

## Appendix A1

### Sample locations

Sample No.	AMG Coordinates		Sample type
	North	East	
WDA1	8074250	302534	Waste rock grab sample composites
WDA2	8074280	302502	“
WDA3	8074311	302544	“
WDB1	8074342	302510	“
WDB2	8074376	302518	“
WDB3	8074405	302537	“
WDC1	8074386	302697	“
WDD1	8074602	302568	“
WDD2	8074609	302542	“
WDD3	8074599	302538	“
WDE1	8074608	302274	“
WDE2	8074577	302274	“
EA1	8074259	302548	Waste rock efflorescences
EA2a,b	8074322	302506	“
EA3a,b	8074252	302496	“
EB1a,b,c	8074352	302510	“
EB2a,b,c,d,e,f,g	8074388	302512	“
EB3a,b,c,d,e	8074358	302526	“
EB4	8074388	302512	“
EB5	8074352	302510	“
EB6	8074358	302526	“
EB7	8074352	302510	“
EB8	8074342	302540	“
EC1	8074388	302710	“
EC2	8074408	302706	“
EC3	8074412	302692	“
ED1	8074603	302551	“
SS1a,b	8074831	303250	Stream sediments, a) >150 $\mu$ m, <2 mm fraction, b) <150 $\mu$ m fraction
SS2a,b	8074018	302807	“
SS3a,b	8073996	302809	“
SS4a,b	8074012	302553	“
SS5a,b	8074010	302402	“
SS6a,b	8073907	302048	“
SS7a,b	8073642	302073	“
SS8a,b	8073760	301013	“
SS9a,b	8073473	300990	“
SS10a,b	8073143	298540	“

Sample No.	AMG coordinates		Sample type
	North	East	
OCW1	8074012	302544	Water sample, June 2001
OCW2	8074012	302544	Water sample, April 2002
OCW3	8074013	302421	"
OCW4	8073658	302037	"
OCE1	8074012	302483	Streambed precipitates
OCE3	8074010	302397	"
OCE4	8074002	302386	"
OCE5	8074023	302512	"
OCE6	8074013	302550	"
OCE7	8074012	302518	"
OCE8	8074013	302550	"
OCE9	8074012	302483	"
OCE11	8074013	302558	"
OCE12	8074013	302558	"
OCE13	8074013	302558	"

## Appendix A2

## Geochemistry

## Mine waste geochemistry

Element	WDA1	WDA2	WDA3	WDB1	WDB2	WDB3	WDC1	WDD1	WDD2	WDD3	WDE1	WDE2
Ag	118	730	30	450	530	780	280	210	260	44	44	42
As	1480	2320	800	4250	6190	2860	3910	1330	2510	667	153	298
Be	<0.5	<0.5	0.6	0.7	0.6	0.6	0.7	<0.5	0.6	0.7	0.9	1
Bi	54	1250	9	51	41	192	7	<5	<5	<5	<5	<5
Ca	<0.01	<0.01	<0.01	0.02	0.01	0.01	0.02	0.03	0.02	0.02	0.01	<0.01
Cd	34	17	13	19	113	47	29	49	11	10	21	<5
Co	11	14	5	11	10	24	<5	26	5	<5	7	<5
Cu	4720	15800	533	16000	6120	35400	1640	149	283	34	2060	276
Fe	1.71	3.97	2.95	2.64	10.7	5.76	10.9	5.94	6.03	2.66	5.13	5.59
Hg	0.36	0.799	0.434	1.42	0.302	0.501	0.106	2.65	0.53	0.36	0.115	<0.04
In	19.9	59.3	10.3	90.1	64	76.9	36.3	18.2	20	5	7.4	3.9
K	0.75	0.72	0.77	0.91	0.55	0.68	1.23	0.2	0.51	0.84	0.47	1.05
Mg	0.04	0.03	0.04	0.04	0.03	0.04	0.06	0.21	0.03	0.06	0.04	0.07
Mn	31	37	78	42	63	44	52	153	48	50	1670	96
Na	0.01	0.01	0.01	0.02	0.01	0.02	0.1	0.02	0.02	0.02	0.01	0.02
Ni	<5	<5	<5	<5	6	<5	<5	107	<5	<5	<5	<5
P	537	368	515	803	354	394	1860	771	927	920	143	281
Pb	10800	13900	13300	18200	46500	69300	15500	48500	33000	9700	41600	32700
S	24800	31900	15500	27400	30000	37100	16500	33900	10400	11600	18800	10100
Sb	1850	6070	628	3390	4680	7660	908	369	312	256	117	151
Se	98.4	37.9	11.5	79.8	85.3	125	280	4	5.8	2.1	36	6.3
Sn	574	531	372	2450	729	350	46.8	157	122	58.6	61.9	28
Te	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tl	9.6	8.2	8.1	5.6	4.7	6.8	17.8	10.4	6.4	11.5	2.1	3.5
U	2.1	1.9	1.9	2.2	1.5	1.9	3.1	1.6	1.9	2	1.8	1.9
W	10	<5	10	59	<5	10	20	80	17	18	25	<5
Zn	8390	2390	8760	679	18600	4350	4130	17600	1690	3340	3950	360

Values of Ca, Fe, K, Mg and Na are given in weight %, Hg is given in ppb dry weight, all other values are given in ppm dry weight.

Stream sediment geochemistry  
>150 µm, <2 mm fraction

Element	SS1a	SS2a	SS3a	SS4a	SS5a	SS6a	SS7a	SS8a	SS9a	SS10a
Ag	<1	<1	<1	<1	2	<1	<1	<1	<1	<1
As	1	13	47	27	53	35	38	33	65	59
Be	1.8	1.7	2.1	1.6	2.4	1.6	1.9	1.5	2.2	1.8
Bi	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ca	0.07	0.09	0.05	0.04	0.03	0.03	0.03	0.06	0.04	0.04
Cd	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Co	11	8	8	8	19	8	8	<5	11	9
Cu	11	10	23	82	431	83	105	7	75	47
Fe	2.95	2.55	2.93	2.48	3.8	2.73	2.83	1.68	2.7	2.55
Hg	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
In	<0.1	<0.1	0.4	0.5	7.9	0.6	0.6	0.1	1.6	1.1
K	1.24	0.87	0.97	0.95	1.33	0.9	1.06	1.33	1.32	1.41
Mg	0.31	0.22	0.25	0.2	0.3	0.23	0.23	0.14	0.27	0.25
Mn	303	333	1020	563	931	476	659	171	874	602
Na	0.29	0.2	0.13	0.16	0.14	0.18	0.15	0.16	0.14	0.15
Ni	21	16	14	13	19	15	14	6	14	14
P	187	188	247	191	314	218	219	135	233	209
Pb	28	31	101	59	161	119	181	60	456	252
S	23	69	51	312	2240	269	283	57	157	104
Sb	<5	9	11	8	25	20	22	7	18	15
Se	0.7	<0.5	1.1	<0.5	1.1	0.9	1.3	0.7	0.5	0.9
Sn	2.3	2.5	5	3	6	5.7	4.6	2.5	20.5	15.9
Te	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tl	1.1	1.6	2.7	1.9	3.2	2.4	2.4	1.3	2.2	1.8
U	2.4	2.3	2.5	2.3	3.3	2.6	2.7	2.3	2.2	2.3
W	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zn	39	46	196	136	355	161	202	102	639	487

Values of Ca, Fe, K, Mg and Na are given in weight %, Hg is given in ppb dry weight, all other values are given in ppm dry weight.

**Stream sediment geochemistry  
<150 µm fraction**

Element	SS1b	SS2b	SS3b	SS4b	SS5b	SS6b	SS7b	SS8b	SS9b	SS10b
Ag	<1	<1	<1	<1	3	<1	<1	4	<1	<1
As	14	17	31	20	70	28	34	32	47	52
Be	1.5	2	2	2.3	3.5	2	2.2	1.9	2.1	2.3
Bi	<5	<5	<5	<5	<5	<5	<5	18	<5	6
Ca	0.09	0.14	0.12	0.29	0.04	0.03	0.05	0.12	0.08	0.09
Cd	<5	<5	<5	<5	6	<5	<5	10	5	5
Co	7	7	8	7	11	7	11	7	9	11
Cu	15	56	39	177	804	154	289	1390	146	209
Fe	1.89	2	2.16	2.55	3.97	2.84	2.81	2.78	2.3	2.61
Hg	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
In	<0.1	1.1	0.5	1.3	15.7	1.5	0.9	36.2	1.9	3.8
K	0.87	1.49	1.27	2.49	1.29	1.04	0.91	1.2	0.86	2.04
Mg	0.2	0.22	0.27	0.28	0.38	0.28	0.29	0.21	0.27	0.26
Mn	178	239	741	333	657	296	422	279	558	466
Na	0.42	0.36	0.26	0.31	0.18	0.28	0.21	0.21	0.27	0.27
Ni	14	14	16	15	25	15	15	14	14	18
P	158	194	261	244	402	276	273	208	219	220
Pb	45	84	109	78	169	114	232	171	382	237
S	187	563	408	2360	3860	640	789	6380	473	1790
Sb	<5	8	6	12	23	20	16	16	16	11
Se	0.7	1.2	1.5	1.2	1.7	1.6	0.9	3.8	1.4	1.9
Sn	4.6	11.5	9.6	5.1	7.7	5.4	12	105	19.8	47.9
Te	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tl	1.1	1.6	2.5	2.5	4.2	3.1	2.9	1.4	2	1.7
U	2.6	2.8	3.1	3.5	4.6	3.6	3.6	3.2	2.7	2.9
W	<5	<5	<5	<5	<5	<5	<5	10	<5	<5
Zn	56	169	216	190	575	233	306	1740	726	712

Values of Ca, Fe, K, Mg and Na are given in weight %, Hg is given in ppb dry weight, all other values are given in ppm dry weight.

## Appendix A3

### Oakey Creek water chemistry analysed during this study

Parameter	OCW1 June 2001	OCW2 April 2002	OCW3 April 2002	OCW4 April 2002
Distance from mine input (m)	0	0	50	500
Generals				
pH	3.59	3.42	3.30	4.79
Conductivity ( $\mu\text{S}/\text{cm}$ )	1379	1438	1294	859
TDS (mg/l)	1091	811	792	541
Hardness (mg/l as $\text{CaCO}_3$ )	352	374	211	308
Alkalinity (mg/l as $\text{CaCO}_3$ )	<0.1	<0.1	<0.1	1.3
Majors (mg/l)				
Na	13	9.8	8.6	28
K	3.8	7.3	8.3	7.5
Ca	85	92	45	69
Mg	34	35	24	33
$\text{SO}_4$	780	525	596	362
Cl	14	10	8.3	7.5
$\text{HCO}_3$	<0.1	<0.1	<0.1	1.6
Trace metals ( $\mu\text{g}/\text{l}$ )				
Ag	0.5	0.5	0.5	0.5
Al	47000	27700	27600	868
As	6	3	1	2
Ba	50	81	45	126
Be	27	8	8	<0.1
Cd	623	561	383	76
Co	289	273	222	59
Cr	3	<1	<0.1	<0.1
Cu	21700	12900	5430	288
Fe	1630	12100	11200	372
In	0.9	0.4	0.4	0.3
Mn	11300	18500	11900	9870
Mo	0.2	<0.1	<0.1	<0.1
Ni	236	172	133	25
Pb	36	52	67	36
Sb	0.4	0.2	0.1	2
Se	22	<1	<1	<1
Zn	79000	60700	45600	13100

### Additional Oakey Creek water analyses

Parameter	Bartareau <i>et al.</i> (1998) April 1996				Bartareau <i>et al.</i> (1998) December 1995				Qld DNRM unpublished data November 2000				
	- 500 upstream	- 500 upstream	0	0	1000	1000	2000	2000	0	250	500	0	500
Distance downstream from mine input (m)													
Filtered or total	<0.45µm	total	<0.45µm	total	<0.45µm	total	<0.45µm	total	<0.45µm	<0.45µm	<0.45µm	unknown	unknown
Generals													
pH	7.5	7.5	4.1	4.1	6.4	6.4	7.3	7.3	3.7	3.8	4.5	7.2	7
Dissolved Oxygen (% saturation)	88	88	44	44	77	77	61	61	n.a.	n.a.	n.a.	n.a.	n.a.
Majors (mg/l)													
SO <sub>4</sub> <sup>2-</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	24	41
Trace metals (µg/l)													
Al	<50	200	77000	70000	110	140	<50	<50	35000	21000	1700	550	30
As	<50	<50	70	<50	<50	<50	<50	<50	<50	<50	<50	<5	7
Cd	<10	<10	700	610	30	20	<10	<10	420	170	70	3.1	1.6
Co	<50	<50	380	320	<50	<50	<50	<50	230	230	200	n.a.	n.a.
Cu	150	<50	20000	24000	170	120	100	100	12000	4600	1300	150	<50
Fe	1100	2100	8900	8100	<50	110	<10	30	3900	600	<50	400	<50
Mn	<50	100	14000	13500	1900	1880	50	50	12000	16000	4400	n.a.	n.a.
Ni	<50	<50	240	190	<50	<50	<50	<50	130	150	<50	n.a.	n.a.
Pb	<54	<50	300	240	<55	<50	<57	<52	50	80	60	2	<2
Sb	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	<5	<5
Zn	90	<50	80000	75000	4300	4100	160	1500	49000	32000	9400	560	450

#### Saturation indices of selected species for Oakey Creek waters calculated using PHREEQC2.

Mineral	OCW1	OCW2	OCW3	OCW4
alunite	1.69	0.43	-0.33	4.04
anglesite	-2.02	-1.94	-1.76	-2.10
anhydrite	-1.21	-1.29	-1.50	-1.41
barite	0.55	0.67	0.49	0.87
Fe(OH) <sub>3</sub>	-8.09	-7.66	-8.09	-5.06
gibbsite	-1.42	-2.00	-2.47	0.58
goethite	-2.31	-1.87	-2.31	0.72
gypsum	-0.98	-1.05	-1.27	-1.18
H <sub>2</sub> O	-1.59	-1.59	-1.59	-1.59
halite	-8.36	-8.61	-8.75	-7.94
hematite	-2.62	-1.75	-2.62	3.44
jarosite	-20.53	-18.77	-19.41	-15.10
melanterite	-5.16	-4.40	-4.34	-5.91
Pb(OH) <sub>2</sub>	-8.37	-8.45	-8.65	-5.87
Zn(OH) <sub>2</sub>	-7.62	-8.01	-8.41	-5.92

## Appendix A4

## Mine waste mineralogy

## SIROQUANT mineral percentages

Sample No.	WDA1	WDA2	WDA3	WDB1	WDB2	WDB3	WDD1	WDD2	WDD3	WDE1	WDE2
quartz	88.7 (0.8)	88.3 (0.68)	89.5 (0.91)	90.3 (1.06)	75.9 (1.1)	76 (0.54)	85.2 (0.47)	91.4 (0.44)	94.6 (0.43)	91.6 (0.14)	88 (0.56)
galena	-	1.6 (0.09)	1.2 (0.05)	-	6.1 (0.1)	9.9 (0.09)	6.6 (0.06)	1.1 (0.04)	1.5 (0.06)	2.4 (0.04)	-
sphalerite	1.1 (0.81)	-	1.2 (0.09)	-	2.8 (0.13)	-	2.2 (0.11)	5.8 (0.43)	-	0.5 (0.1)	0.2 (0.15)
chalcocopyrite	-	5.2 (0.33)	-	-	3.3 (0.43)	2.6 (0.18)	2.9 (0.5)	-	-	-	-
tetrahedrite	-	1.1 (0.33)	1.1 (0.22)	8.3 (0.37)	-	8.3 (0.4)	-	-	-	-	-
pyrite	-	2.2 (0.31)	-	-	-	-	-	-	3.9 (0.43)	-	-
anglesite	-	0.6 (0.13)	-	0.8 (0.22)	3.3 (0.17)	2.5 (0.09)	3.1 (0.16)	1.6 (0.14)	-	5.5 (0.1)	8.6 (0.13)
dickite	10.3 (0.08)	1 (0.49)	-	0.6 (1.08)	8.7 (1.24)	0.7 (0.5)	-	-	-	-	3.1 (0.59)
illite	-	-	7 (0.92)	-	-	-	-	-	-	-	-
global $\chi^2$	2.36	2.37	2.17	2.69	2.29	2.53	2.31	2.28	2.25	2.23	2.26

Mineral values in percentages, values in brackets represent errors in percentages.

## Summary of XRD results

## Waste rock bulk samples

	quartz	dickite	galena	chalcocopyrite	tetrahedrite	sphalerite	pyrite	anglesite	plumbojarosite
WDA1	x	x				x			
WDA2	x	x	x	x	x		x		
WDA3	x	x	x	x	x	x			
WDB1	x	x			x			x	x
WDB2	x	x	x	x		x	x	x	x
WDB3	x	x	x	x	x			x	x
WDC1	x	x	x			x			x
WDD1	x		x	x		x		x	x
WDD2	x	x	x			x		x	x
WDD3	x	x	x				x		x
WDE1	x		x			x		x	
WDE2	x	x				x		x	

x denotes presence of mineral in XRD trace.

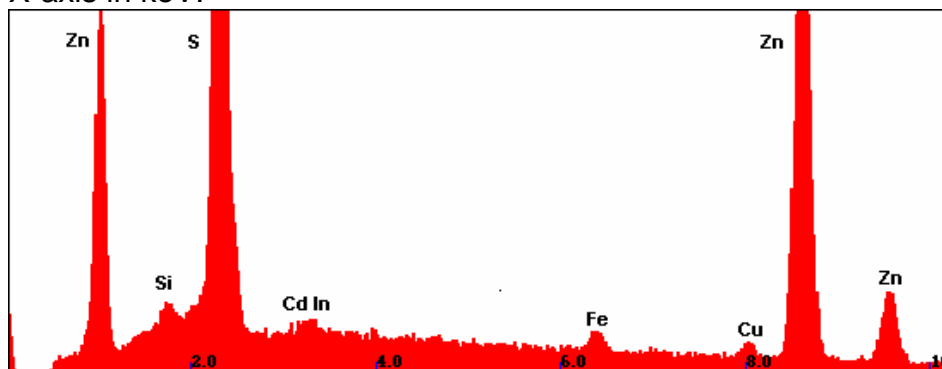
## Waste rock scrapings

	quartz	melanterite	chalcocanthite	anglesite	beaverite	K-alum	others
EA1	x						illite
EA2a	x						native Cu, cuprite
EA2b		x					gypsum
EA3a	x						
EA3b	x	x	x				
EB1a	x	x	x				chalcocopyrite
EB1b	x						dickite
EB1c	x						antlerite, brochantite
EB2f				x	x		antlerite, sphalerite
EB2g	x			x	x		
EB3a	x			x			osarizawaite
EB3c				x			brochantite
EB3e				x			galena
EB4	x			x	x		plumbojarosite
EB5	x			x			antlerite
EB6	x						scorodite
EB7	x						native S, pyrite, chalcocopyrite, plumbojarosite
EB8							hematite
EC1			x			x	
EC2			x			x	tamarugite, goethite, ramsbeckite
EC3						x	metavoltine, sideronatrite, tamarugite, szomolnokite, beudantite

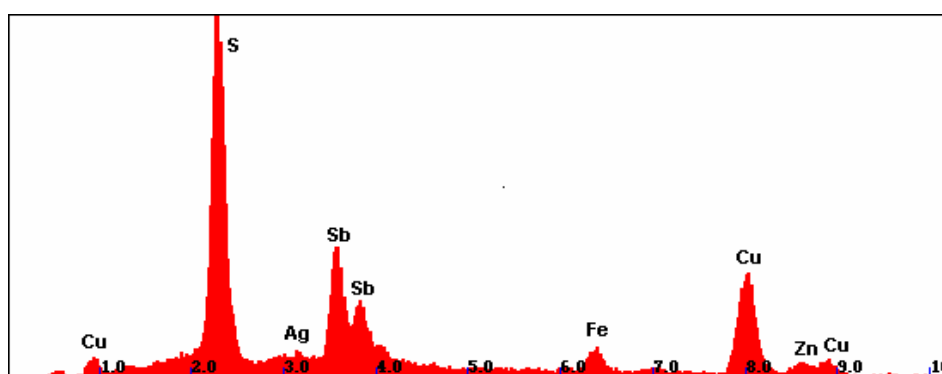
x denotes presence of mineral in XRD trace.

## Representative EDS traces of sulphide minerals

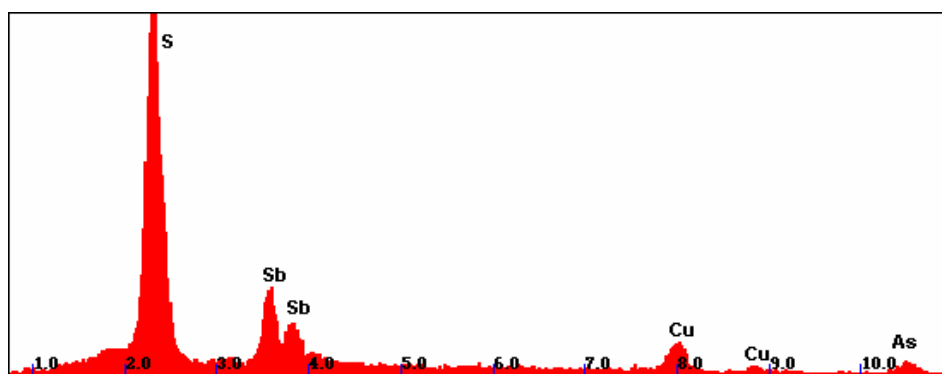
X-axis in keV.



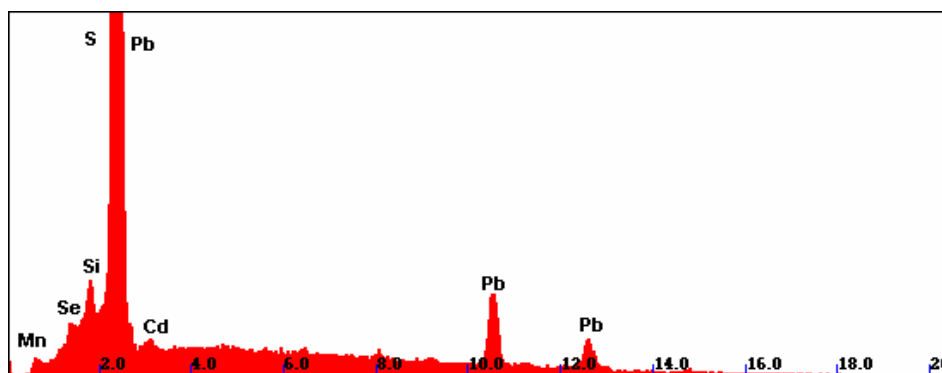
cadmium and indium-bearing sphalerite



argentic tetrahedrite



arsenian tetrahedrite



cadmium and selenium-bearing galena



## Appendix A5

### Dissolution experiment results

	WDB1			WDB2			WDB3		
	1 day	1 week	1 month	1 day	1 week	1 month	1 day	1 week	1 month
pH	2.67	2.89	3.17	2.99	3.25	3.41	3.86	4.23	4.66
cond	990	614	542	647	303	257	384	312	434
Al	4590	554	770	5400	1480	723	1840	1950	1320
As	704	16.6	109	1450	450	27.6	51.4	880	1.35
Ca	1160	2420	1960	2710	2320	1490	3910	821	321
Cd	43.1	46	151	306	163	38.8	74	34.7	35.6
Cu	78500	60200	2660	34600	7710	108000	58800	51500	66500
Fe	25800	260	<100	12200	321	<100	1320	5870	557
In	<0.1	<0.1	0.161	<0.1	<0.1	<0.1	<0.1	<0.1	1.72
K	3800	1490	682	1290	1120	1160	2580	988	<500
Mg	550	1460	429	1820	748	794	3380	238	94
Mn	52600	70200	57300	84500	37900	82100	152000	23800	23100
Na	589	380	152	947	1590	127	1210	331	77
Pb	3010	5180	12500	4230	7290	4640	5000	4080	2590
Sb	34.8	47.5	32.8	44.7	36.1	57.5	63	35.1	31.3
Se	101	31.3	17.7	100	48.3	42	47.3	74.6	99.9
SO <sub>4</sub> <sup>2-</sup>	374.06	175.28	83.36	299.96	108.3	265.41	225.51	231.92	209.48
Zn	2730	6420	19300	39700	17400	6120	12600	1860	2260

cond – conductivity, reported in  $\mu\text{S}/\text{cm}$  at 25 °C. SO<sub>4</sub><sup>2-</sup> reported in mg/l, all other values reported in  $\mu\text{g}/\text{l}$ .

**Appendix A6**

**Oakey Creek streambed precipitates**

**Summary of XRD results**

	OCE1	OCE3	OCE4	OCE5	OCE6	OCE7	OCE8	OCE11	OCE12	OCE13
alunogen		x		x			x			
bonattite				x			x	x	x	
chalcantite		x		x			x	x		
dietrichite- pickeringite- apjohnite phase	x	x		x			x	x	x	x
goethite					x	x				
gunningite		x		x				x		
gypsum	x	x					x	x	x	x
kalinite	x	x		x			x	x	x	
kroehnkite		x		x				x		
rostite	x	x		x				x		
schwertmannite			x		x			x	x	x
zaherite	x	x		x				x	x	x
others					illite, quartz	illite, quartz			aluminite, epsomite, hexahydrite, pentahydrite, picromerite	hexahydrite

x denotes presence of mineral in XRD trace.

**ICP-MS results**

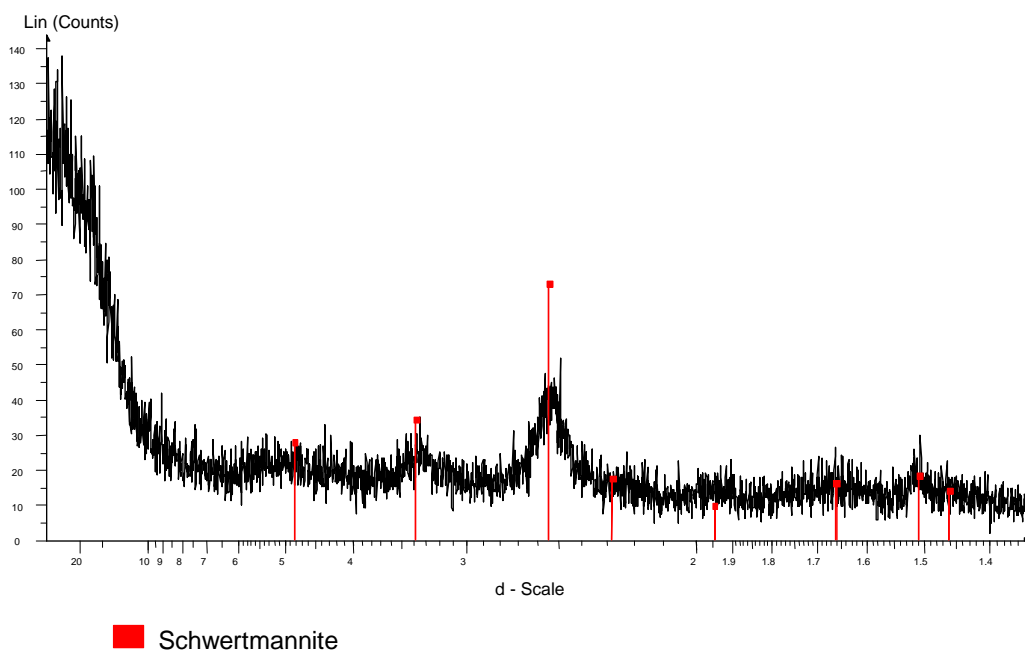
Sample No.	OCE4 (schwertmannite)	OCE6 (schwertmannite and goethite)	OCE11 (efflorescences)
Al	1920	13100	31000
As	39.1	105	1.85
Ca	30.1	200	6240
Cd	0.636	0.712	350
Cu	414	239	10300
Fe	373000	88000	2150
In	2.88	0.117	0.361
K	245	7170	3200
Mg	28.7	1070	10900
Mn	59.8	188	6050
Na	<100	230	3210
Pb	29.4	52.7	18.9
S	30700	7490	163000
Sb	0.946	0.804	0.073
Se	<1	<1	2.09
Zn	115	141	51300

Values in ppb.

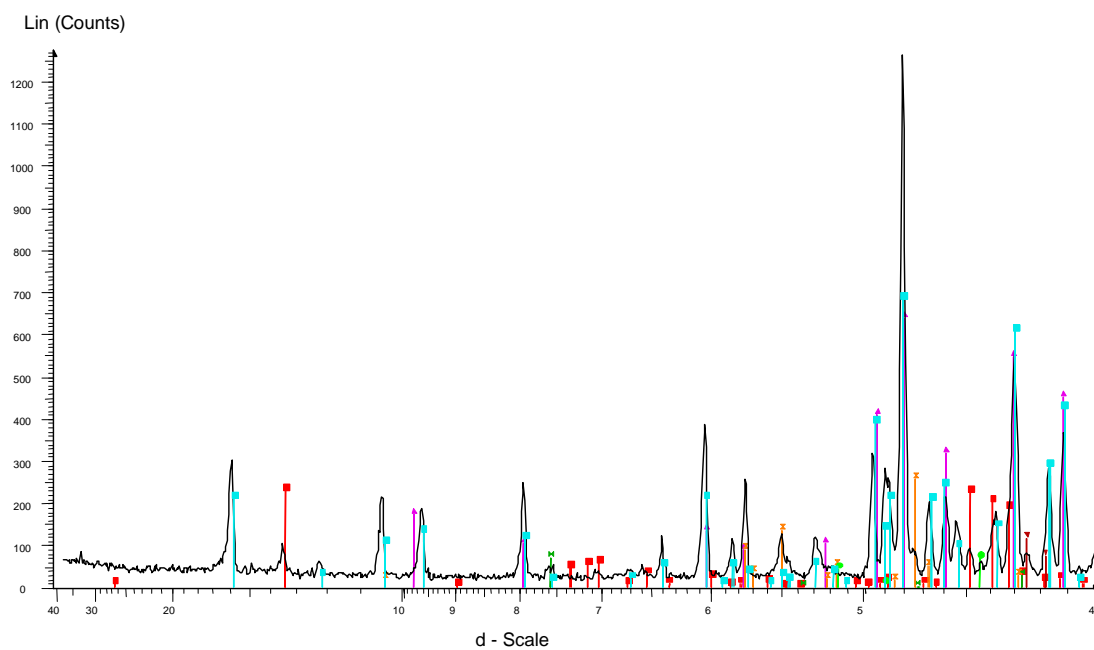
**Microprobe results**

Element	OCE 1 Analysis 6		OCE 1 Analysis 7		OCE 1 Analysis 8	
	Weight %	Atomic %	Weight %	Atomic %	Weight %	Atomic %
Al	9.543	7.884	9.391	7.770	9.755	7.950
Ca	0.025	0.014	0.013	0.007	0.020	0.011
Cu	0.574	0.201	0.581	0.204	0.449	0.155
Mg	1.828	1.676	1.748	1.605	1.652	1.494
Mn	0.884	0.359	0.921	0.374	0.922	0.369
O	56.533	78.755	56.601	78.970	57.424	78.921
S	13.553	9.423	13.332	9.283	13.741	9.425
Zn	4.952	1.688	5.233	1.787	4.978	1.674
Total	87.892	78.755	87.820	78.970	88.941	78.921

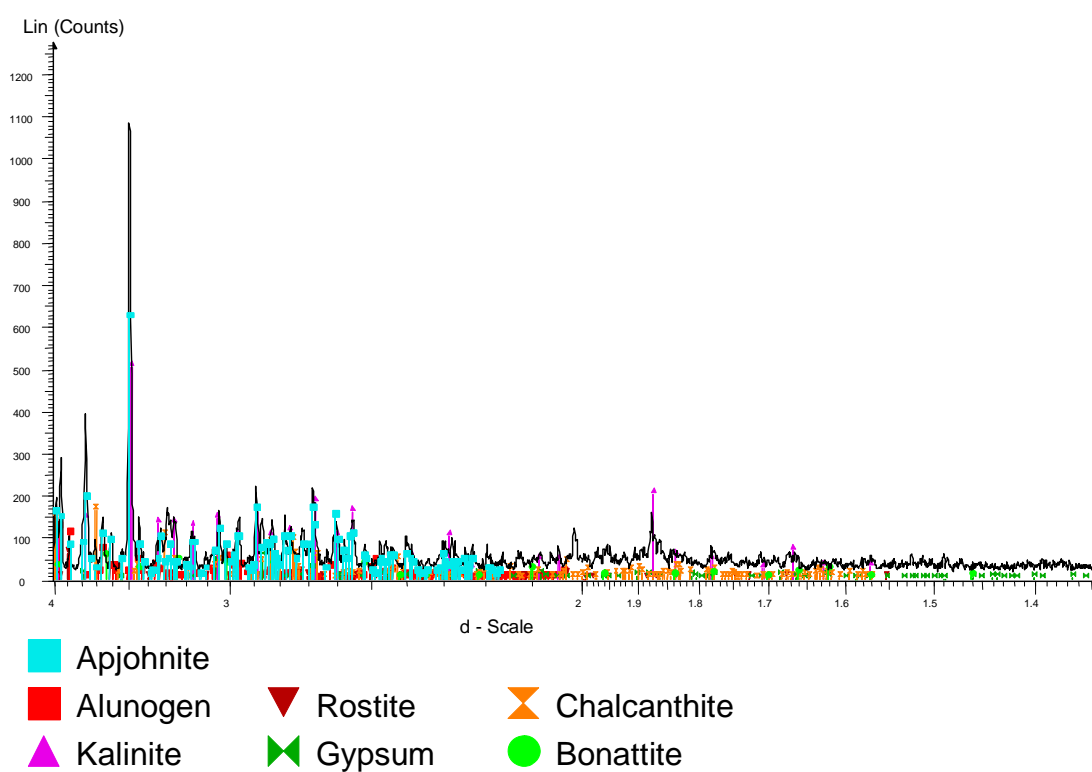
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**Representative XRD traces**

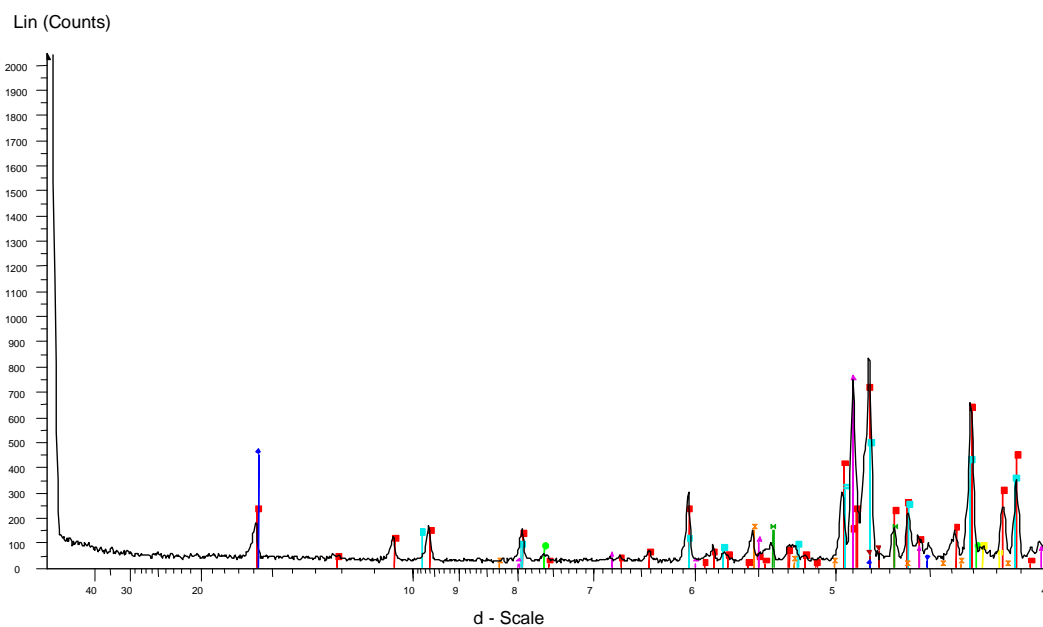
XRD trace of streambed precipitate sample OCE4.



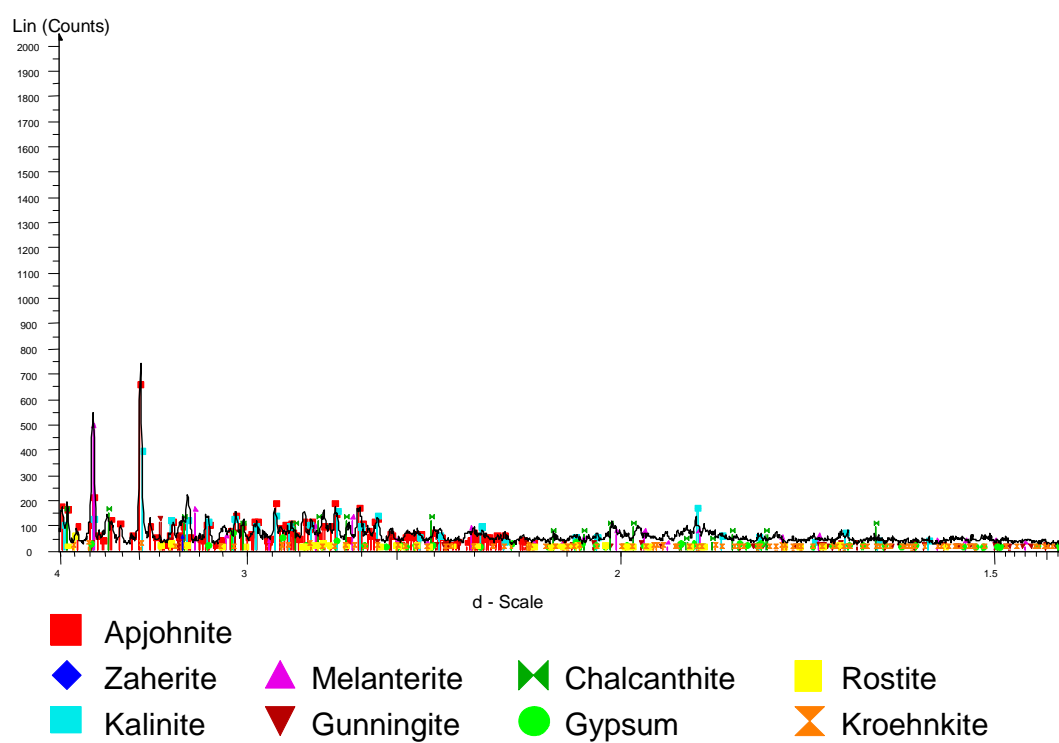
XRD trace of efflorescence sample OCE8, d-spacing 40 – 4.



XRD trace of efflorescence sample OCE8, d-spacing 4 – 1.3.



XRD trace of efflorescence sample OCE11, d-spacing 50 – 4.



XRD trace of efflorescence sample OCE11, d-spacing 4 – 1.4.