06	asp	6.18	22.43	21.61	8.48	41.12	100
296	Spectrum 134	Grain-09	asp	44.02	35.45	0.98		19.56	100
536	Spectrum 10	Grain-21	asp	32.76	22.64	3.07	0.7	40.84	100
537	Spectrum 11	Grain-21	asp	32.81	23.37	2.81	0.72	40.29	100
539	Spectrum 13	Grain-21	asp	32.38	23.69	3.1	0.64	40.06	100
528	Spectrum 2	Grain-21	asp	31.72	23.99	3.44	0.69	40.15	100
529	Spectrum 3	Grain-21	asp	33.22	23.47	2.21	0.67	40.42	100
530	Spectrum 4	Grain-21	asp	29.82	24.11	5.03	0.82	40.22	100
531	Spectrum 5	Grain-21	asp	32.8	23.19	2.85	0.6	40.57	100
607	Spectrum 81	Grain-28	asp	34.51	24.45	0.93	0.46	39.65	100
608	Spectrum 82	Grain-28	asp	32.93	24.44	2.38	0.6	39.64	100

4.4.7. Ullmannite [NiSbS]

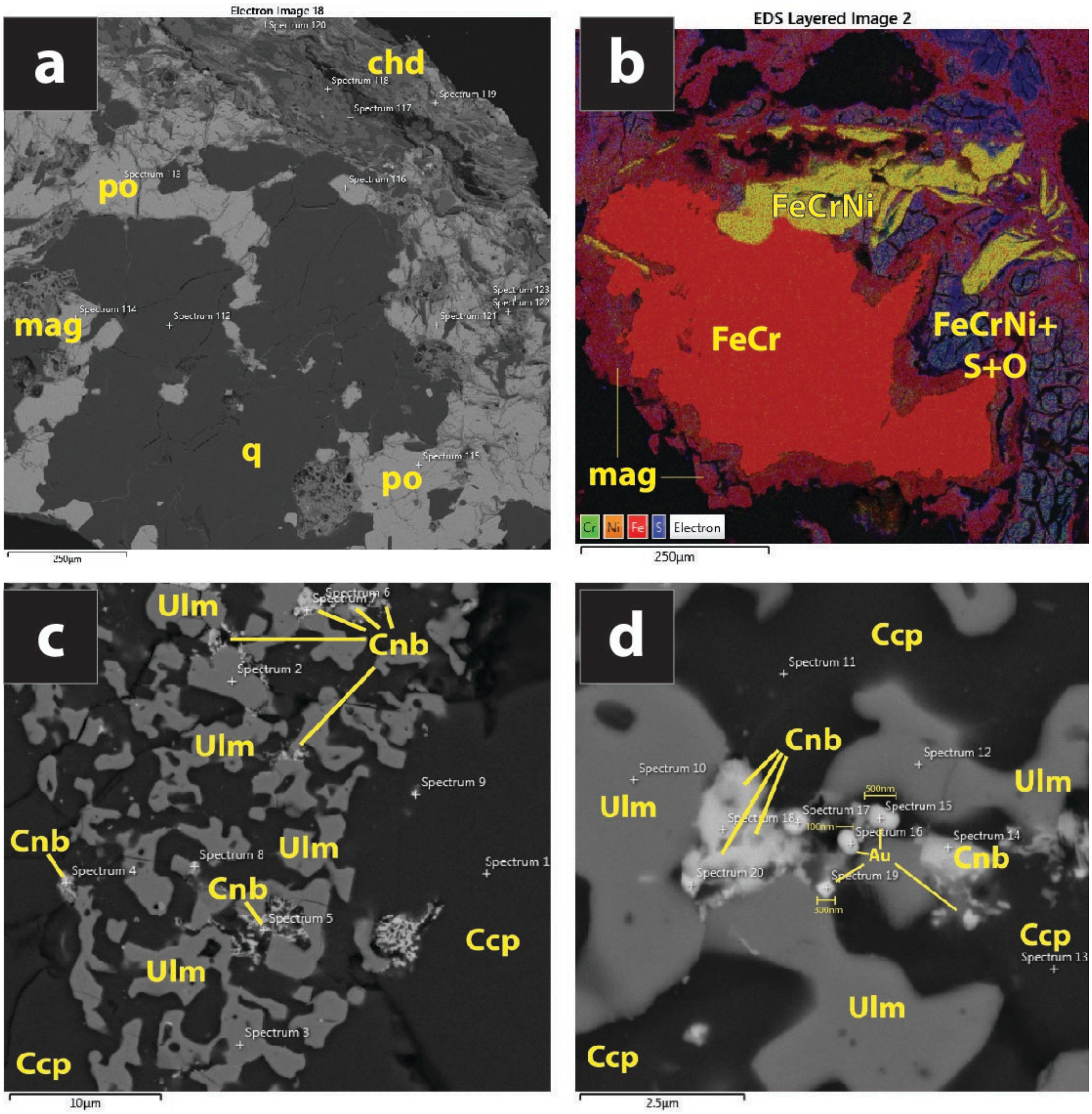
Rare ullmannite is observed along the rims of pyrrhotite (Figure 4.3f) and as symplectite? in chalcopyrite. (Figure 4.4 c, d). Anhedral ullmannite in chalcopyrite seldom contains cinnabar with electrum ~100 – 500 nm in size. Selected chemical analyses of ullmannite is presented in Table 4.8.

Table 4-8. Selected cobaltoan arsenopyrite analyses from unprocessed samples

AnID	Spectrum Label	Sample	mineral	O	Si	Al	Fe	S	Na	Co	Ni	Sb	Total
178	Spectrum 16	Grain-01	ulm	13.13	6.4	4.37	7.2	16.65	2.59		14.57	35.09	100
179	Spectrum 17	Grain-01	ulm	11.75	5.96	4.29	6.37	16.2	2.18	3.47	13.66	36.12	100
180	Spectrum 18	Grain-01	ulm	14.28	7.53	4.55	8.72	16.6	2.86	3.06	11.52	30.87	100
181	Spectrum 19	Grain-01	ulm	12.74	6.59	4.55	5.5	15.33	2.44	2.06	14.99	35.81	100
182	Spectrum 20	Grain-01	ulm	1.96	0.48		2.21	15.66		3.92	20.83	54.94	100
183	Spectrum 21	Grain-01	ulm	2.36	0.97	0.36	4.48	16.9		4.37	19.91	50.66	100

4.5. Fe-Ti Oxides

Although Fe-Ti oxides are omnipresent in all the samples, their abundance is relatively more pronounced in oxidized/altered and deformed grains (Figure 3.2). Fe-Ti oxides are represented by magnetite (s.l.) (and/or hematite), titanomagnetite (ulvöspinel – magnetite series), rutile and ilmenite (Figure 4.4).



4.5.1. Magnetite (s.l) (Hematite) [$Fe^{2+}Fe^{3+}{}_2O_4$]

Magnetite (s.l.) is the most abundant Fe-Ti oxide phase in all the samples with varying chemical composition. They are intensely oxidized and exhibit coarse exsolution textures in highly deformed/altered rock fragments (Figure 4.4a). One rock fragment (# 19) contains chromian-magnetite, mantling a CrNiFe-phase (UM2001-06-E:CrFeNi www.mindat.org) (see section 4.6.2). The selected chemical analyses of magnetite (s.l) and titanomagnetite are given in (Table 4.9.

Table 4-9. Selected magnetite (s.l) and titanomagnetite analyses from unprocessed and processed samples

Spectrum Label	Sample	mineral	O	Si	Mg	Al	Fe	S	Ca	Ti	Cr	Mn	Co	Ni	Total
Spectrum 56	FM3-25	mt	38,34	3,1			53,74	4,06	0,32					0,44	100
Spectrum 56	Grain-04	mt	42,76				53,72	3,41	0,11						100
Spectrum 119	Grain-08	mt	40,73	1,72		1,64	55,12	0,13		0,14					100
Spectrum 144	Grain-09	mt	38,9				60,89	0,21							100
Spectrum 145	Grain-09	mt	40,72				59,02	0,26							100
Spectrum 146	Grain-09	mt	38,69	0,74			60,26	0,31							100
Spectrum 151	Grain-10	mt	41,27				58,47	0,26							100
Spectrum 153	Grain-10	mt	42,52				57,12	0,36							100
Spectrum 200	Grain-14	mt	41,26				58,11	0,21						0,42	100
Spectrum 236	Grain-19	mt	43,61				53,48	2,39			0,52				100
Spectrum 237	Grain-19	mt	43,87	0,2			53,63	1,95			0,34				100
Spectrum 243	Grain-19	mt	43,35	0,46			53,89	1,62	0,1					0,58	100
Spectrum 246	Grain-19	mt	14,93	0,8			63,94	1,06	0,14		12,03			7,08	100
Spectrum 268	Grain-19	mt	41,69	0,47			55,83	1,15			0,86				100
Spectrum 271	Grain-19	mt	38,7	0,83			57,94	0,78	0,23		1,52				100
Spectrum 272	Grain-19	mt	42,29	0,28			56	1,16			0,27				100
Spectrum 274	Grain-19	mt	43,2	0,21			54,38	1,18			0,59			0,44	100
Spectrum 276	Grain-19	mt	37,99	0,49			59,11	0,84	0,18		1,39				100
Spectrum 313	Grain-19	mt	38,32	1,49		0,38	58,91	0,65				0,25			100
Spectrum 320	Grain-19	mt	42,52	0,26			54,26	2,18	0,18	0,13		0,48			100
Spectrum 321	Grain-19	mt	41,4	0,29			57,83	0,33	0,14						100
Spectrum 322	Grain-19	mt	38,6	0,53			60,44	0,3	0,13						100
Spectrum 340	Grain-19	mt	32,64	0,55			66,53	0,15	0,14						100
Spectrum 341	Grain-19	mt	33,47	1,18			64,79	0,21	0,35						100
Spectrum 350	Grain-19	mt	42,75	0,32			55,27	0,35	0,38			0,47		0,47	100
Spectrum 353	Grain-20	mt	39,66	0,3			56,95	2,64						0,44	100
Spectrum 357	Grain-20	mt	35,9	0,52			62,05	1,09						0,44	100
Spectrum 359	Grain-20	mt	41,88	0,3			56,03	0,7	0,66					0,42	100
Spectrum 29	Grain-23	mt	40,74				57,68	0,35	0,7			0,53			100
Spectrum 60	Grain-27	mt	36,59	1,75			60,64	0,46	0,24						100
Spectrum 85	Grain-29	mt	25,78	1,34		0,41	70,5	0,49		0,59					100
Spectrum 142	Grain-33	mt	41,84				56,61	1,04						0,51	100
Spectrum 214	Grain-17	tmt	38,06				30,72			28,95		2,27			100
Spectrum 328	Grain-19	tmt	36,51				25,23			29,66		8,6			100
Spectrum 329	Grain-19	tmt	37,64	0,46		0,6	24,16			28,39		8,75			100
Spectrum 333	Grain-19	tmt	37,27				27,99		0,21	28,89		5,55			100
Spectrum 338	Grain-19	tmt	41,8	0,85		0,73	22,68			25,93		7,76			100
Spectrum 348	Grain-19	tmt	39,43	0,84		0,52	24,76		0,46	26,97		6,4		0,39	100
Spectrum 349	Grain-19	tmt	35,84				29,12			29,52		5,06		0,46	100

4.5.2. Titanomagnetite (Ulvöspinel – Magnetite Series) [$Fe^{2+}(Fe^{3+},Ti)_2O_4$]

Titanomagnetite is a sparse Fe-Ti oxide phase and observed only in a highly deformed rock fragment (# 19)

4.5.3. Ilmenite [$FeTiO_3$]

Ilmenite is scarce and observed in (highly) oxidized rock fragment sample (# 19) as trellis-type exsolution lamellae in titanomagnetite.

4.5.4. Rutile [TiO_2]

Rutile is only observed as acicular, individual crystals in quartz without any genetic relationship with sulfide mineralization.

4.6. Native Metals

Native metal phases (and/or alloys) containing Fe, Cr, and to some degree Ni are observed in the samples. Moreover, submicron-sized electrum grains are also documented.

4.6.1. Cr-Ni-Fe

One single rock fragment (# 19) contains highly deformed and subsequently dissolved Cr-bearing iron phase/alloy (Figure 4.4b). In the sample, where significant P/T-induced deformation and alteration is believed to occur, the coarse Cr-bearing Fe phase/alloy is observed to be mantled by (chromian) magnetite (Table 4.10). A rare Fe-Cr-Ni phase is detected, originating from the Cr-bearing Fe phase/alloy due to dissolution(?) and mechanically oriented by prevailing deformation (Figure 4.4b). Although the Fe-Cr-Ni phase is not identified/named clearly, it is highly probable that it can be related to UM2001-06-E:CrFeNi (www.mindat.org) (Table 4.11).

Table 4-10. Analyses of Cr-bearing Fe phase/alloy in rock fragment #19

AnID	Sample	Spectrum Label	mineral	Si	Fe	Cr	Total
421	Grain-19	Spectrum 259	fecr-mtl	0,39	98,06	1,55	100,0
422	Grain-19	Spectrum 260	fecr-mtl	0,33	98,6	1,07	100,0
428	Grain-19	Spectrum 266	fecr-mtl	0,44	98,21	1,36	100,0
429	Grain-19	Spectrum 267	fecr-mtl	0,47	98,2	1,33	100,0
432	Grain-19	Spectrum 270	fecr-mtl	0,38	98,51	1,1	100,0
480	Grain-19	Spectrum 318	fecr-mtl	0,33	98,6	1,06	100,0

Table 4-11. Analyses of Fe-Cr-Ni phase/alloy (UM2001-06-E:CrFeNi?) in rock fragment #19

Sample	ectrum Lab	mineral	O	Si	Fe	S	Ni	Cr	Total
Grain-19	244	mtl	3,35	0,65	70,5	0,6	9,11	15,79	100
Grain-19	245	mtl	9,31	0,68	67,75	0,65	7,94	13,56	99,89
Grain-19	247	mtl		0,48	71,09	0,87	9,51	18,05	100
Grain-19	248	mtl		0,68	70,78	0,82	9,53	18,2	100,01
Grain-19	249	mtl	2,48	0,56	70,71	0,47	9,22	16,55	99,99
Grain-19	250	mtl		0,55	71,48	0,4	9,71	17,86	100
Grain-19	251	mtl	1,77	0,62	69,64	0,63	9,15	17,9	99,71
Grain-19	252	mtl	2,25	0,58	69,93	0,44	9,32	17,49	100,01
Grain-19	253	mtl	2,16	0,66	69,97	0,46	9,15	17,6	100
Grain-19	254	mtl		0,61	70,74	0,62	9,35	18,68	100
Grain-19	255	mtl		0,59	70,77	0,31	9,62	18,71	100
Grain-19	256	mtl		0,62	69,94	1,08	9,65	18,72	100,01
Grain-19	257	mtl		0,56	70,74	0,45	9,53	18,73	100,01
Grain-19	258	mtl		0,69	70,74	0,44	9,51	18,62	100
Grain-19	261	mtl		0,54	70,84	0,45	9,58	18,59	100
Grain-19	262	mtl		0,48	71,44	0,43	9,55	18,09	99,99
Grain-19	263	mtl		0,54	70,87	0,62	9,47	18,49	99,99
Grain-19	264	mtl	1,63	0,5	70,1	0,4	9,37	18	100
Grain-19	265	mtl		0,64	71,09	0,49	9,46	18,32	100
Grain-19	278	mtl	2,01	0,73	68,73	0,58	9,5	17,47	99,02
Grain-19	279	mtl	4,63	1,62	66,68	0,45	9,02	17,59	99,99
Grain-19	280	mtl		0,55	70,69	0,59	9,61	18,56	100
Grain-19	281	mtl	1,91	0,69	72,11	0,41	8,79	16,09	100
Grain-19	282	mtl		0,6	71,42	0,52	9,63	17,82	99,99
Grain-19	283	mtl		0,58	71,61	0,56	9,45	17,8	100
Grain-19	284	mtl	2,65	0,61	68,92	0,57	9,29	17,96	100
Grain-19	285	mtl	1,75	0,53	69,47	0,42	9,59	18,23	99,99
Grain-19	286	mtl		0,58	70,67	0,9	9,58	18,27	100
Grain-19	287	mtl	4,02	0,84	68,14	1,45	8,79	16,57	99,81
Grain-19	288	mtl	1,55	0,62	70,35	0,57	9,38	17,53	100
Grain-19	289	mtl	2,14	0,63	69,84	0,8	9,34	17,26	100,01
Grain-19	290	mtl	5,4	0,83	67,24	0,84	9,15	16,54	100
Grain-19	291	mtl		0,62	71,04	0,54	9,38	18,43	100,01
Grain-19	292	mtl		0,59	70,7	0,25	9,59	18,87	100
Grain-19	293	mtl	4,83	0,7	67,81	0,76	8,66	17,23	99,99

4.6.2. Electrum

Electrum grains < 1 µm are observed together with cinnabar (HgS) with symplectitic ullmannite in chalcopyrite (Figure 4.4 c, d). The results of point analyses on electrum grains are given in Table 4.12.

Table 4-12. Chemical analyses of electrum in cinnabar (HgS)

Spectrum Label	S	Fe	Ni	Cu	Ag	Sb	Au	Hg	Total
Spectrum 19	10,3	5,29	3,85	4,46	12,73	9,02	38,8	15,4	99,85
Spectrum 20	14,29	7,24	5,05	0,37	12,47	9,25	31,66	19,53	99,86
Spectrum 29	22,82	15,19	3,03	10,86	6,42	6,74	22,32	12,61	99,99
Spectrum 30	17,57	12,06	5,31	5,13	9,34	11,63	27,69	11,27	100
Spectrum 35	7,84	3,14	3,98	3,33	13,66	13,17	36,04	15,07	96,23
Spectrum 36	10,82	5,41	6,56	5,49	7,51	18,34	26,69	12,08	92,9
Spectrum 37	18,18	9,9	4,64	5,08	7,03	13,69	21,28	15,21	95,01
Spectrum 38	10,07	5,55	3,33	1,8	13,67	7,49	34,76	21	97,67
Spectrum 39	11,51	4,32	8,42	2,43	9,02	22,3	28,96	11	97,96
Spectrum 40	12,97	6,89	4,92	3,25	10,47	13,23	31,2	14,66	97,59
Spectrum 41	12,97	9,53	2,16	2,81	14,05	3,88	38,24	16,36	100
Spectrum 42	10,62	2,25	8,05	2,29	8,9	28,47	28,78	10,64	100