

Trace metal enrichment in the colloidal fraction in soils developing on abandoned mine spoils

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Supporting Information Document

Table S1. Mineralogical analyses of the colloids collected from bulk mine spoils

Spoil Pile	Quartz	Feldspar	Biotite and Muscovite	Chlorite and vermiculite	Kaolinite	Chalcopyrite	Jarosite	Sum	Rwp	Rp	Re	S	χ^2	Maximum shift/e.s.d.
1	34.8		38.1	1.1	21		5	100.00	8.71	6.57	3.31	2.63	6.93	0.31
2	5	75.9	17.1				1.98	99.98	12.37	8.73	3.03	4.07	16.59	0.41
3	24	1	40		24	11		100.00	9.5	7.3	3.33	2.85	8.14	1.39
4	9.9	64.6	25.35					99.85	9.78	7.28	3.31	2.95	8.7	0.28
5	5.9	1.9	81		11			99.80	8.53	6.55	4.29	1.99	3.95	0.19
6	9	17	74					100.00	18.66	13.69	3.07	2.06	37.04	10
7	25	18	38		19			100.00	12.37	9.1	3.02	4.04	16.7	0.21
8	4.69	20.34	50.49		24.47			99.99	8.27	6.45	3.08	2.68	7.2	0.46
9	13.6	0	32.4		39.6	9.2	5.1	99.90	9.88	7.63	2.91	3.39	11.51	0.14
10	5.1	60.8	0	3.5	30.5			99.90	8.88	6.86	3.04	2.92	8.51	0.17
11	54	3.1	41.7	0.71				99.51	22.61	14.77	3.01	7.5	56.27	0.12
Avg	17.36	26.26	39.83	1.77	24.22	10.1	4.03							
SD	± 15.76	± 29.39	± 23.14	± 1.51	± 9.02	± 1.27	± 1.77							

Table S2. Representative elemental composition of pyrite, Fe(III)oxyhydroxide/oxide, and Fe(III)oxyhydroxysulfate of grains observed by SEM and analyzed by EDS.

Element	AN Series	Net	Norm. C (wt.%)	Atom. C (wt.%)	Error %		Net	Norm. C (wt.%)	Atom. C (wt.%)	Error %		Net	Norm. C (wt.%)	Atom. C (wt.%)	Error %
Sulfur	16 K	32894	33.42	23.78	1.1	Pyrite	158	0.15	0.09	0	Fe(II)oxyhydroxide/oxide	423	0.55	0.29	0
Iron	26 K	5048	29.25	11.95	0.8		4418	25.22	8.43	0.7		92	0.57	0.17	0
Oxygen	8 K	819	6.78	9.67	1.1		8345	41.49	48.43	4.4		5747	35.02	36.95	2.1
Silicon	14 K	1094	1.13	0.92	0.1		5716	5.41	3.60	0.2		16327	14.83	8.91	0.3
Aluminum	13 K	442	0.52	0.44	0		2296	2.45	1.70	0.1		351	0.34	0.21	0
Potassium	19 K	105	0.16	0.09	0		425	0.50	0.24	0		49	0.09	0.04	0
Manganese	25 K	88	0.4	0.16	0		117	0.45	0.15	0					
Phosphorus	15 K	106	0.11	0.08	0		269	0.26	0.16	0		15110	17.02	9.28	0.3
Titanium							54	0.12	0.05	0		10	0.03	0.01	0
Chlorine	17 K	125	0.17	0.11	0		70	0.07	0.04	0		64	0.09	0.04	0
Magnesium	12 K	240	0.35	0.33	0		16	0.02	0.02	0		15	0.02	0.01	0
Sodium	11 K	76	0.17	0.17	0		0	0.00	0.00	0					
Carbon	6 K	1181	27.54	52.31	4		2353	23.87	37.11	2.9		2115	31.33	44.04	2.1
Chromium												34	0.12	0.04	0
		Total:	100	100			Total:	100.00	100			Total:	100.00	100	

Table S3. Acid extractable metal concentration in bulk (B) mine spoils and colloids (C); Al, Mn, and Fe concentrations are g/kg, all other values are in mg/kg.

Spoil Pile	(B) Na	(C) Na	(B) Al	(C) Al	(B) Si	(C) Si	(B) Ca	(C) Ca	(B) Mn	(C) Mn	(B) Fe	(C) Fe	(B) Ni	(C) Ni	(B) Cu	(C) Cu	(B) Zn	(C) Zn
1	5.91	8.7	0.52	0.71	17.72	31.47	0.08	0.11	0.05	0.05	2.83	3.73	0.99	1.28	1.53	1.77	4.16	5.54
2	17.47	39.3	0.31	0.3	16.98	42.26	0.08	0.15	0.02	0.03	3.89	7.97	0.43	0.58	1.83	2.65	2.29	3.73
3	4.27	5.03	0.53	0.54	16.82	50.92	0.03	0.04	0.03	0.04	10.76	10.5	0.45	0.77	1.42	2.18	4.3	6.87
4	7.36	7.49	1.31	1.11	12.02	25.61	0.04	0.05	0.23	0.16	6.19	5.53	3.67	3.3	3.58	3.34	12.52	12.05
5	6.42	10.68	1.17	1.03	15.22	44.54	0.15	0.23	0.09	0.11	4.42	6.18	2.65	3.58	1.99	3.15	7.4	10.97
6	4.81	ND	1.08	0.08	8.05	24.74	0.04	0.03	0.46	0.17	3.85	2.11	4.76	2.1	2.67	1.32	10.9	5.89
7	7.62	7.71	1.19	1.03	16.69	45.5	0.27	0.31	0.65	0.81	6.08	8.66	7.86	10.7	3.26	4.44	16.87	23.91
8	3.92	3.1	0.8	0.81	14.76	37.99	0.03	0.06	0.09	0.17	2.62	4.95	2.27	4.15	1.71	3.31	9.24	16.75
9	4.57	ND	1.13	0.11	20.05	44.69	0.03	0.01	0.03	0.01	3.25	1.13	1.46	0.59	2.03	0.79	6.1	2.4
10	2.99	NA	0.76	NA	19.02	NA	0.08	NA	0.03	NA	1.69	NA	1.16	NA	0.83	NA	4.9	NA
Max	17.47	39.3	1.31	1.11	20.05	50.92	0.27	0.31	0.65	0.81	10.76	10.5	7.86	10.7	3.58	4.44	16.87	23.91
Min	2.99	3.1	0.31	0.08	8.05	24.74	0.03	0.01	0.02	0.01	1.69	1.13	0.43	0.58	0.83	0.79	2.29	2.4
Average	6.53	11.72	0.88	0.64	15.73	38.63	0.08	0.11	0.17	0.17	4.56	5.64	2.57	3	2.08	2.55	7.87	9.79
SD	4.13	12.41	0.34	0.4	3.51	9.33	0.08	0.1	0.22	0.25	2.6	3.07	2.33	3.19	0.85	1.15	4.52	6.96
Average Enrichment Factor		1.79		0.72		2.46		1.33		1.03		1.24		1.17		1.22		1.24

ND = Not detected

NA = Not Analyzed due to lack of colloid availability

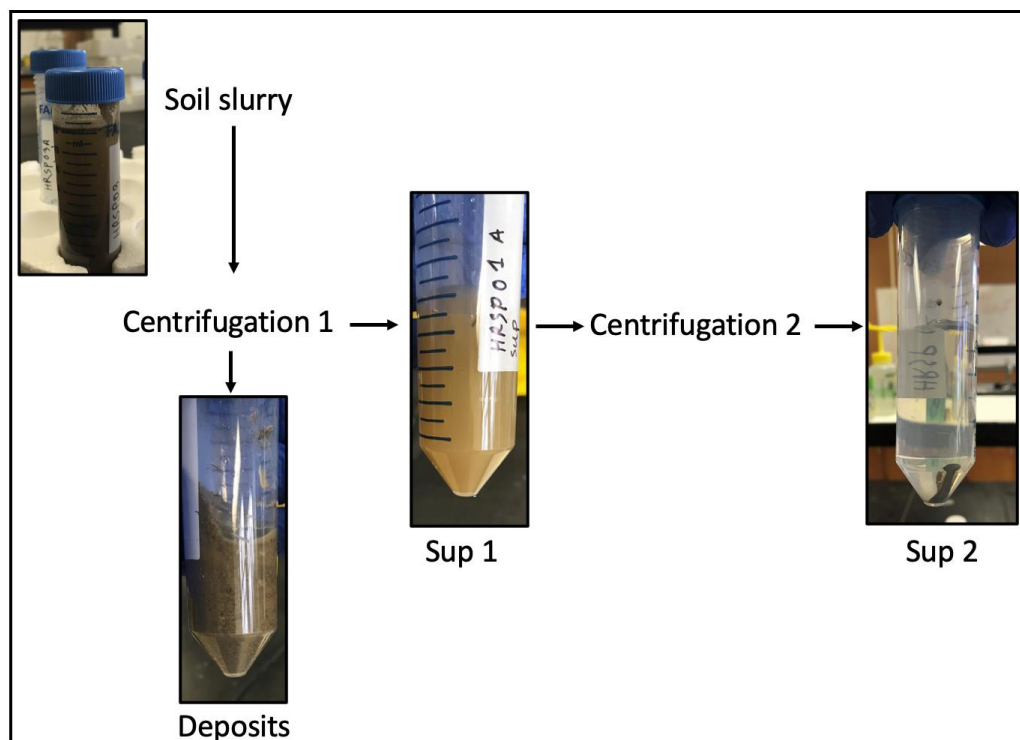


Figure S1. Colloid extraction method from bulk soil samples.

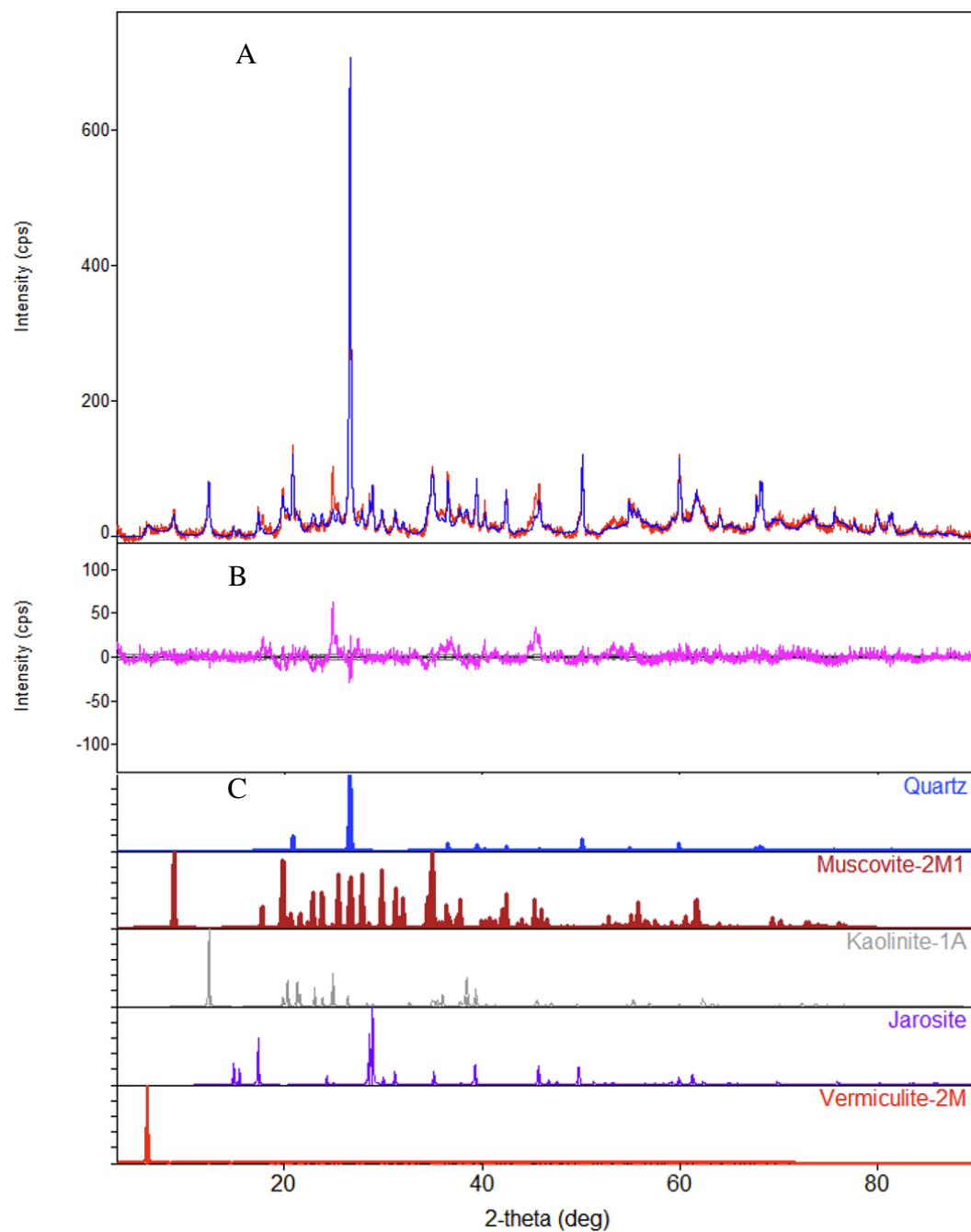


Figure S2. Mineralogical composition of colloids collected from spoil pile #1. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet), and panel (C) shows mineral composition.

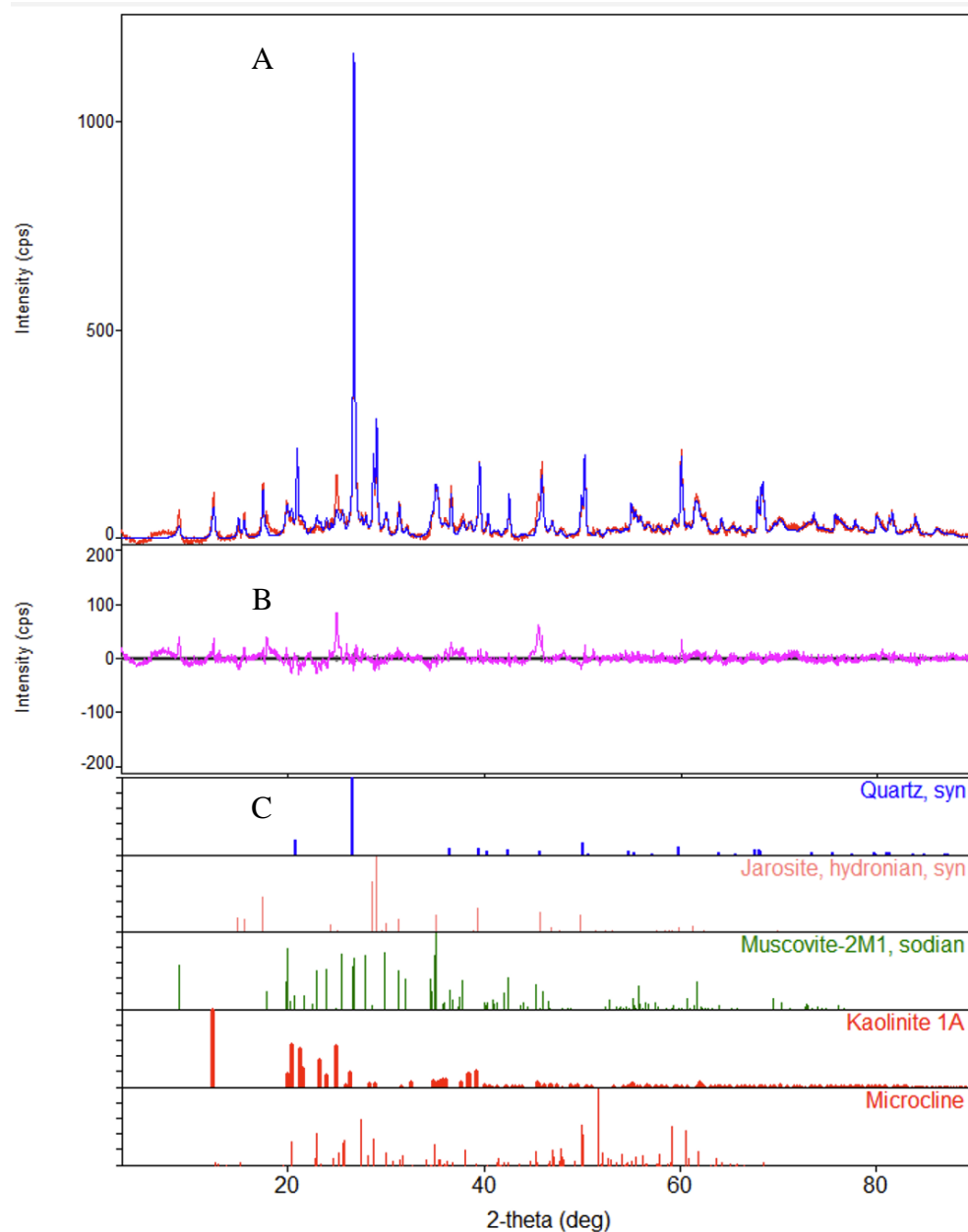


Figure S3. Mineralogical composition of colloids collected from spoil pile #2. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet), and panel (C) shows mineral composition.

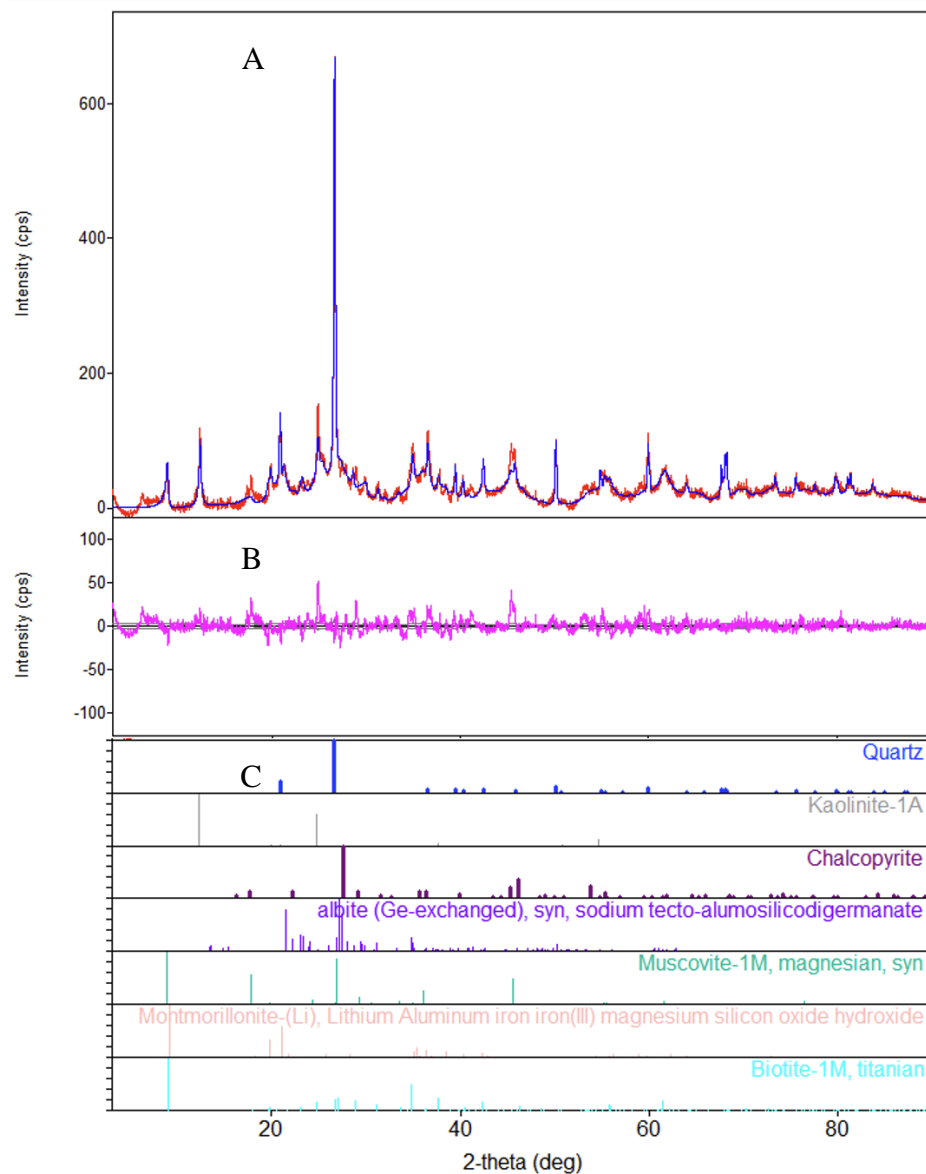


Figure S4. Mineralogical composition of colloids collected from spoil pile #3. Panel (A) shows the measured diffraction pattern (blue), and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

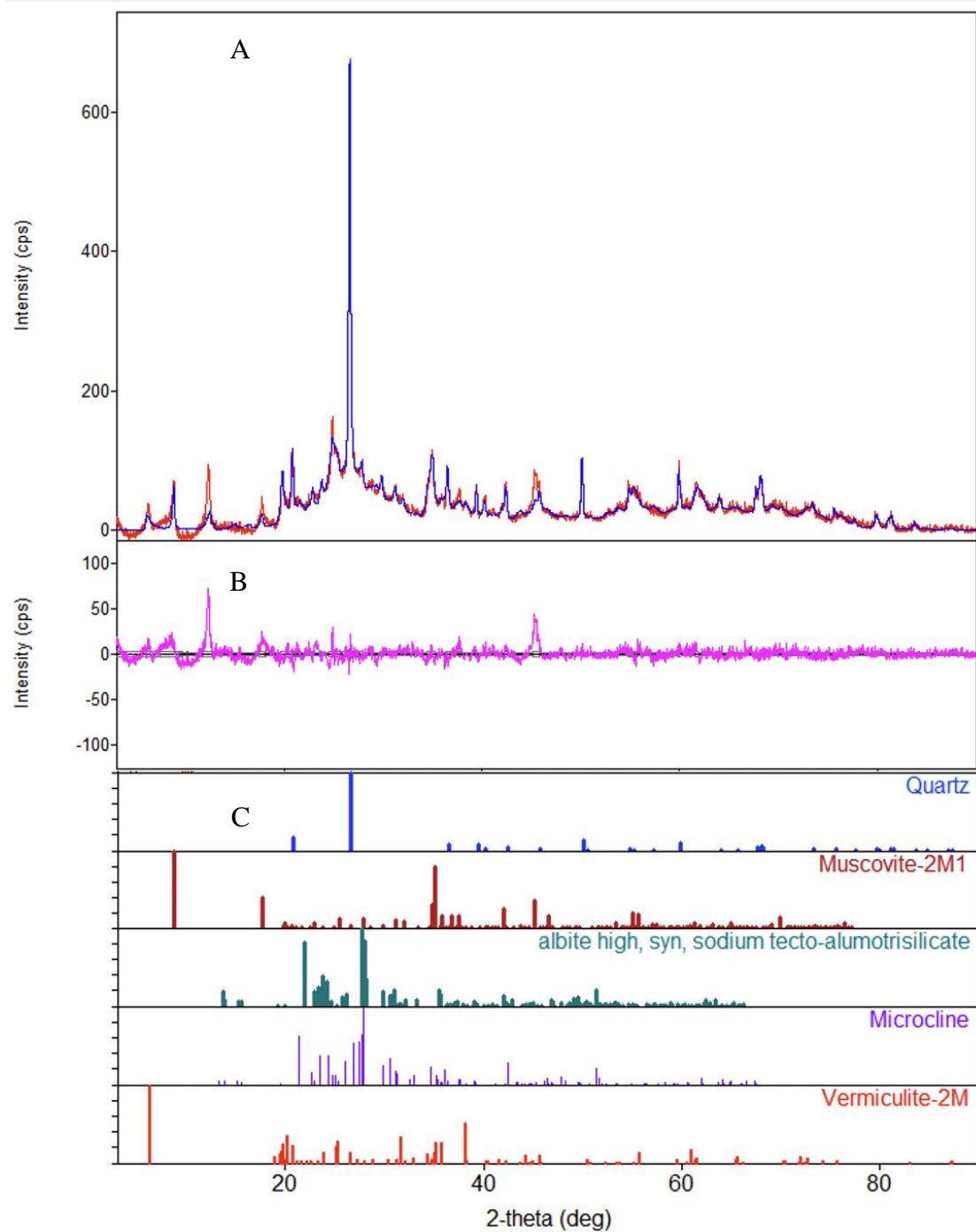


Figure S5. Mineralogical composition of colloids collected from spoil pile #4. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

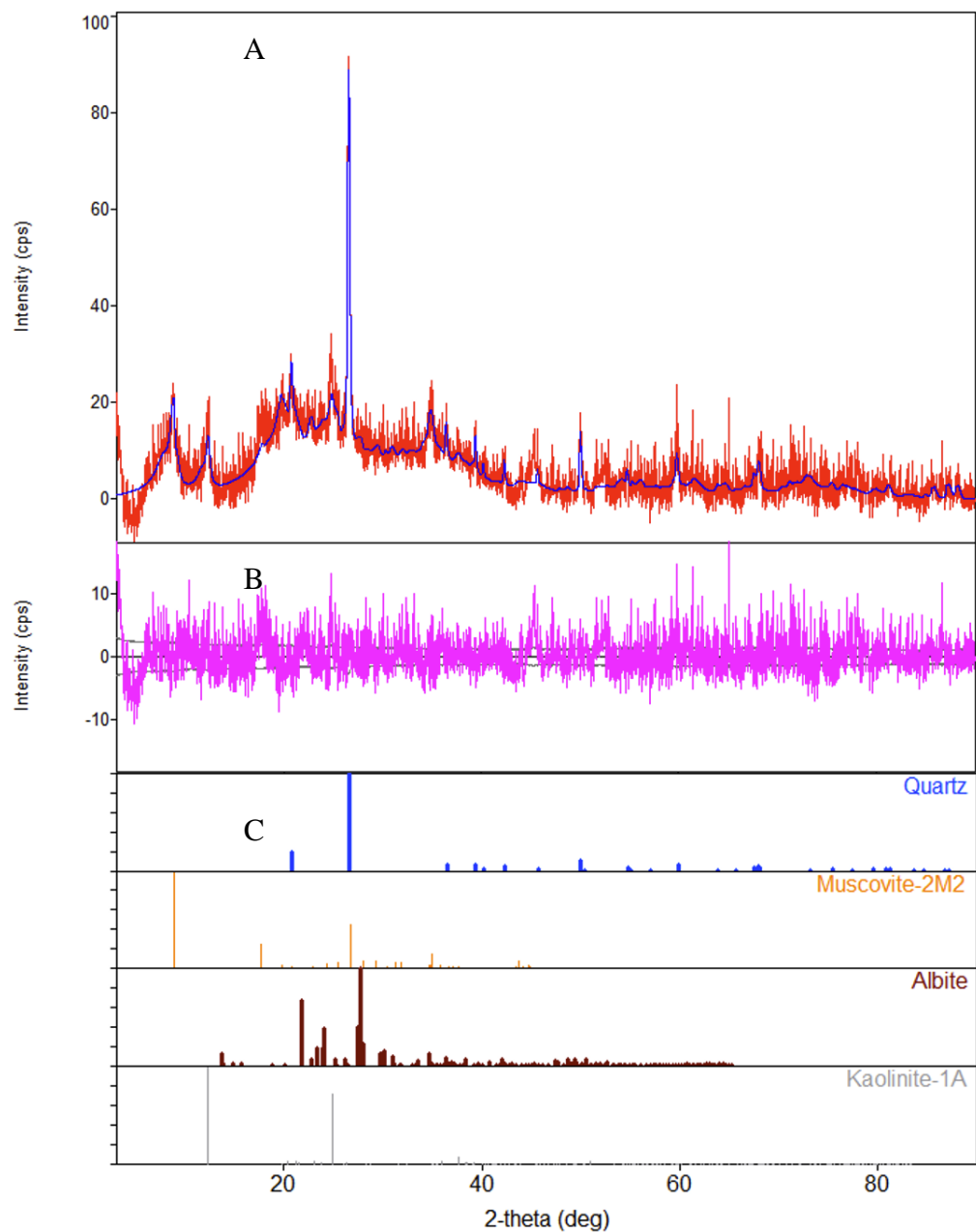


Figure S6. Mineralogical composition of colloids collected from spoil pile #5. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

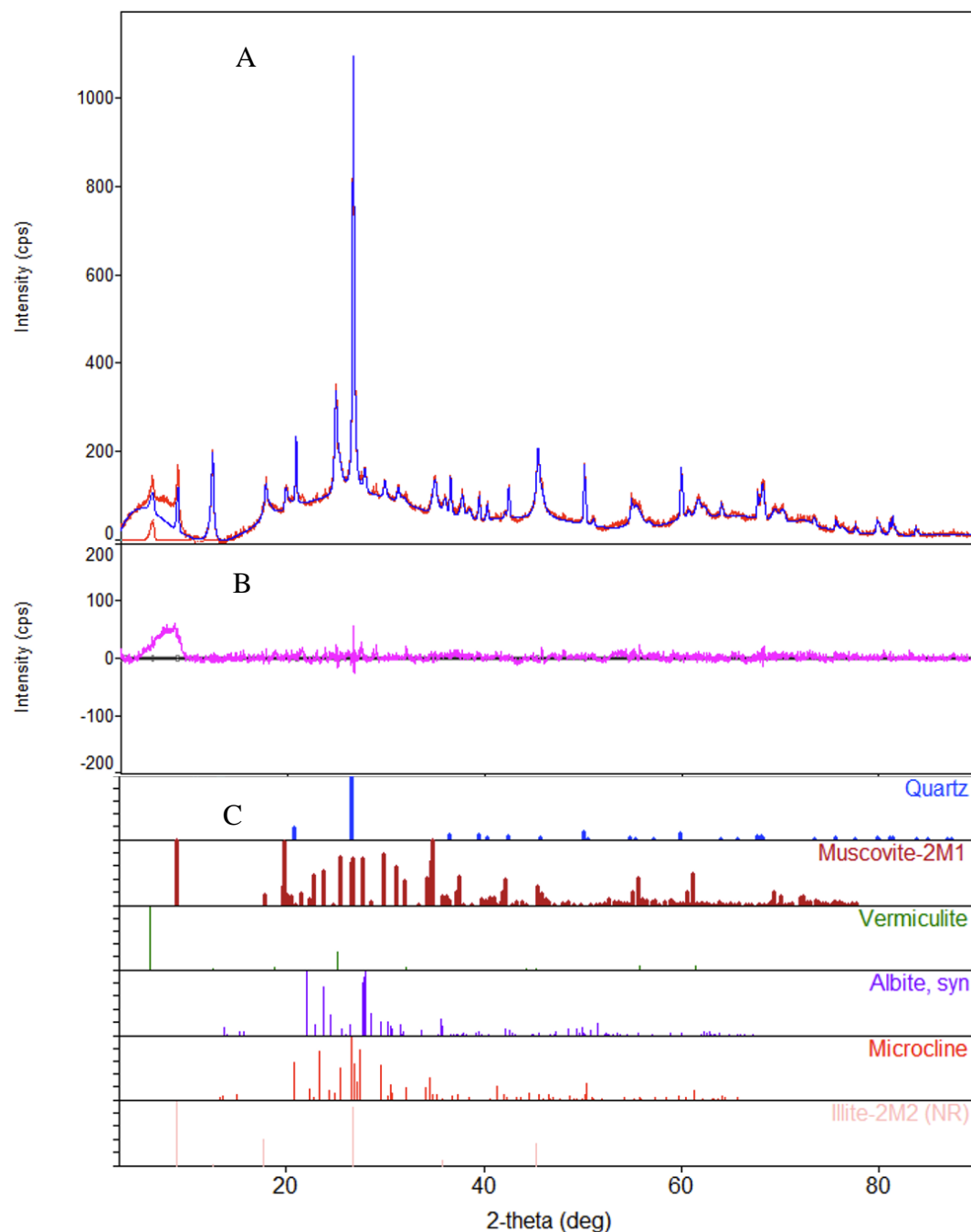


Figure S7. Mineralogical composition of colloids collected from spoil pile #6. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

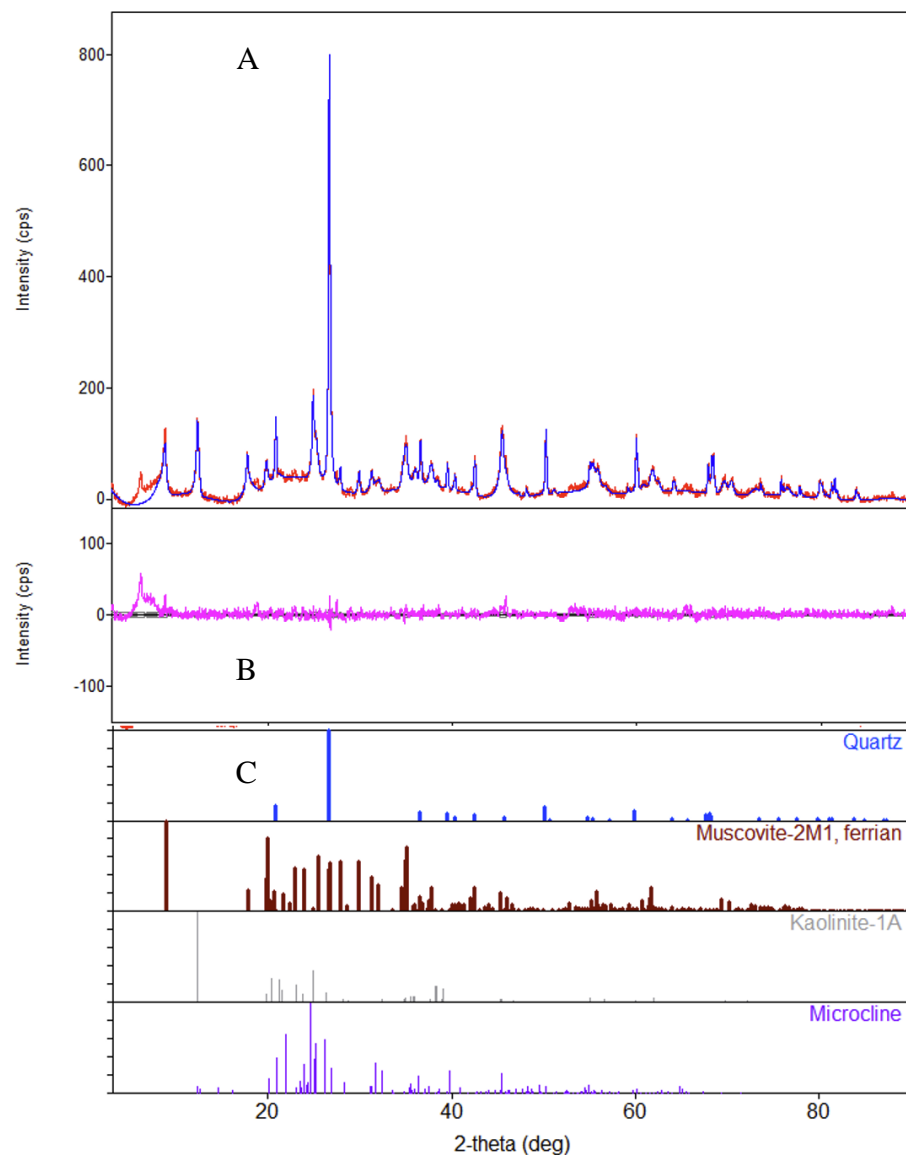


Figure S8. Mineralogical composition of colloids collected from spoil pile #7. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

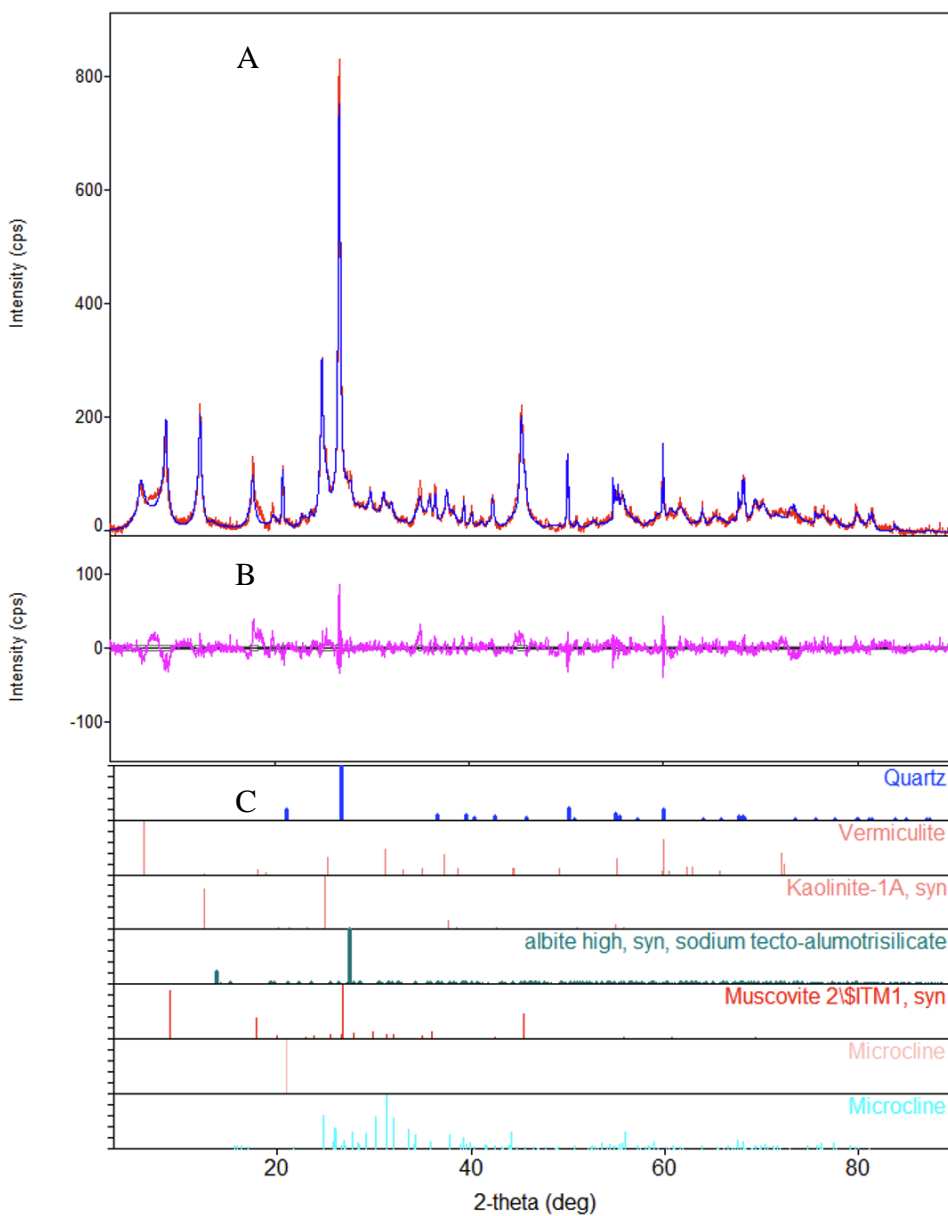


Figure S9. Mineralogical composition of colloids collected from spoil pile #8. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

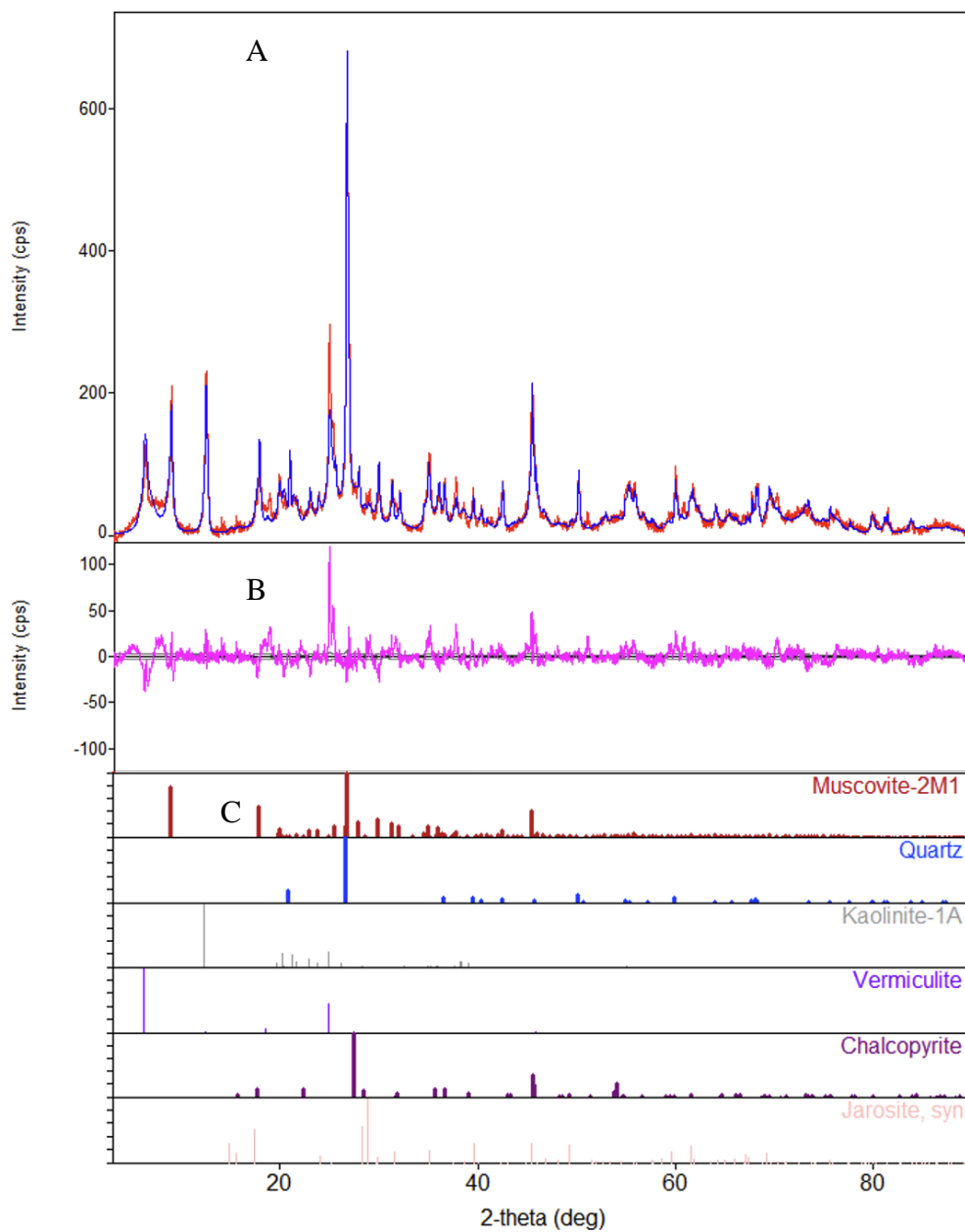


Figure S10. Mineralogical composition of colloids collected from spoil pile #9. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition

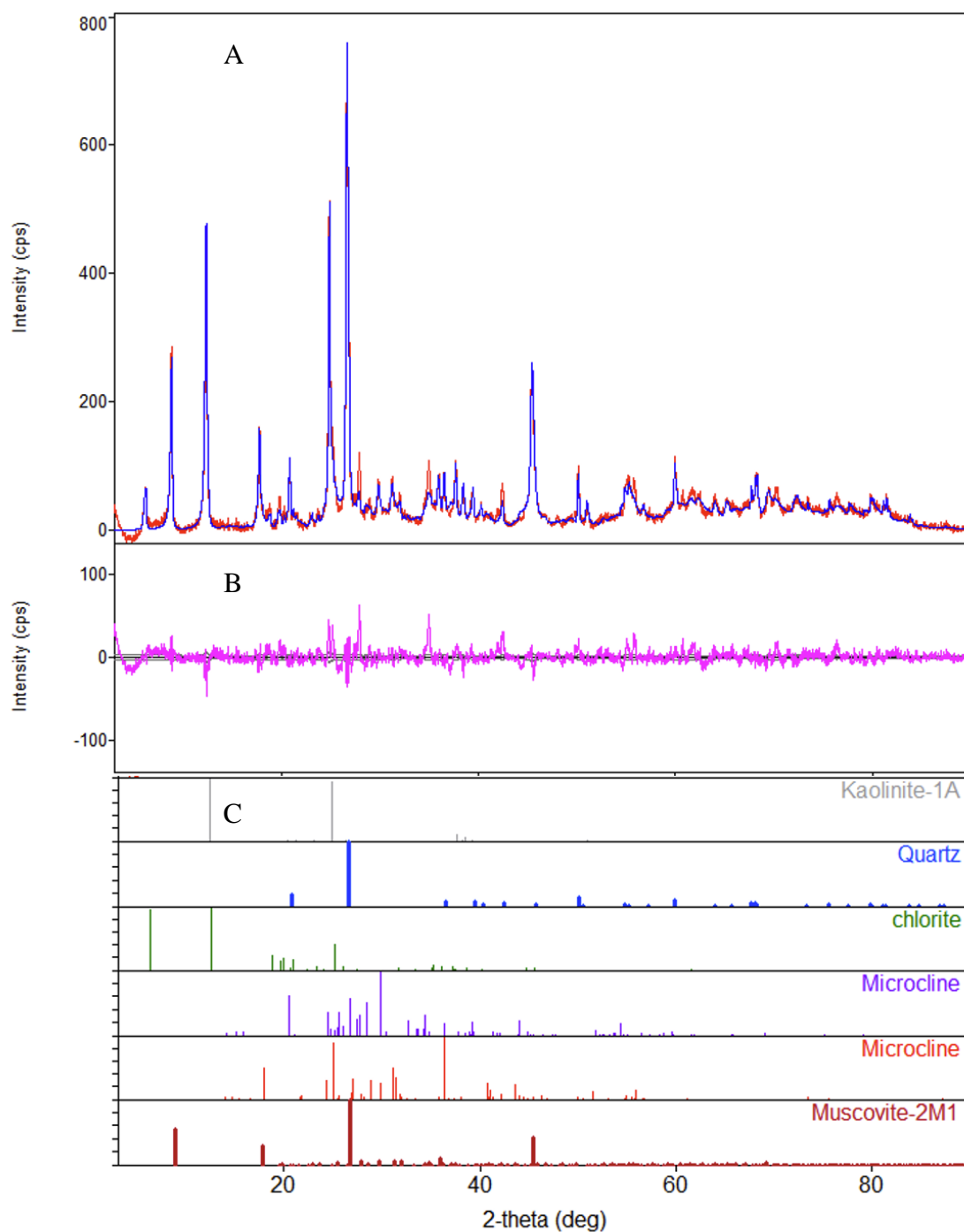


Figure S11. Mineralogical composition of colloids collected from spoil pile #10. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

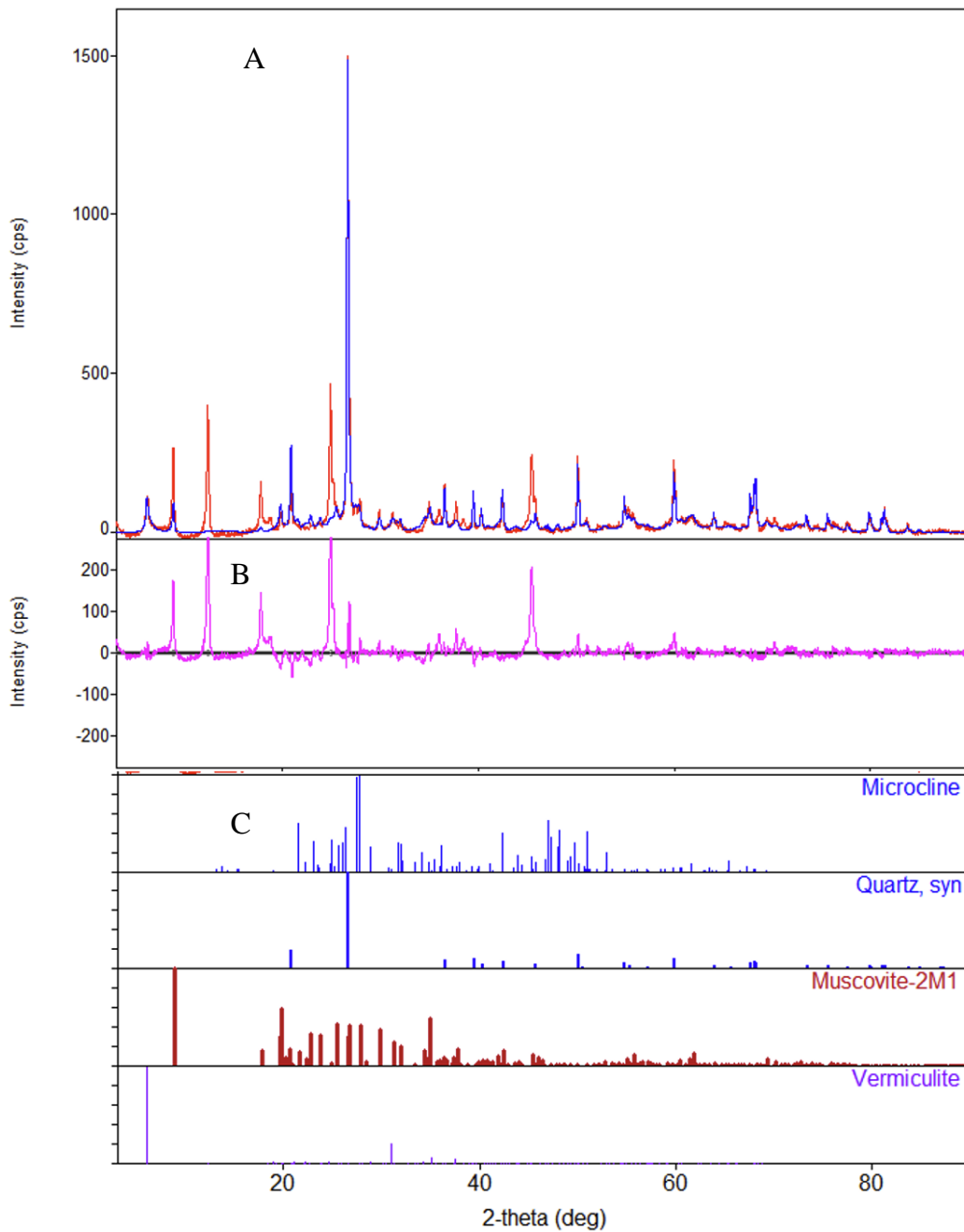


Figure S12. Mineralogical composition of colloids collected from spoil pile #11. Panel (A) shows the measured diffraction pattern (blue) and whole powder pattern fit or WPPF (violet) lines; panel (B) shows the calculated residual plot (violet); panel (C) shows mineral composition.

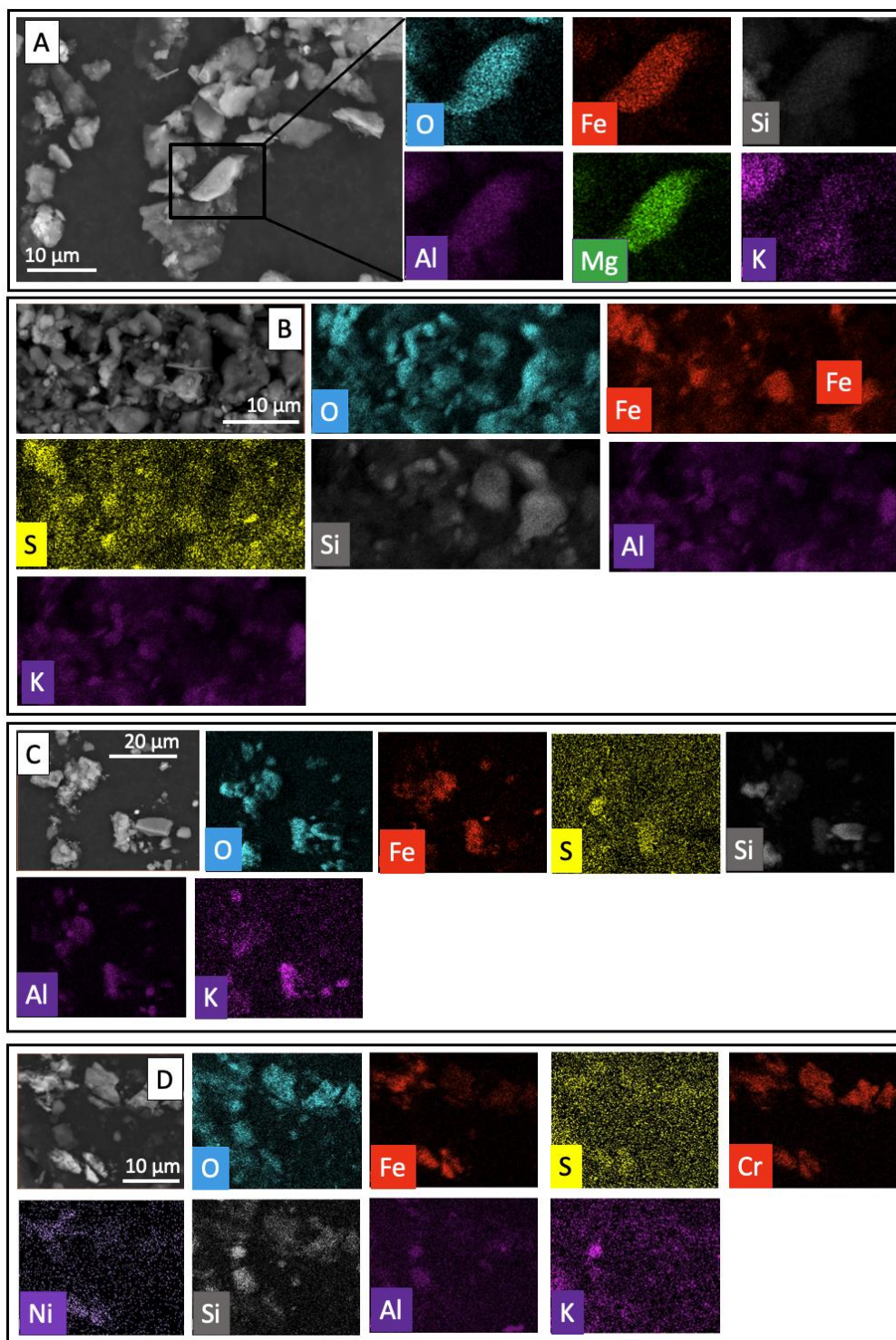


Figure S13. Representative colloids collected from bulk soil samples. Colloids were collected from spoil piles #1 (C and D), 3 (B), and 10 (A).

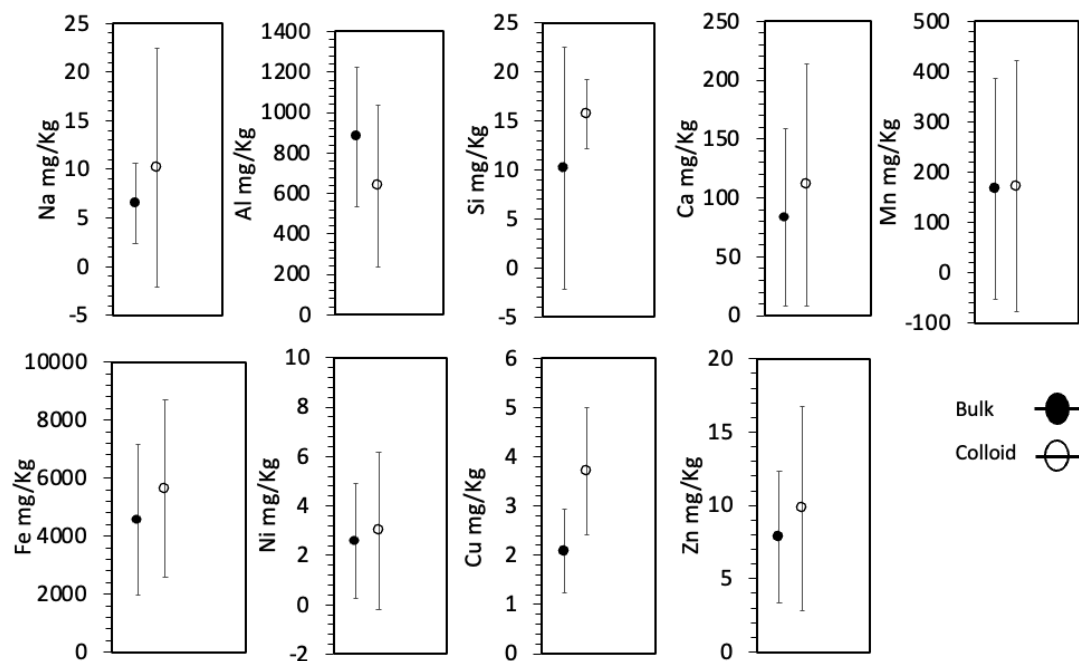


Figure S14. Average concentrations of acid extractable Na, Al, Si, Ca, Mn, Fe, Ni, Cu and Zn with standard deviations in bulk extract and colloidal extract collected from bulk mine spoil samples.

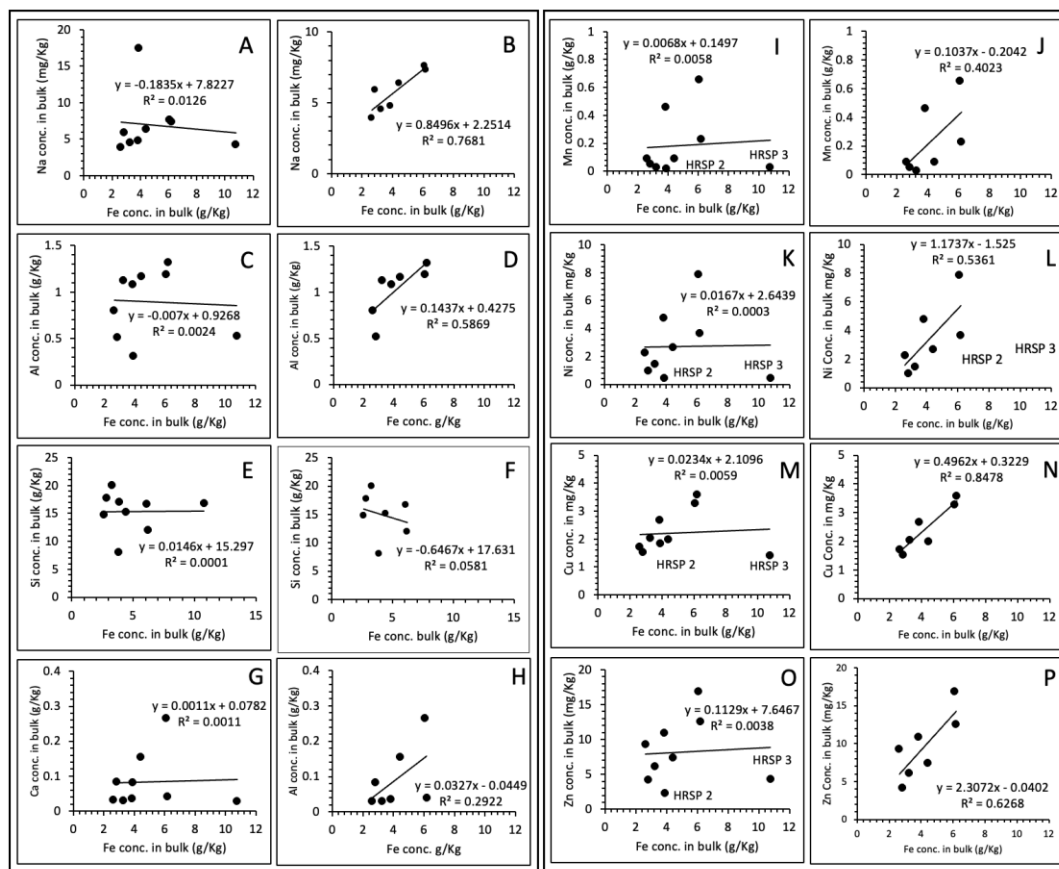


Figure S15. Relationship between acid extractable metals (Na, Al, Si, Ca, Ni, Cu, and Zn) and acid extractable Fe both in colloidal extracts collected from mine spoil samples. including Fe concentration in HRSP 2 and 3 (vertical panels A-G and I-O) and without including Fe concentration in HRSP 2 and 3 (vertical panels B-H, and J-P).

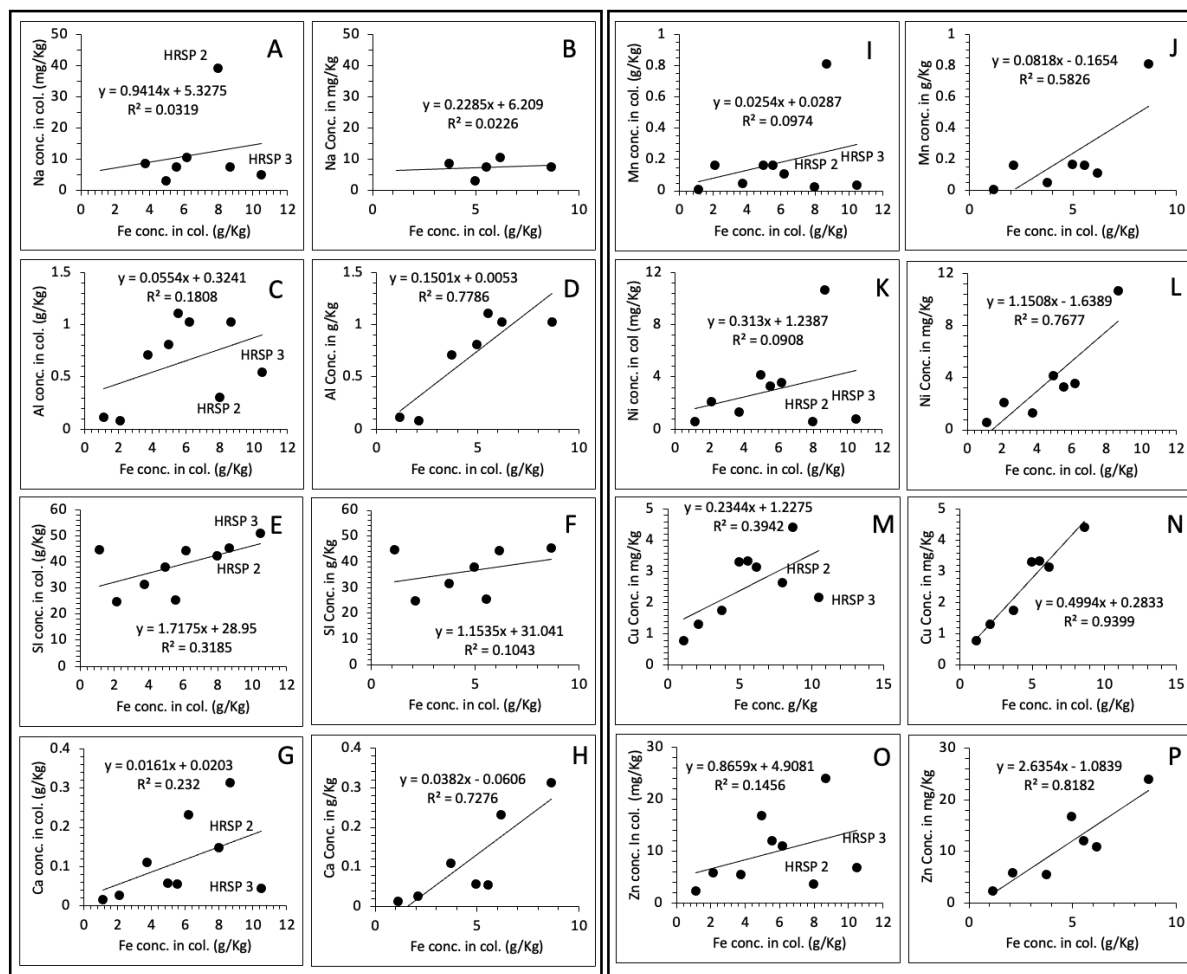


Figure S16. Relationship between acid extractable metals (Na, Al, Si, Ca, Ni, Cu, and Zn) and acid extractable Fe both in bulk extracts collected from mine spoil samples. including Fe concentration in HRSP 2 and 3 (vertical panels A-G and I-O) and without including Fe concentration in HRSP 2 and 3 (vertical panels B-H and J-P).