GSA Data Repository Item 2017148
Carmichael, S.K., Doctor, D.H., Wilson, C.G., Feierstein, J., and McAleer, R.J., 2017, New insight into the origin of manganese oxide ore deposits in the Appalachian Valley and Ridge of northeastern Tennessee and northern Virginia, USA: GSA Bulletin, doi:10.1130/B31682.1.

DATA REPOSITORY TABLES

DR File 1: sample data

DR File 2: SEM data

EDS data for Mtn City Window Appendix

USGS_EDS APPENDIX_FINAL

DR File 3: wholerockgeochem

DR File 4.

Figure DR1

for PCA analysis -wt%

Sample	Location	Lat (°N)	Long (°W)	Host Rock	Hand Sample Description	Analysis method	Confirmed Mineralogy
JC-Clay1	Mountain City Window - Mining Town Road	36.42706898	-81.83638655	Shady Dolomite	white and red laminated clay	field ID only	
JC-Clay2	Mountain City Window - Gate Hollow Road	36.4268052	-81.83558678	Shady Dolomite	contains ore float in Shady Dolomite clay residuum - red clay with Mn oxide, jasperoid float	field ID only	
JC-4A	Mountain City Window - TN Rt. 167, Radford Quarry, Butler, TN	36.38675424	-81.96293365	Erwin Formation	sugary quartzite with Fe oxide following bedding planes	powder XRD	goethite, hisingerite, schallerite(?)
JC-4B	Mountain City Window - TN Rt. 167, Radford Quarry, Butler, TN	36.38682167	-81.96285121	Erwin Formation	Fe oxides following bedding planes in sugary quartzite associated with with vein of chlorite	powder XRD, TEM-EDS	goethite, hisingerite
JC-4C	Mountain City Window - TN Rt. 167, Radford Quarry, Butler, TN	36.38675424	-81.96293365	Erwin Formation	sugary quartzite with Fe oxide following bedding planes	powder XRD, SEM-EDS, TEM-EDS	goethite, hisingerite
JC-5	Mountain City Window - TN Rt. 167, Butler Stone and Gravel Quarry, Butler, TN	36.41718298	-81.83736739	Erwin Formation	sugary quartzite with fewer Fe oxide veins than JC-4 samples, taken from top of quarry, Fe oxide vein does not follow strike/dip	field ID only	
AM-01	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	botryoidal nodule growing in clay	powder XRD, whole rock geochemistry	romanechite, Ba-rich orthoclase
DR150124-A1	Mountain City Window - US Rt. 421, parking lot across street from Shouns prospect	36.439477	-81.795763	Rome Formation	fracture fill from jasperoid breccia matrix	SEM-EDS, whole rock geochemistry	cryptomelane-hollandite solid solution; minor quartz, feldspar, and muscovite
DR150124-A2	Mountain City Window - US Rt. 421, parking lot across street from Shouns prospect	36.439134	-81.796171	Rome Formation	chert clast and rock fragments from jasperoid breccia	SEM-EDS, whole rock geochemistry	quartz, minor feldspar and mica (SEM-EDS)
DR150124-B	Mountain City Window - US Rt. 421, Shouns prospect	36.439477	-81.795763	Rome Formation	botryoidal nodule growing in clay, flat "platy" appearance	whole rock geochemistry	romanechite, K-feldspar
JC-7A	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	jasperoid breccia pod - thick (5 mm diameter) Mn oxide dendrites in breccia matrix voids	single crystal µ-XRD, TEM-EDS, TEM-ED, SEM-EDS	cryptomelane-hollandite solid solution
JC-7A inset	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	jasperoid breccia pod - interior "pellet" of Mn oxide came out of geode lined with quartz crystals upon cutting. Numerous similar pellets within geodes in single hand sample.	powder XRD, TEM-EDS, TEM-ED, SEM-EDS	cryptomelane-hollandite solid solution
JC-7B	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	botryoidal nodule growing in clay	powder XRD, single crystal µ-XRD, TEM-EDS, TEM-ED, SEM-EDS, whole rock	romanechite, Ba-rich orthoclase
JC-7C	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	Mn oxide shrub in jasperoid breccia matrix void	powder XRD, single crystal µ-XRD, TEM-EDS, TEM-ED, SEM-EDS, whole rock	cryptomelane-hollandite solid solution, goethite
JC-7D	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	wrinkled 5 mm thick sheet of Mn oxide filling in joints and bedding planes	powder XRD, single crystal µ-XRD, TEM-EDS, TEM-ED, SEM-EDS	cryptomelane-hollandite solid solution
JC-7E	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	wrinkled sheets of Mn oxide filling in joints and bedding planes	field ID only	
JC-7F	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	dendrites and coatings from red shale, N of jasperoid pod	field ID only	
JC-7G	Mountain City Window - US Rt. 421, Shouns prospect	36.33934201	-81.53323949	Rome Formation	jasperoid breccia pod - thick (5 mm diameter) Mn oxide dendrites in breccia matrix voids	SEM-EDS	cryptomelane-hollandite solid solution
JC-7H	Mountain City Window - US Rt. 421, Shouns prospect	36.34569973	-81.48430567	Rome Formation	jasperoid breccia pod - porous Fe-oxide filaments	powder XRD, TEM-EDS, TEM-ED, SEM-EDS, FIB-EM	goethite
JC-8A	Mountain City Window - Mining Town Road	36.34569974	-81.48430568	Shady Dolomite	clay matrix, crumbly, brown/yellow with lots of jasperoid, brecciated goethite (some Mn?) in clasts.	field ID only	
JC-8B	Mountain City Window - Mining Town Road	36.34569974	-81.48430568	Shady Dolomite	clay matrix, crumbly, brown/yellow with lots of jasperoid, brecciated goethite (some Mn?) in clasts.	field ID only	
JC-9A	Mountain City Window - Mining Town Road	36.37294963	-81.7464023	Shady Dolomite	bedded claystone, mudstone with laminated Fe-rich ore	field ID only	
JC-9B	Mountain City Window - Mining Town Road	36.37294963	-81.7464023	Shady Dolomite	bedded claystone, mudstone with laminated Fe-rich ore; darker samples	field ID only	
JC-10A	Mountain City Window - Mining Town Road (on private property)	36.42254518	-81.82409458	Shady Dolomite	anticline containing substantial Fe oxide ore, mix of laminations and "frothy" textures, some Cu green staining on frothy area	powder XRD, whole rock geochemistry	goethite
JC-10B	Mountain City Window - Mining Town Road (on private property)	36.42254518	-81.82409458	Shady Dolomite	anticline containing substantial Fe oxide ore, mix of laminations and "frothy" textures, some Cu green staining on frothy area	field ID only	

JC-10C	Mountain City Window - Mining Town Road (on private property)	36.42254518	-81.82409458	Shady Dolomite	anticline containing substantial Fe oxide ore, mix of laminations and "frothy" textures, some Cu green staining on frothy area	field ID only	
JC-10D	Mountain City Window - Mining Town Road (on private property)	36.42254518	-81.82409458	Shady Dolomite	anticline containing substantial Fe oxide ore, mix of laminations and "frothy" textures, some Cu green staining on frothy area	field ID only	
JC-10E	Mountain City Window - Mining Town Road (on private property)	36.42254518	-81.82409458	Shady Dolomite	brecciated sample, Fe-rich, many reaction rims	field ID only	
JC-11A	Mountain City Window - Mining Town Road	36.42706898	-81.83638655	Shady Dolomite	breccia with matrix of Fe and Mn oxides, in appearance to sample SH-2	field ID only	
JC-12	Mountain City Window - Mining Town Road	36.426967	-81.840133	Shady Dolomite	Mn nodules on side of road in ditch, form dendrites (macro scale ~ 10 cm dendrite pattern), embedded in clay.	field ID only	
JC-13	Mountain City Window - Gate Hollow Road	36.4268052	-81.83558678	Shady Dolomite	jasperoid breccia sample - unaltered Shady outcrop next to brecciated jasperoid and some Mn, Fe oxide ore blocks.	field ID only	
JC-14	Mountain City Window - Gate Hollow Road	36.4268052	-81.83558678	Shady Dolomite	ore float in Shady Dolomite residuum - red clay with Mn oxide, jasperoid float	field ID only	
JC-15A	Mountain City Window - Mine Ridge Road	36.42611918	-81.8333998	Shady Dolomite	breccia sample: mix of bulk nodules on jasperoid, breccia matrix ore. Mostly Mn (no yellow or red staining), only black and brown rock/clay. White cherty areas in contact with jasperoid, both chert and jasperoid are associated with Mn oxidation.	field ID only	
JC-15B	Mountain City Window - Mine Ridge Road	36.42611918	-81.8333998	Shady Dolomite	large nodule on curved jasperoid: mix of bulk nodules on jasperoid, breccia matrix ore. Mostly Mn (no yellow or red staining), only black and brown rock/clay. White cherty areas in contact with jasperoid, both chert and jasperoid are associated with Mn oxidation.	field ID only	
JC-15C	Mountain City Window - Mine Ridge Road	36.42611918	-81.8333998	Shady Dolomite	euhedral quartz crystals with Mn oxides (appears to be part of geode): mix of bulk nodules on jasperoid, breccia matrix ore. Mostly Mn (no yellow or red staining), only black and brown rock/clay. White cherty areas in contact with jasperoid, both chert and jasperoid are associated with Mn oxidation.	field ID only	
SH-1	Mountain City Window - Ruritan Club ditch - TN Rt. 133, Shady Valley, TN	36.52895	-81.909042	Erwin Formation	thin dendrites (1 mm diameter), form complex anastomizing network along quartzite samples surfaces	single crystal μ-XRD, TEM-EDS, TEM-ED, SEM-EDS	hollandite-cryptomelane series
SH-2	Mountain City Window - TN Rt. 167, Butler Stone and Gravel Quarry, Butler, TN	36.384012°	-81.946124°	Erwin Formation	Mn oxide forms breccia matrix in quartzite	powder XRD, SEM-EDS, whole rock geochemistry	romanechite, goethite
DRBYC-646	Shenandoah Valley - Va. Rt. 638, Howellsville Road (on private property)	39.019281°	-78.024100°	Antietam Formation	quartzite breccia matrix, well-formed crystals of cryptomelane/hollandite solid solution form cement between quartzite breccia clasts	SEM-EDS, whole rock geochemistry	cryptomelane-hollandite solid solution
K130618-A	Shenandoah Valley - Va. Rt. 638, Howellsville Road (on private property)	39.019281°	-78.024100°	Antietam Formation	Well-formed crystals form cement between quartzite breccia clasts. Botryoidal fracture coating.	powder XRD, whole rock geochemistry	cryptomelane-hollandite solid solution
K130618-B	Shenandoah Valley - Va. Rt. 638, Howellsville Road (on private property)	39.019281°	-78.024100°	Antietam Formation	Well-formed crystals form cement between quartzite breccia clasts. Botryoidal fracture coating.	SEM-EDS, powder XRD, whole rock geochemistry	cryptomelane-hollandite solid solution
K130618-C	Shenandoah Valley - quarry at Howellsville Road and Heavens Tree Trail	38.995568°	-78.058470°	Antietam Formation	Mn oxide forms breccia matrix in quartzite	whole rock geochemistry	cryptomelane-hollandite solid solution
K130712-A	Shenandoah Valley - Stanley Mine	38.559980°	-78.510960°	Antietam Formation, near contact with Waynesboro Formation	nodules of Mn-oxide formed in clay, float on surface of landfill and quarry site	SEM-EDS, powder XRD, whole rock geochemistry	mutli-phase MnO (cryptomelane, lithiophorite, other?), feldspar, quartz, micas
K130712-B	Shenandoah Valley - Stanley Mine	38.559980°	-78.510960°	Antietam Formation, near contact with Waynesboro Formation	nodules of Mn-oxide formed in clay, float on surface of landfill and quarry site	SEM-EDS, whole rock geochemistry	mutli-phase MnO (cryptomelane, lithiophorite, other?), feldspar, quartz, micas
K130712-B2	Shenandoah Valley - Stanley Mine	38.559980°	-78.510960°	Antietam Formation, near contact with Waynesboro Formation	nodules of Mn-oxide formed in clay, float on surface of landfill and quarry site	SEM-EDS, whole rock geochemistry	mutli-phase MnO (cryptomelane, lithiophorite, other?), feldspar, quartz, micas

K130712-C1	Shenandoah Valley - Compton Mine bedrock sample	38.769607°	-78.357938°	Tomstown Dolomite/Waynesboro Formation, near contact with Antietam Formation	well-formed bluish-black crystals on fracture surface in quartzite breccia	whole rock geochemistry	cryptomelane-hollandite solid solution (XRD)
K130712-C2	Shenandoah Valley - Compton Mine bedrock sample	38.769607°	-78.357938°	Tomstown Dolomite/Waynesboro Formation, near contact with Antietam Formation	well-formed crystals in black cement coating quartzite breccia clasts	--	cryptomelane-hollandite solid solution
DR150417-A	Shenandoah Valley - Lyndhurst mine spoil pile, approximately .025 km south of Inch Branch in George Washington and Jefferson National Forest (Glenwood and Pedlar Ranger District)	38.012098°	-78.931256°	Antietam Formation	quartzite breccia matrix, float from mine pit, with botryoidal MnO surrounding clasts	SEM-EDS, powder XRD, whole rock geochemistry	cryptomelane-hollandite solid solution; minor quartz, feldspar, and muscovite
DR150417-B	Shenandoah Valley - Lyndhurst mine spoil pile, approximately .025 km south of Inch Branch in George Washington and Jefferson National Forest (Glenwood and Pedlar Ranger District)	38.012098°	-78.931256°	Antietam Formation	quartzite breccia matrix, float from mine pit, with botryoidal MnO surrounding clasts	SEM-EDS, powder XRD, whole rock geochemistry	cryptomelane-hollandite solid solution; minor quartz, feldspar, and muscovite

EDS data for Figures 7, 8, and 9 (Mountain City Window samples)

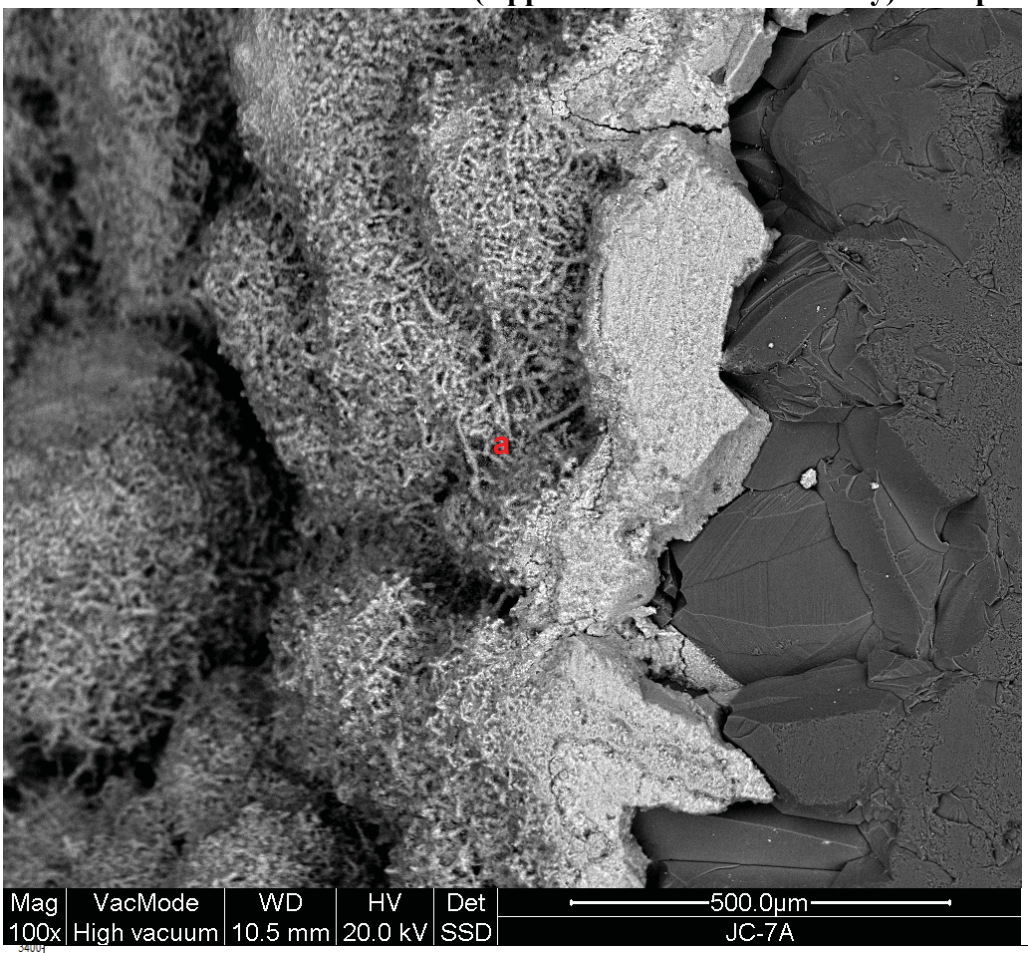
All Mountain City Window SEM-EDS data were collected at Appalachian State University on a FEI Quanta 200 Environmental SEM with a Si-Li EDS detector, or at the Smithsonian National Museum of Natural History on a FEI Nova NanoSEM 600 SEM equipped with a ThermoFisher silicon drift EDS detector (SDD)

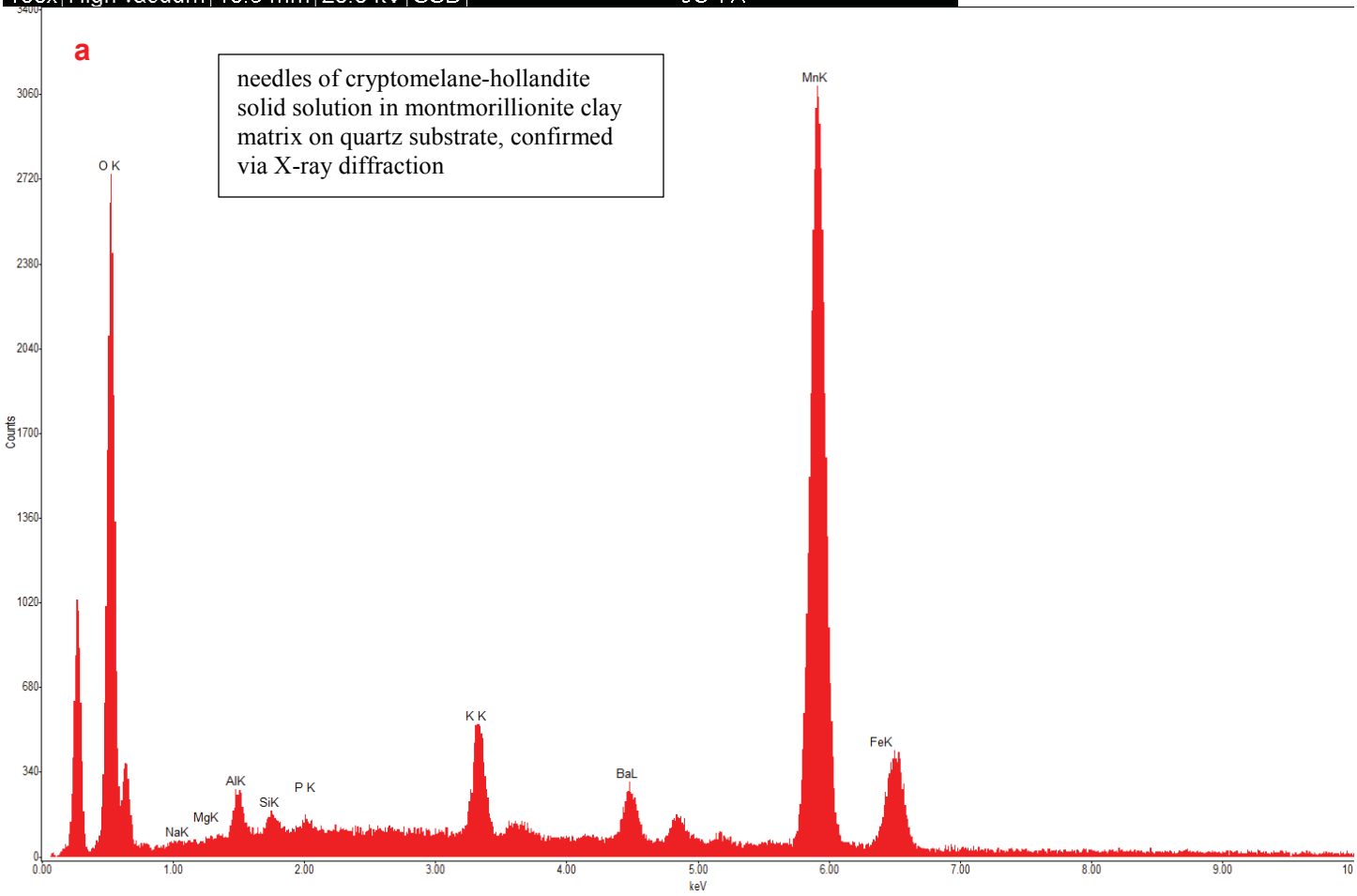
Samples were carbon coated and examined under high vacuum at an accelerating voltage of 20kV (FEI Quanta 200 ESEM) or 15kV (FEI Nova NanoSEM 600) and a working distance of ~10 mm (working distance for maximum collection efficiency on the EDS detectors).

Peak identification was done by the EDAX software. EDS analyses were used in a qualitative capacity for phase identification and to document major element variations (e.g. Mn vs. Fe) that resulted in observed brightness variations in manganese and iron oxide minerals in backscatter electron images.

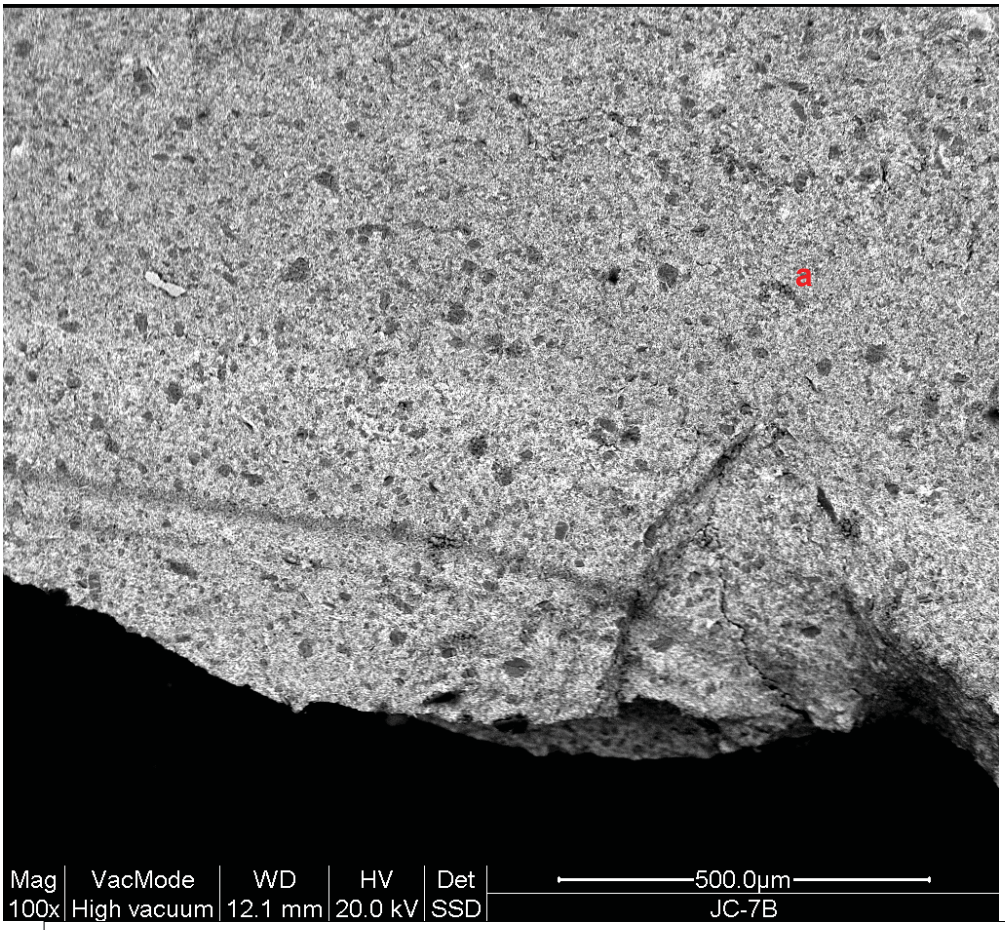
Provided here is a subset of EDS analyses with annotation. We emphasize that these spectra were used in a qualitative capacity only. All sample mineralogy was confirmed via powder or single crystal X-ray diffraction.

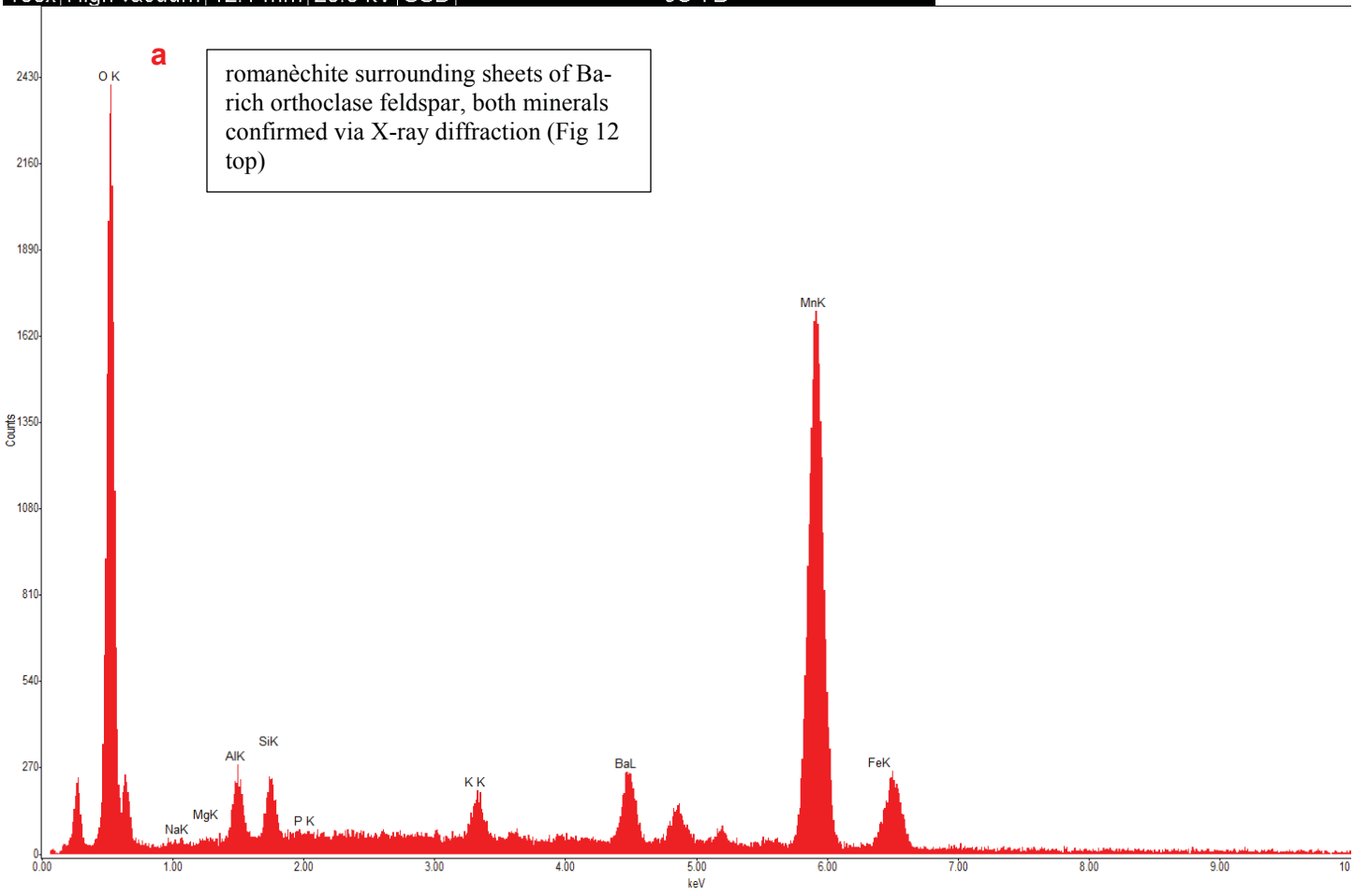
Associated SEM-EDS data (Appalachian State University): Sample JC-7A (Fig 4D, 7C, 7D)



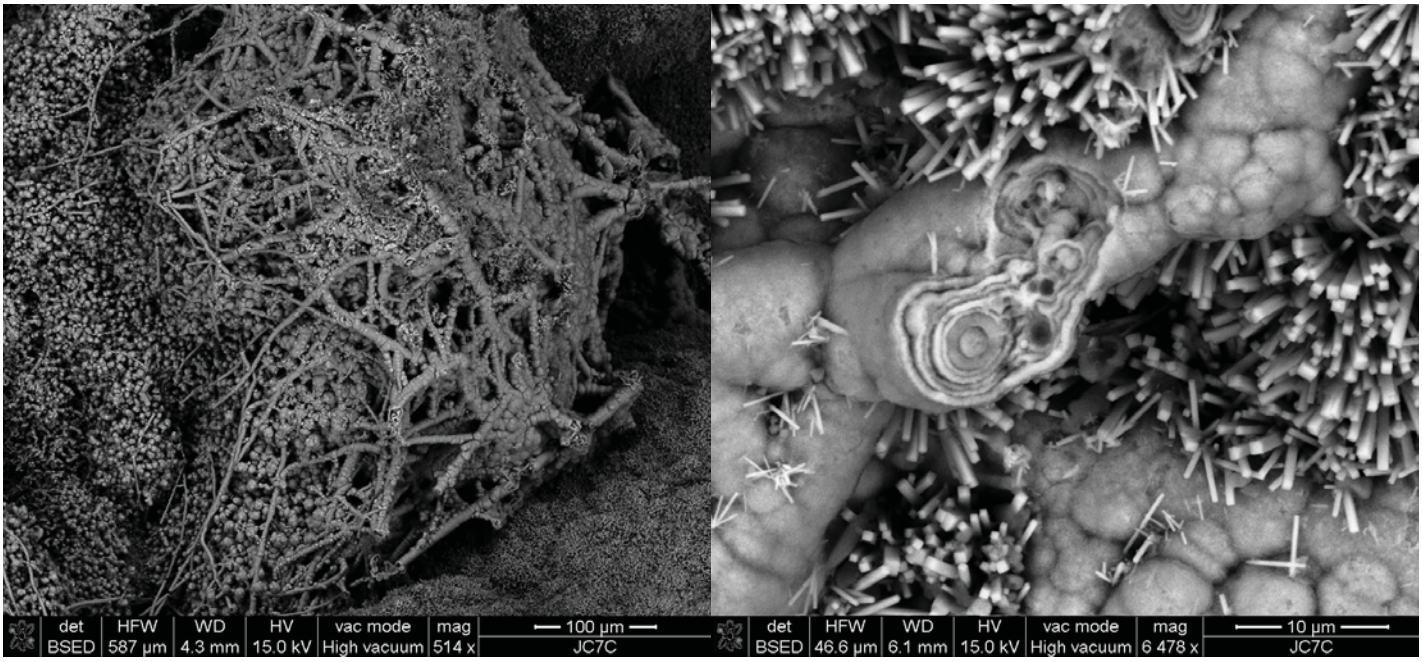


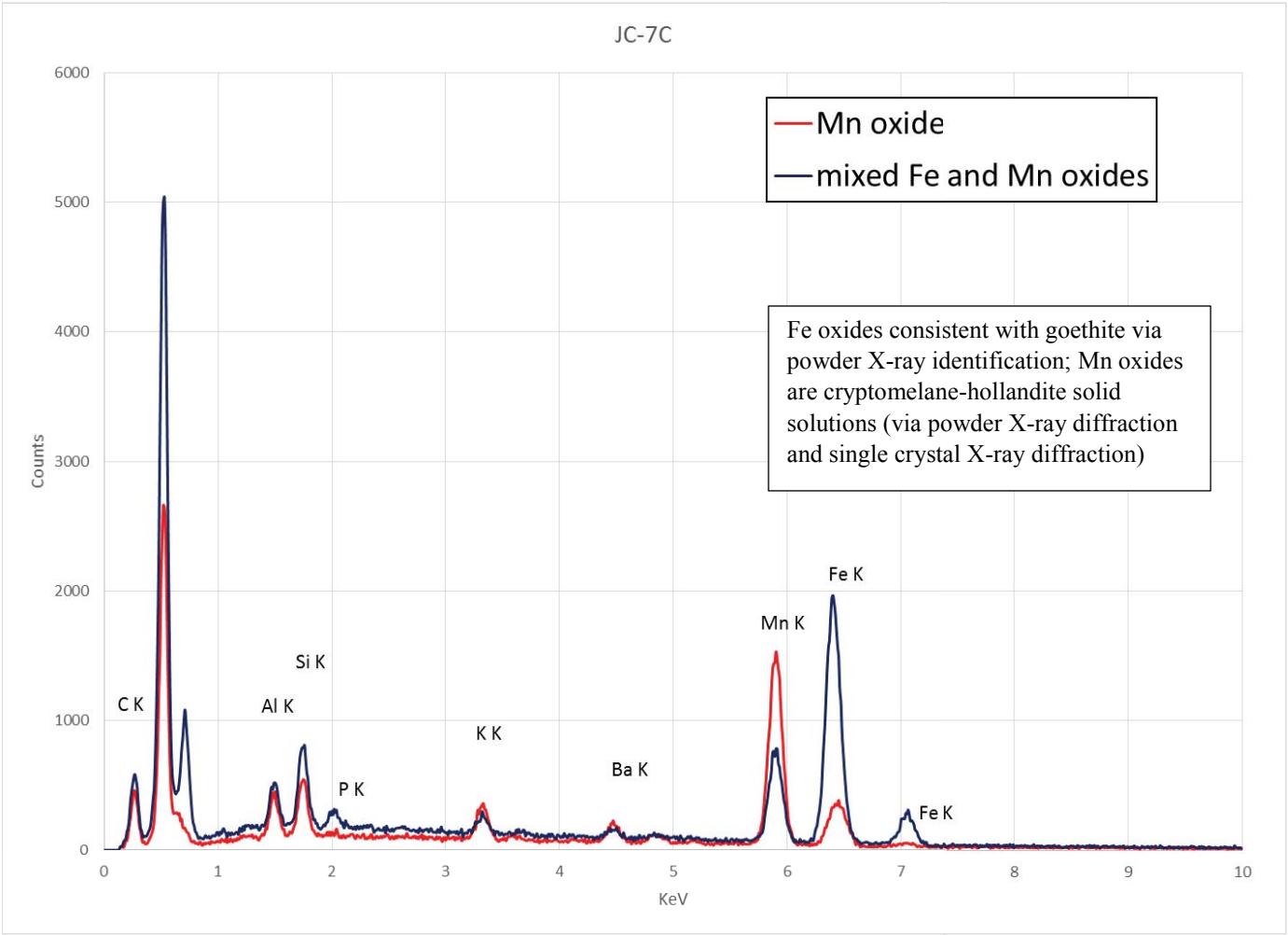
Associated SEM-EDS data (Appalachian State University): Sample JC-7B (Fig 4H, 9A, 9B)



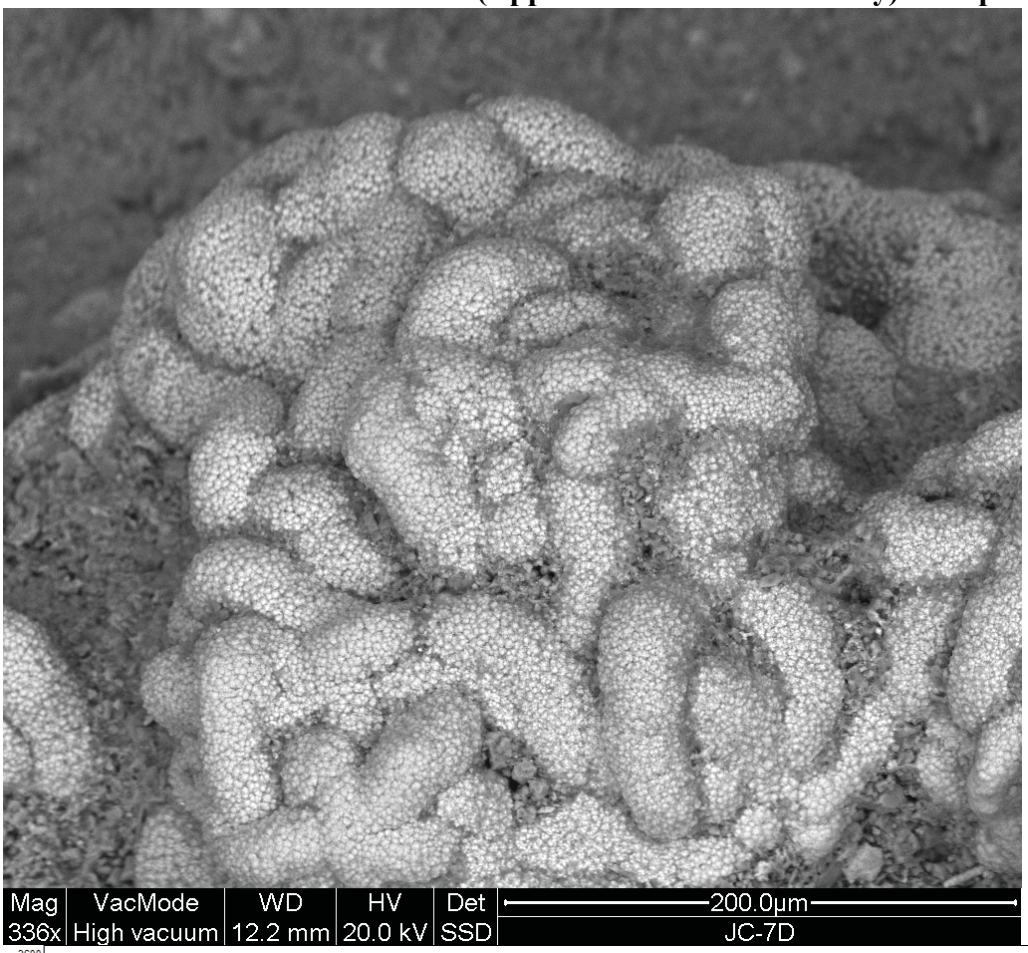


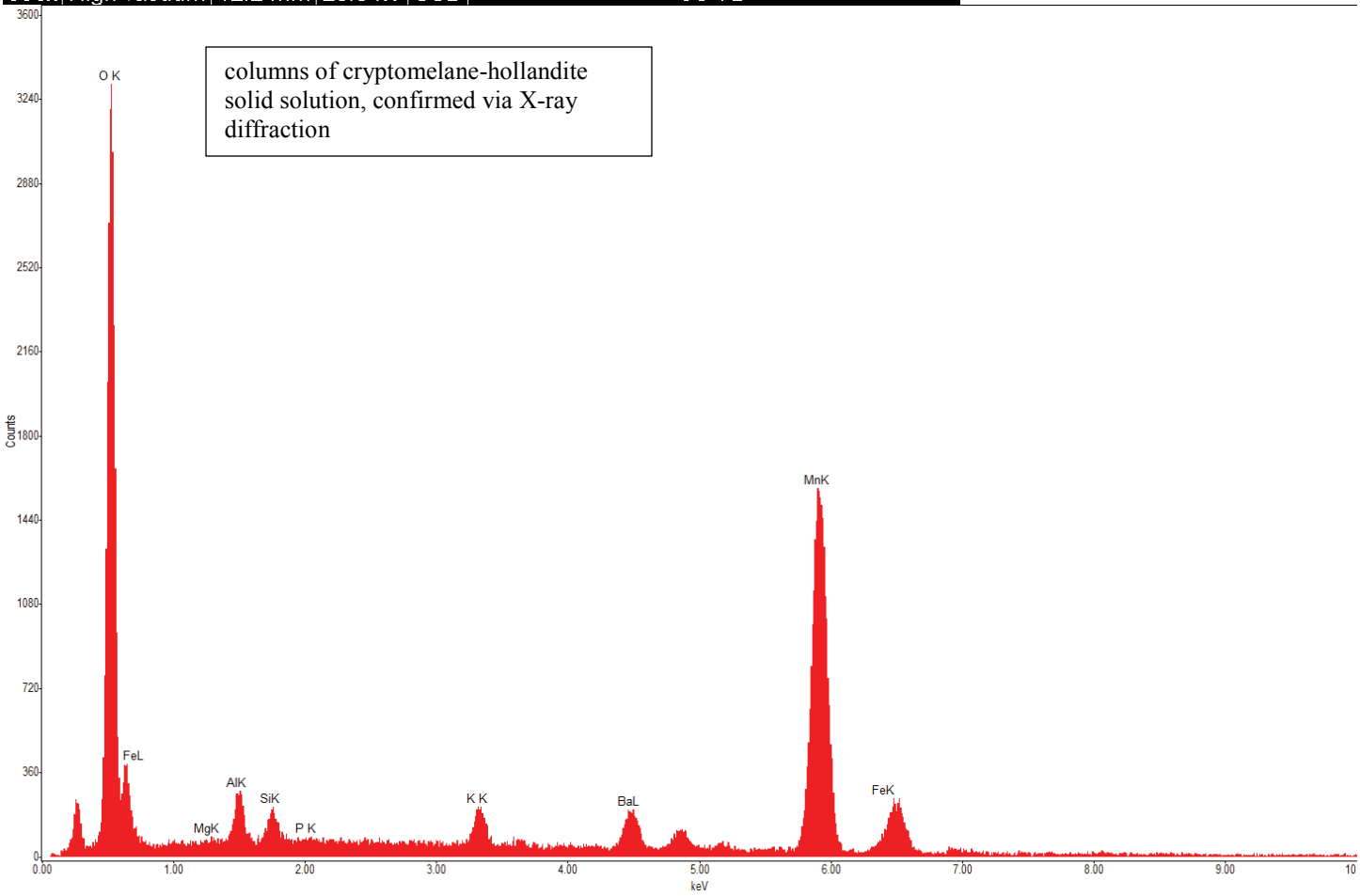
Associated SEM-EDS data (Smithsonian Mineral Sciences): Sample JC-7C (Fig 4G, 8A, 8B)



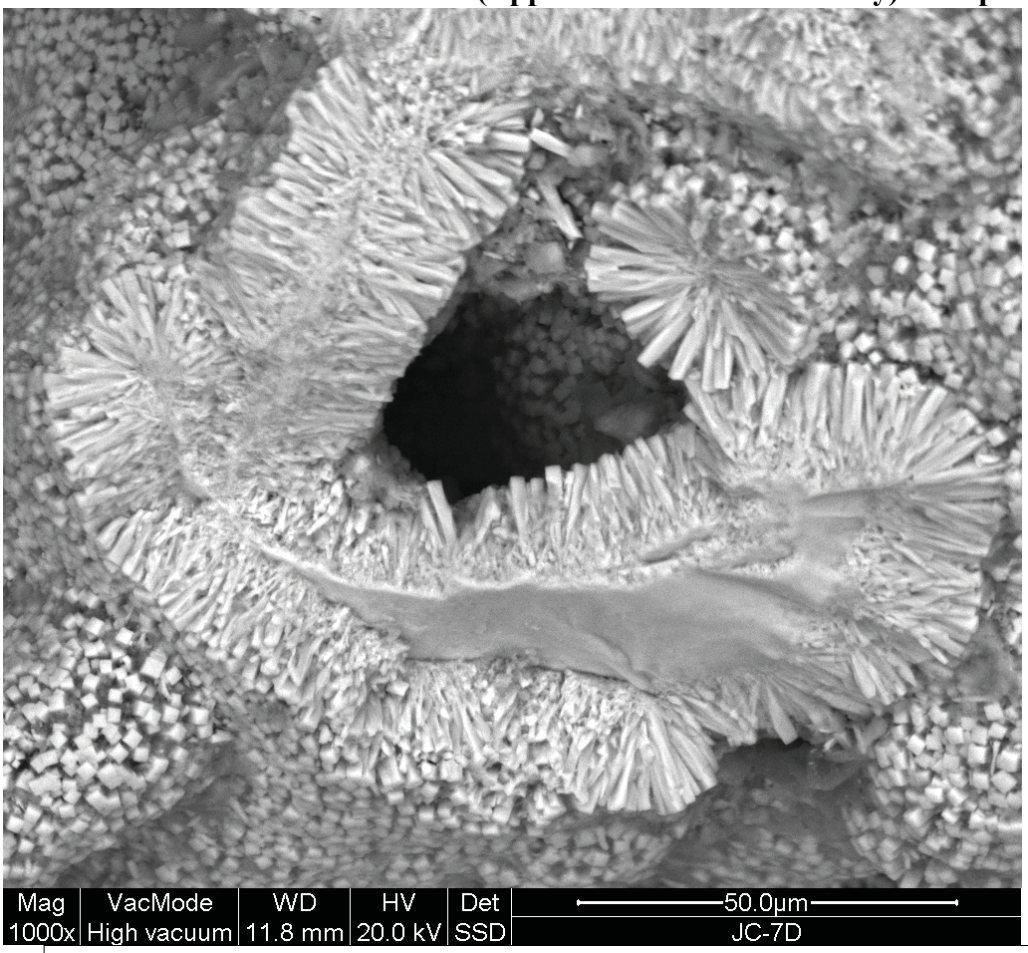


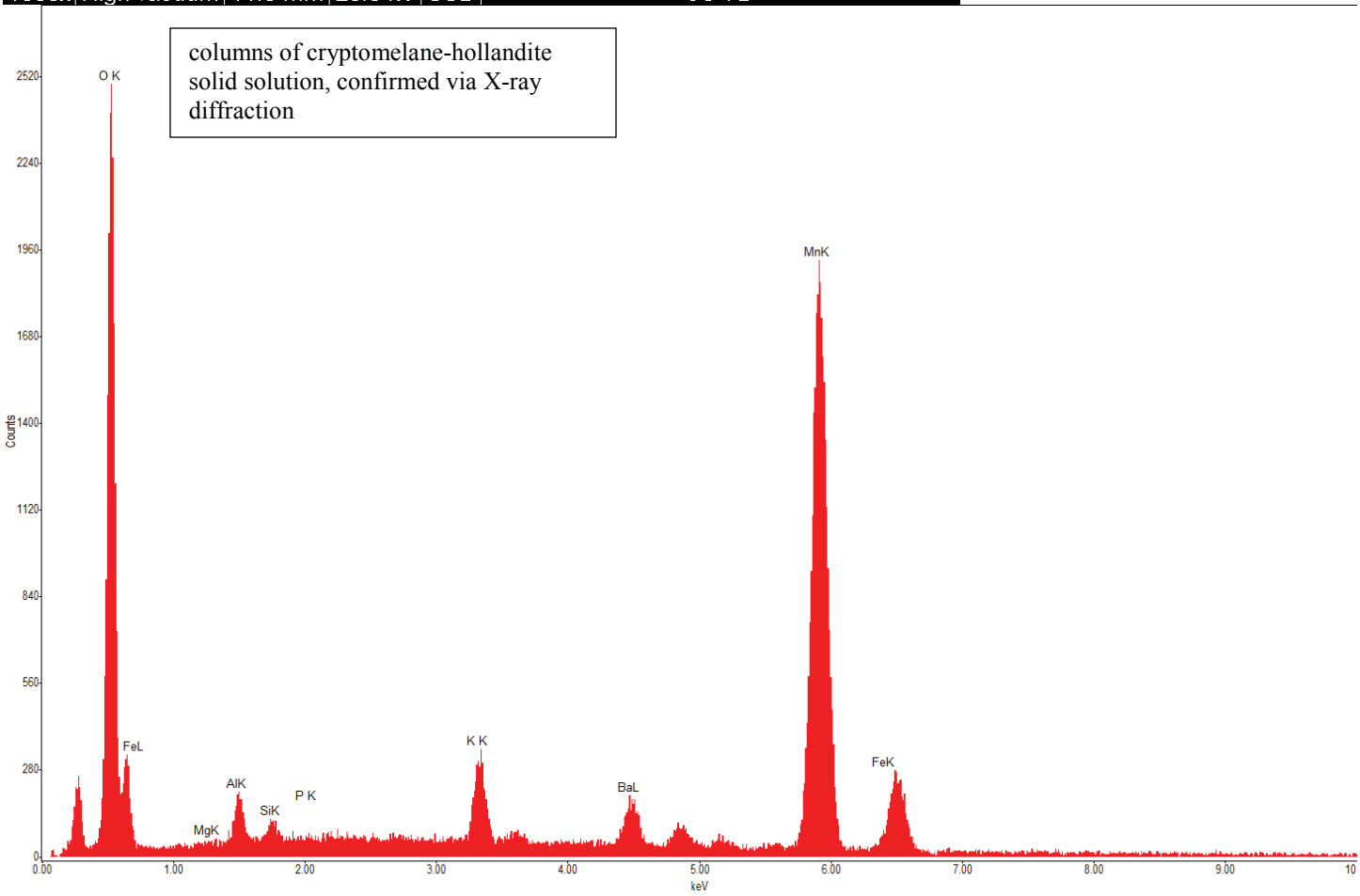
Associated SEM-EDS data (Appalachian State University): Sample JC-7D (Fig 4C, 7E, 7F)





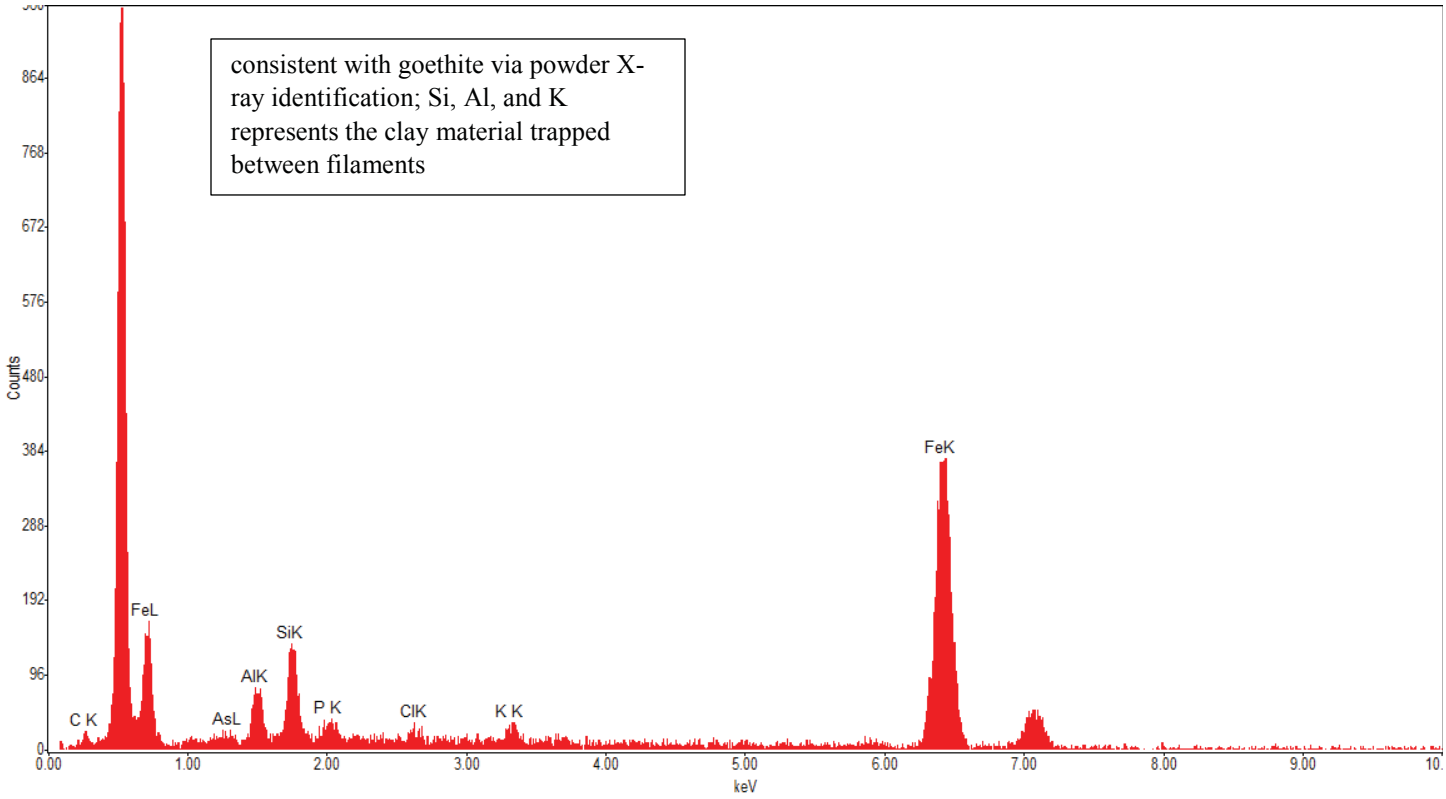
Associated SEM-EDS data (Appalachian State University): Sample JC-7D (Fig 4C, 7E, 7F)





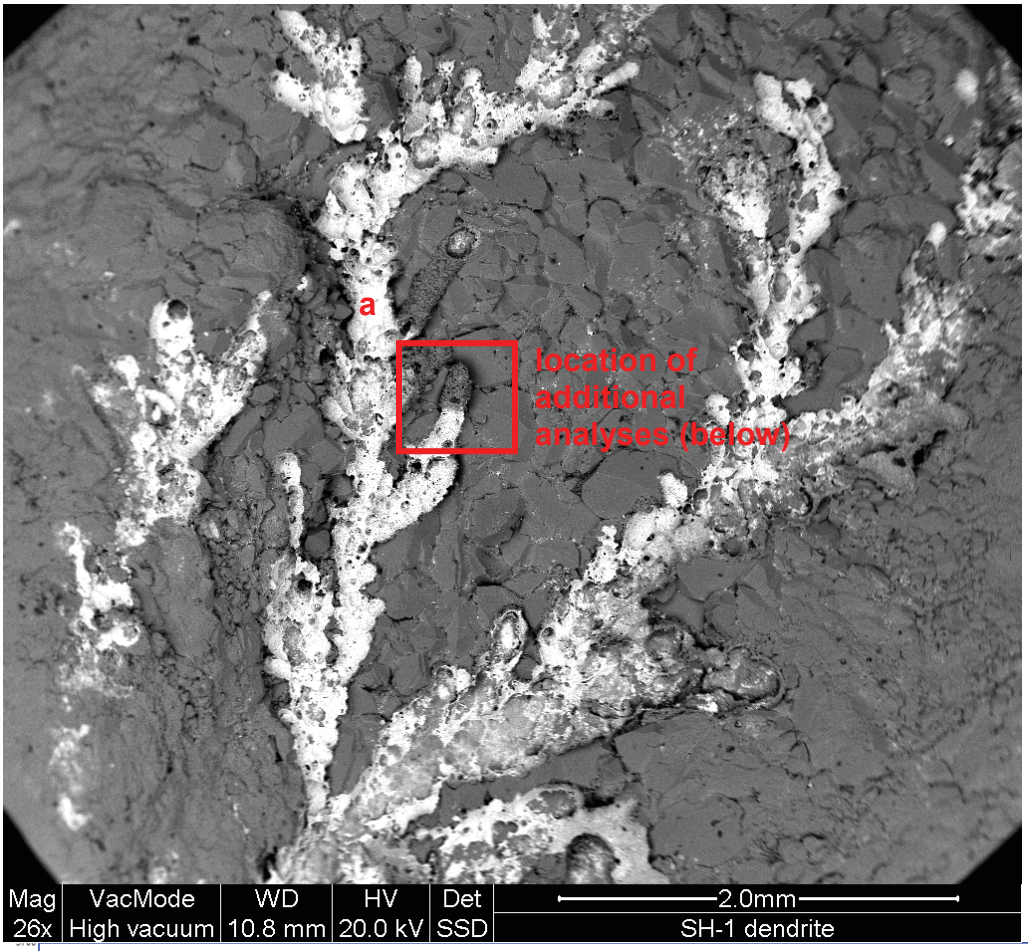
Associated SEM-EDS data (Appalachian State University): Sample JC-7H (Fig 8C, 8D, 8E)

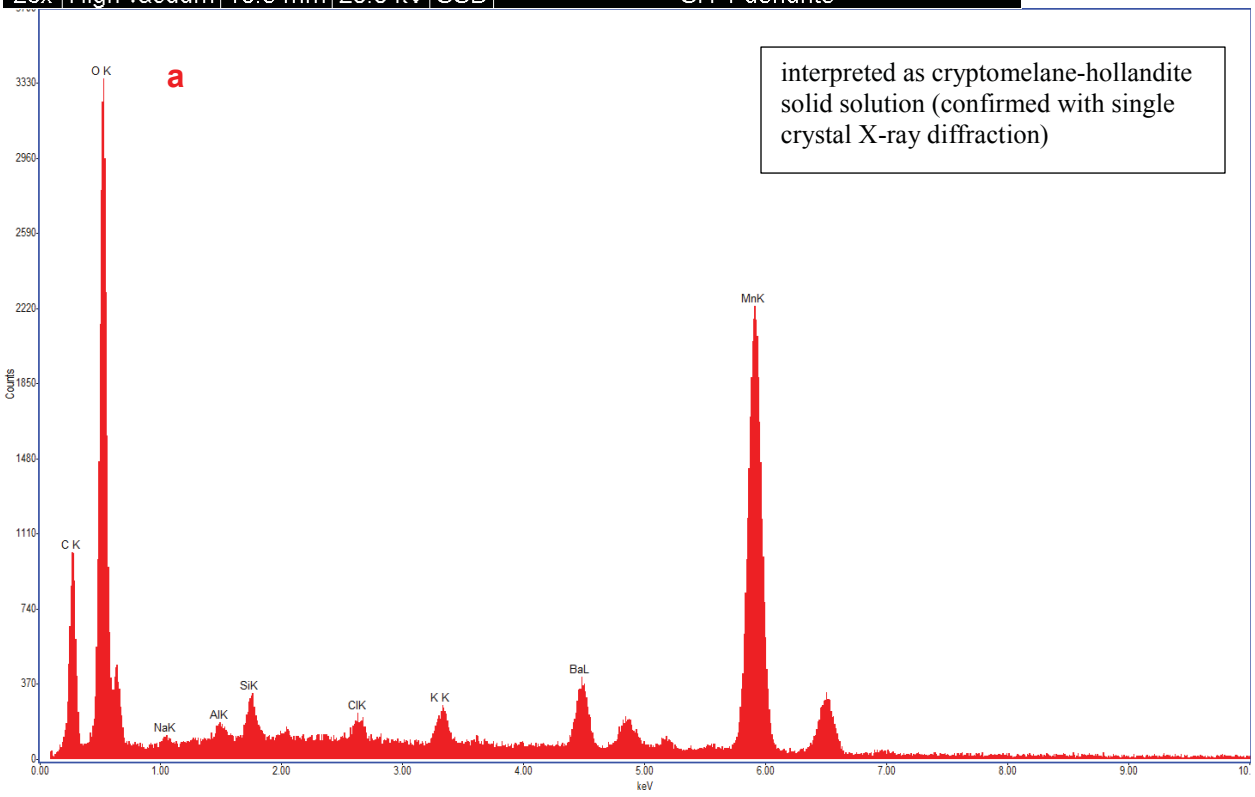
piece of this sample later used for FIB ablation; original SEM image of sample to left, EDS spectra shown below.



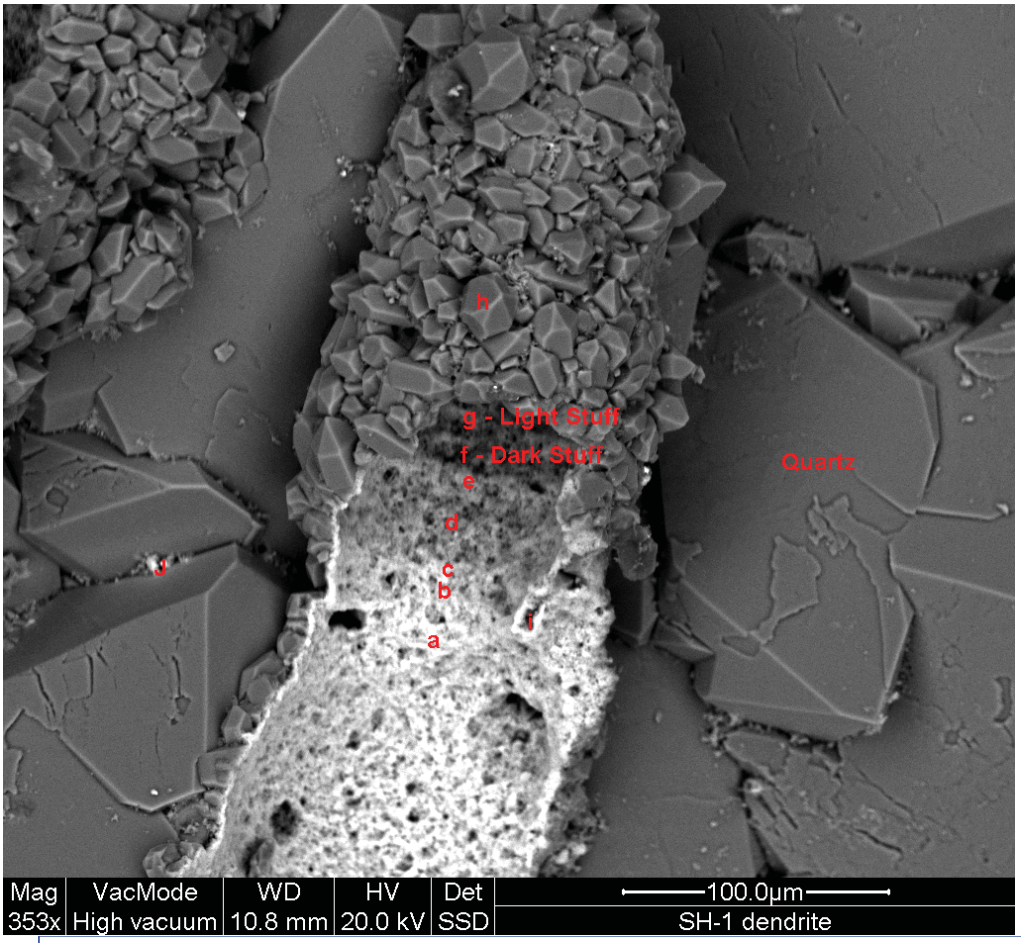
consistent with goethite via powder X-ray identification; Si, Al, and K represents the clay material trapped between filaments

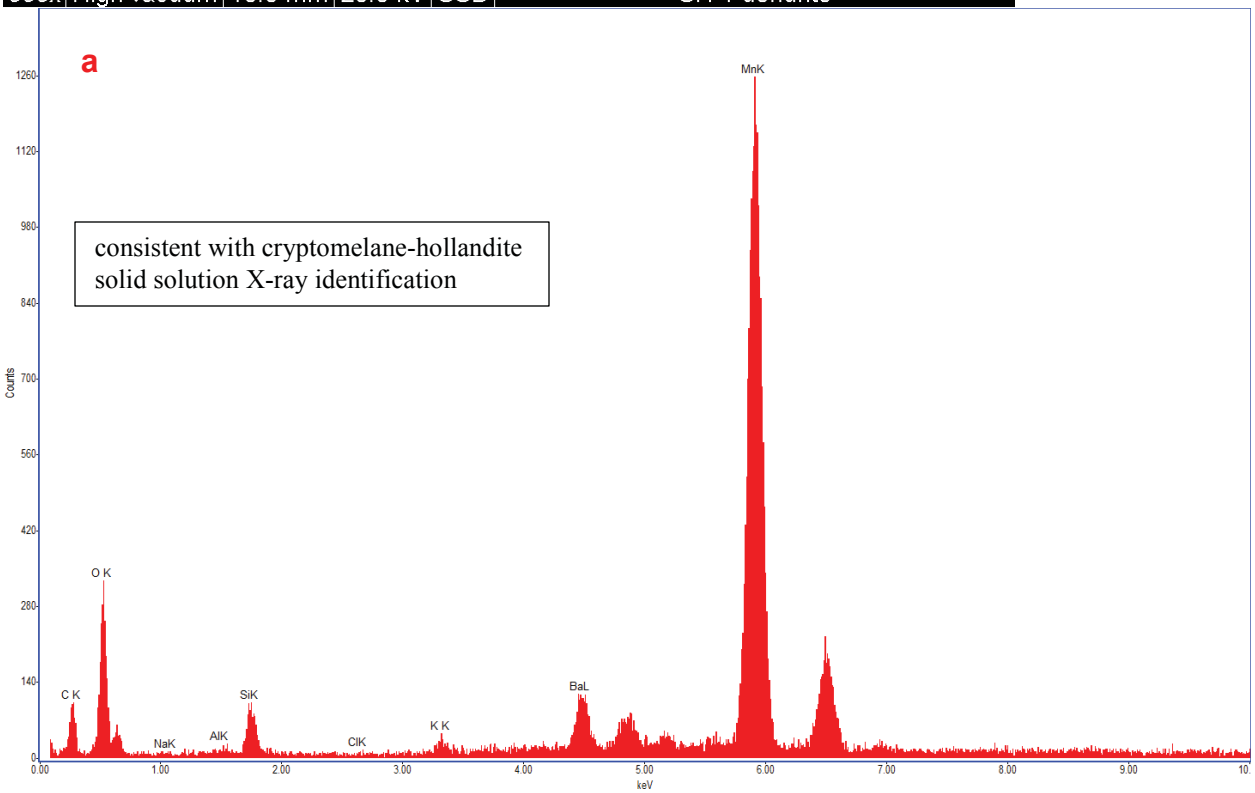
Associated SEM-EDS data (Appalachian State University): Sample SH-1 (Fig 5D, 7A, 7B)





Associated SEM-EDS data (Appalachian State University): Sample SH-1 (Fig 5D, 7A, 7B)





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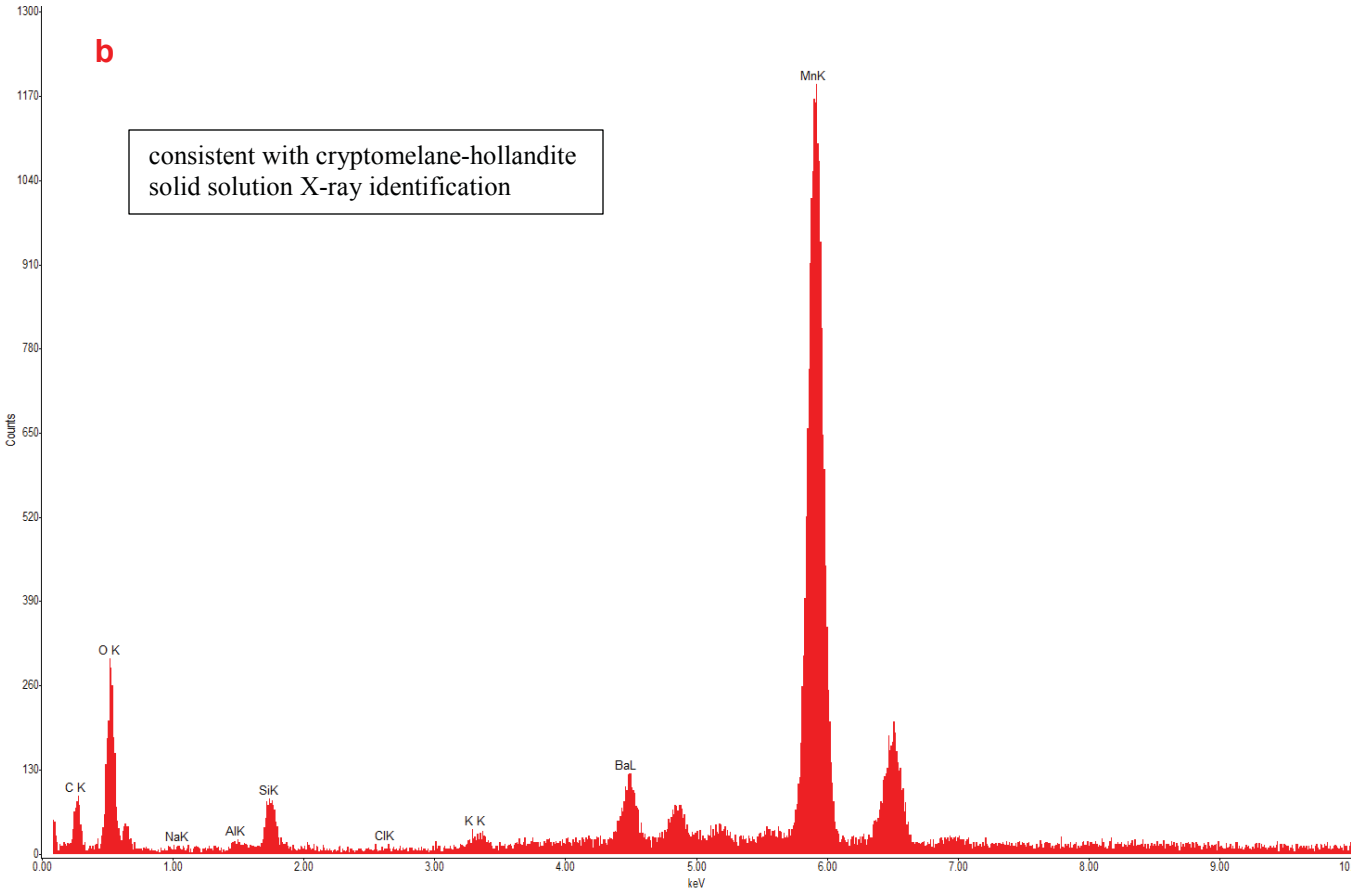
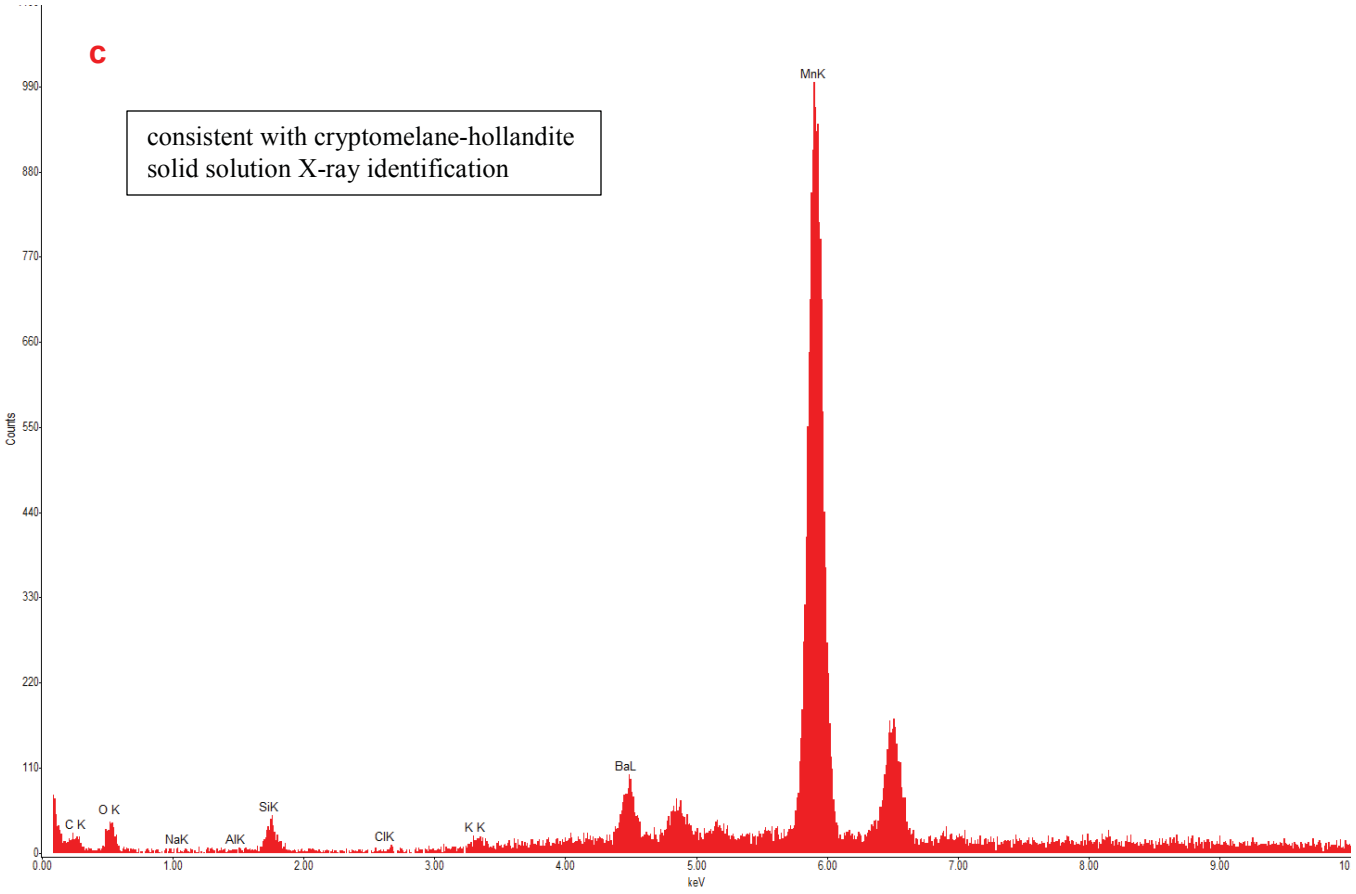
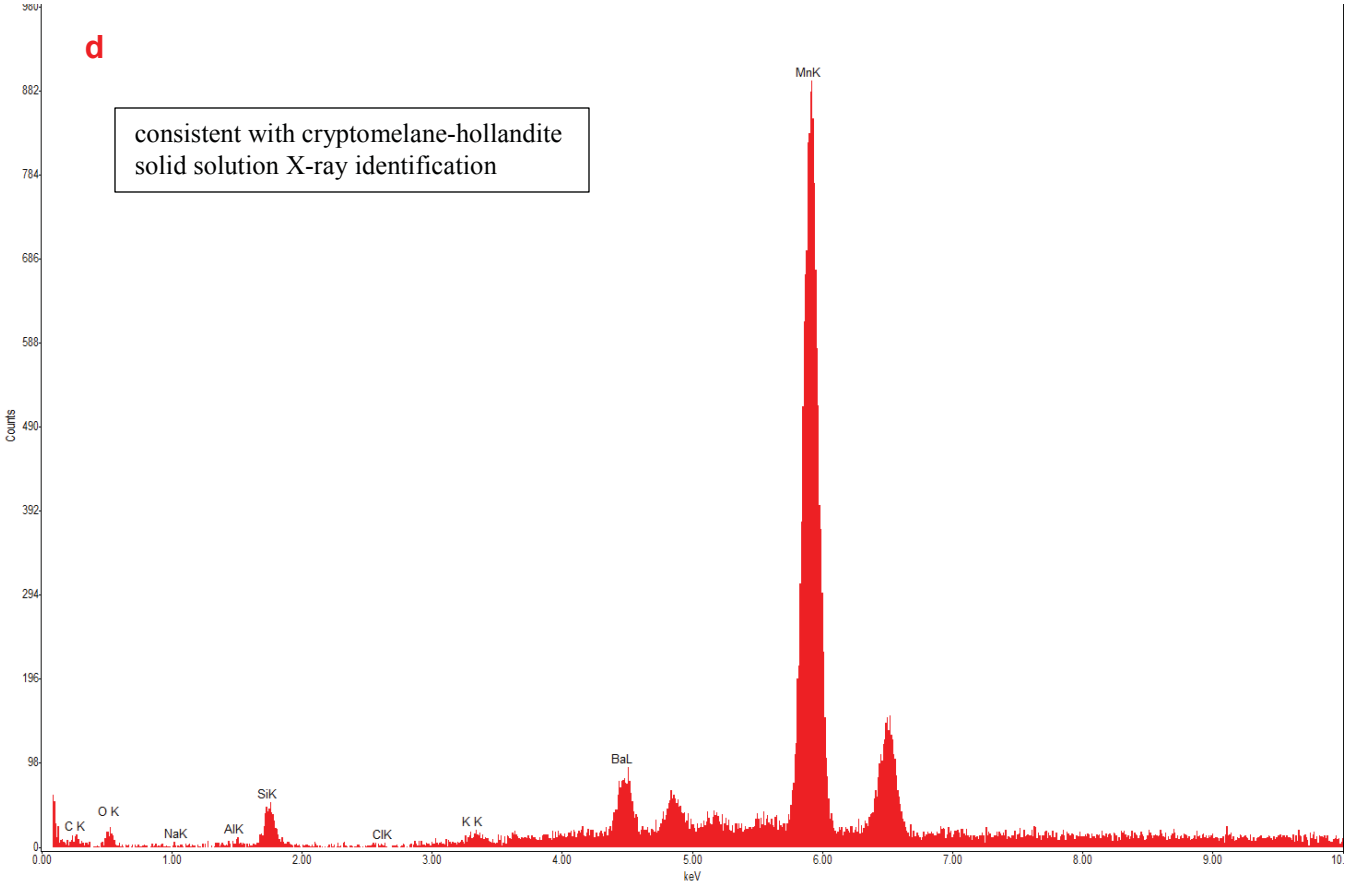
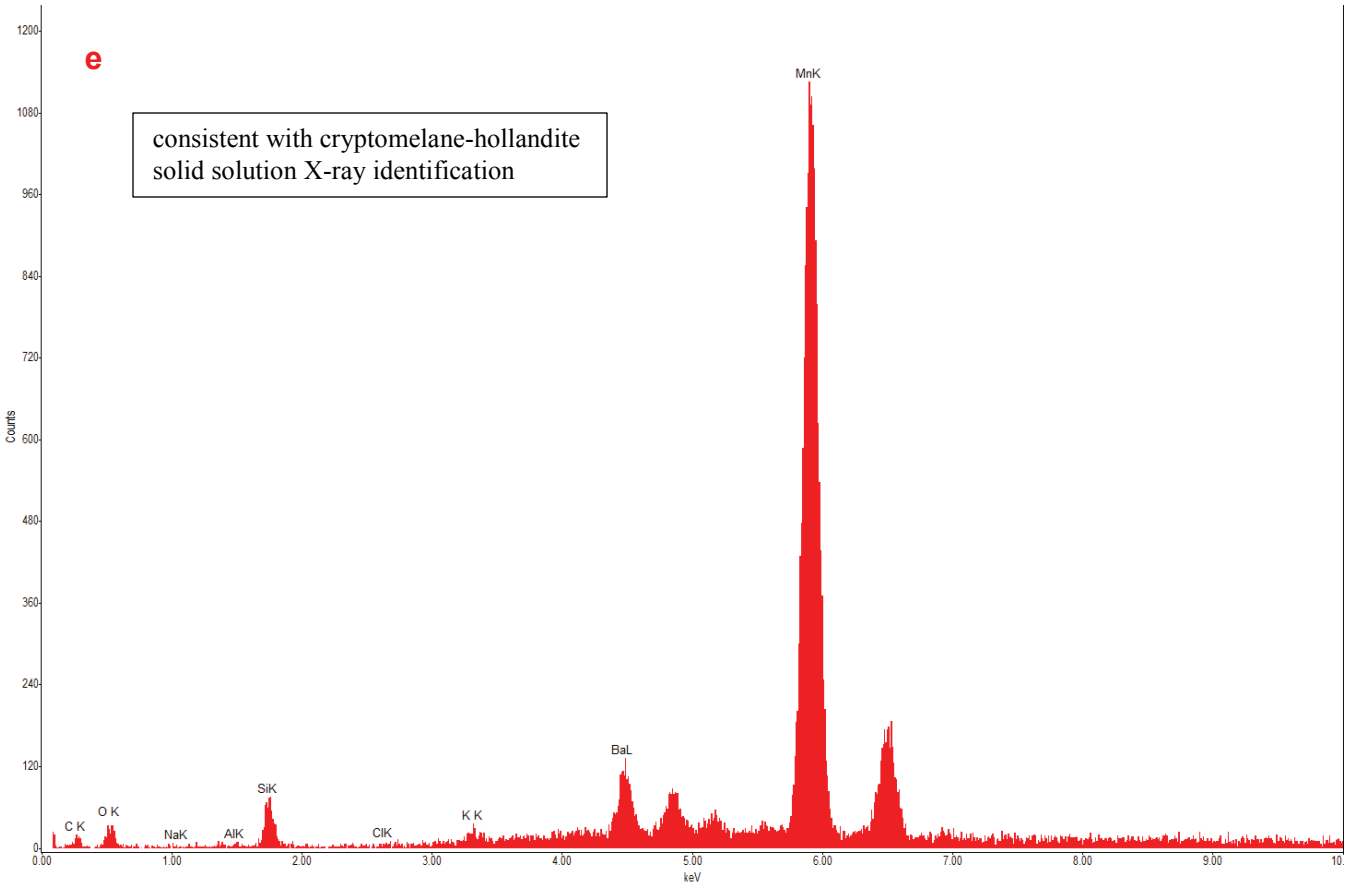




Associated SEM-EDS data (Appalachian State University): Sample SH-1 (Fig 5D, 7A, 7B)





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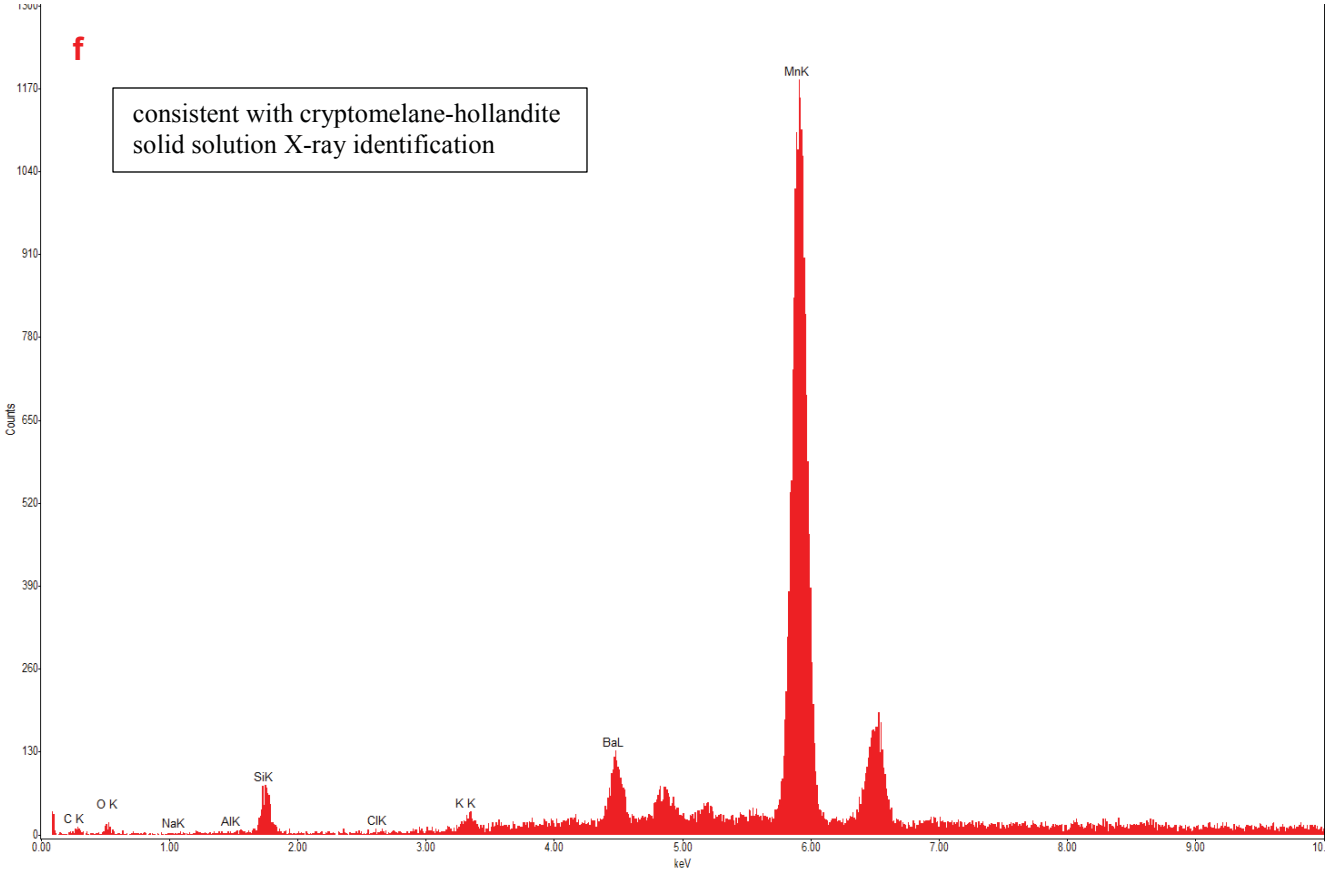
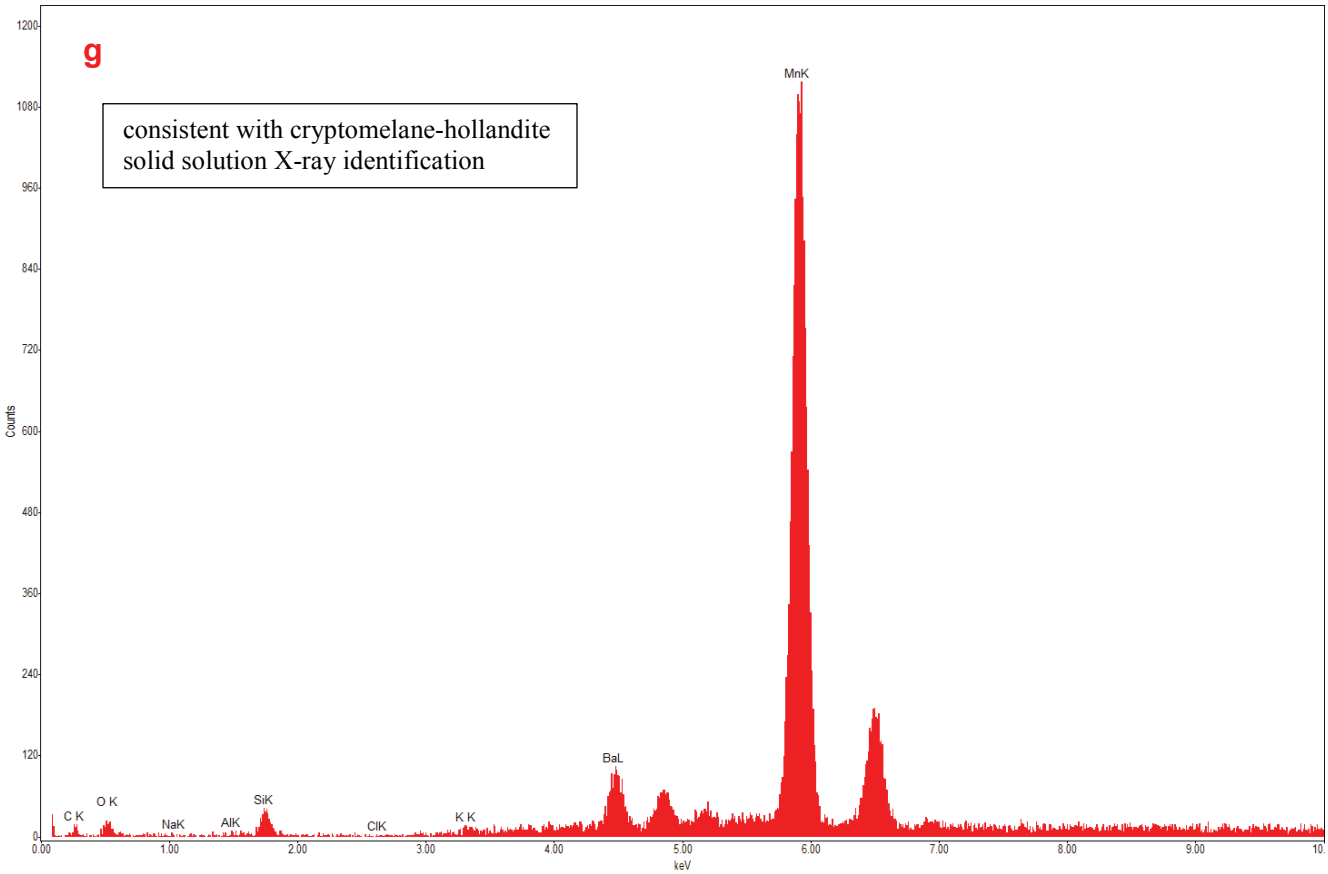
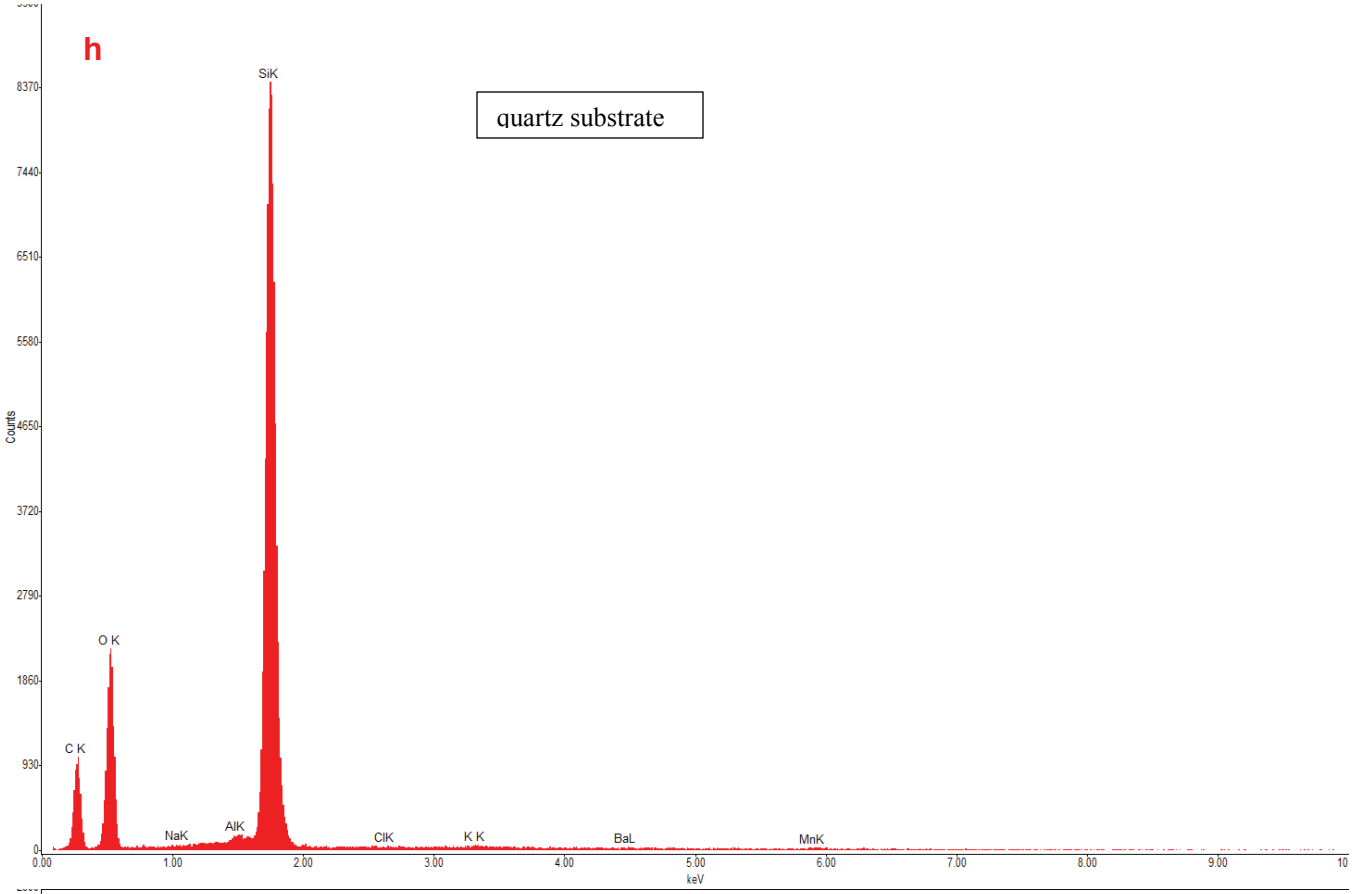
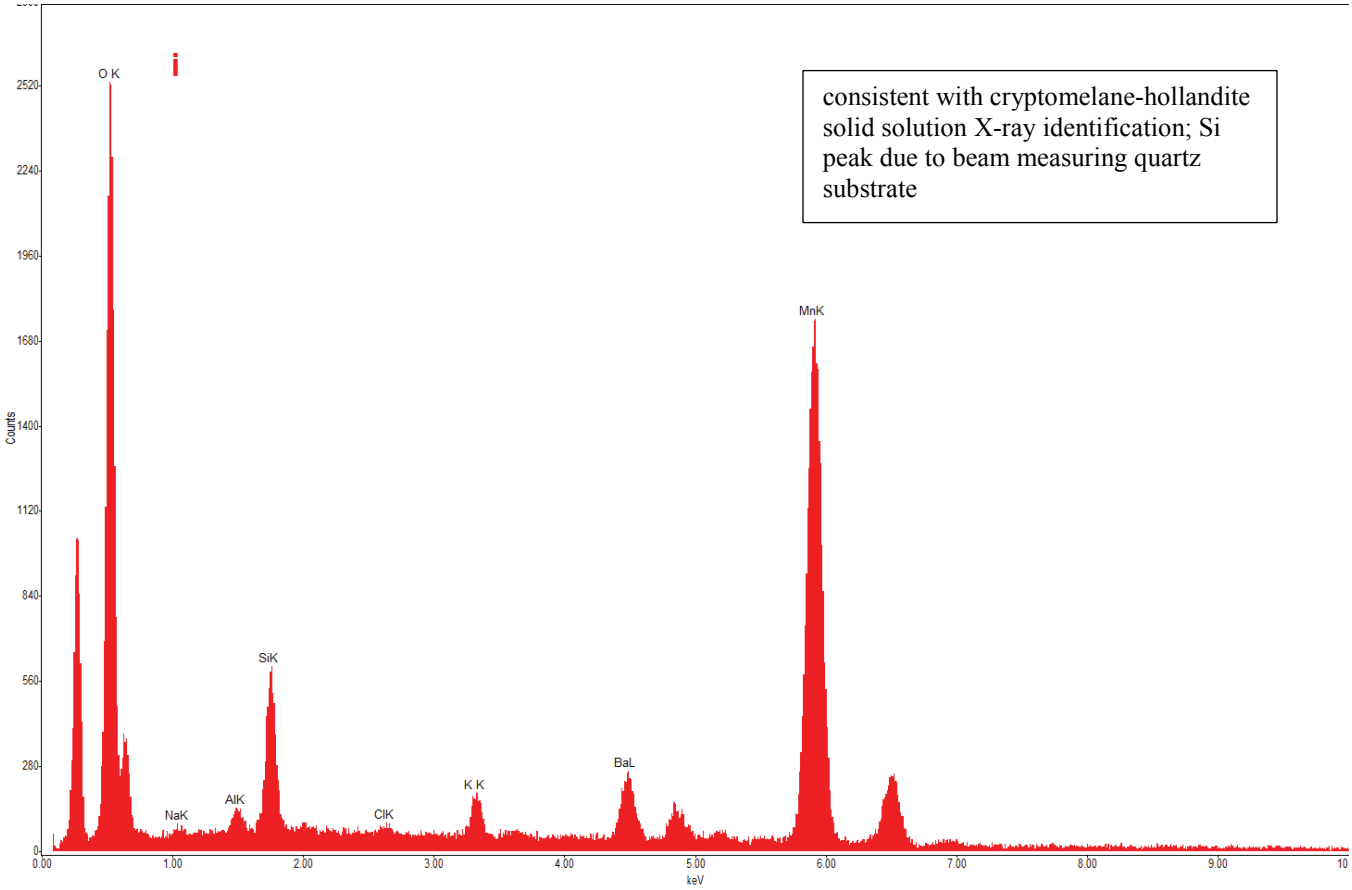


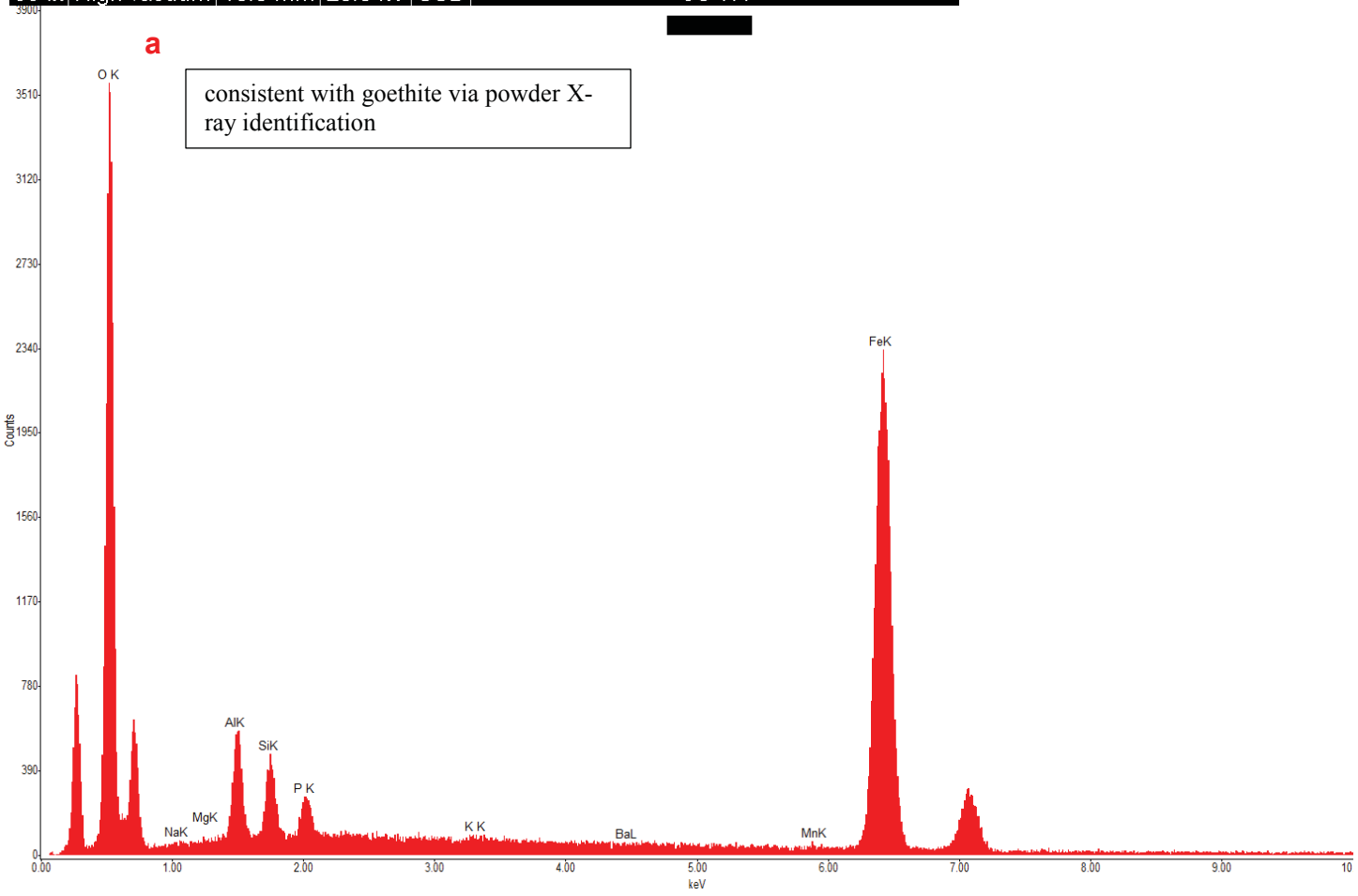


Associated SEM-EDS data (Appalachian State University): Sample SH-1 (Fig 5D, 7A, 7B)

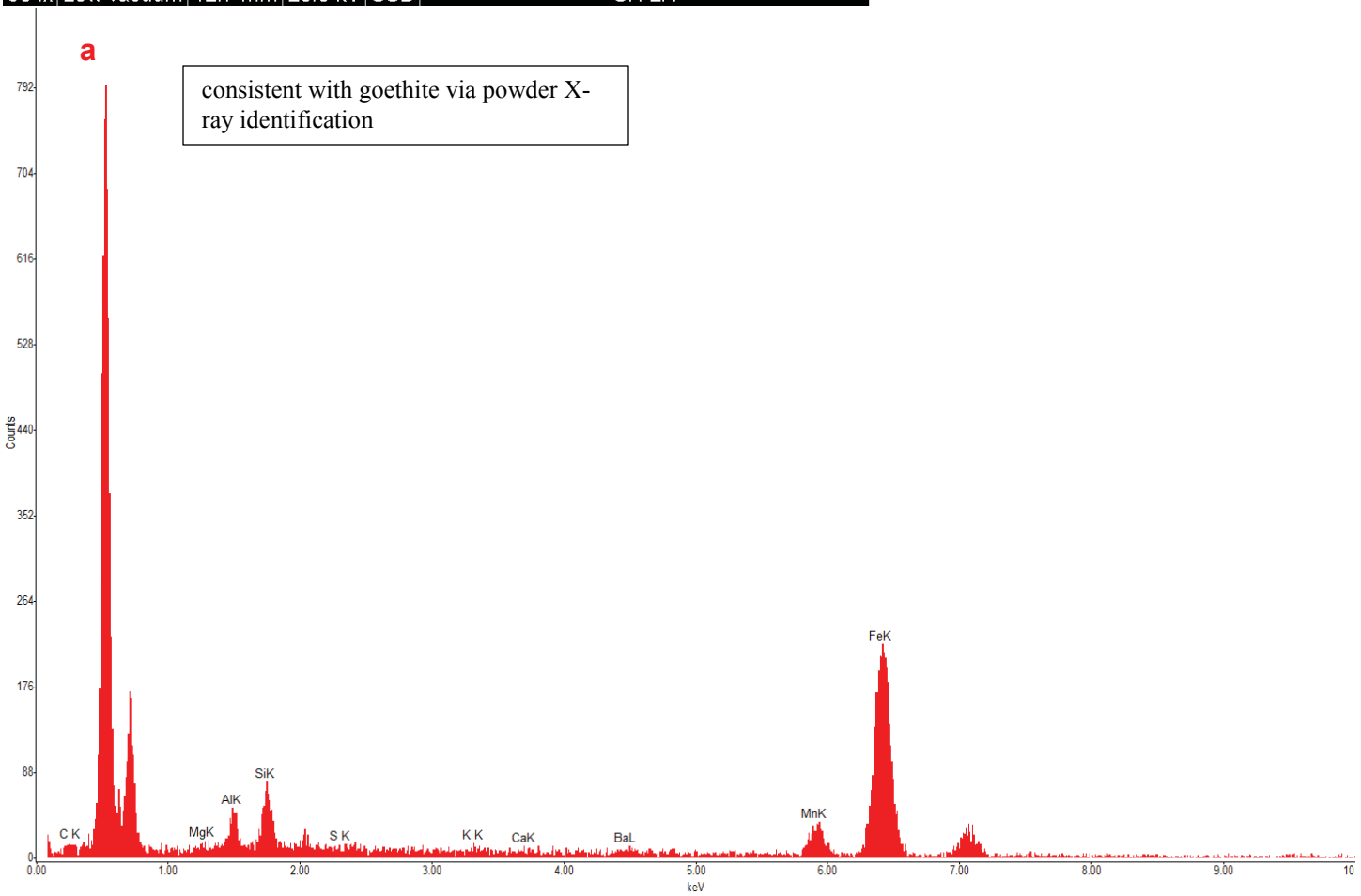




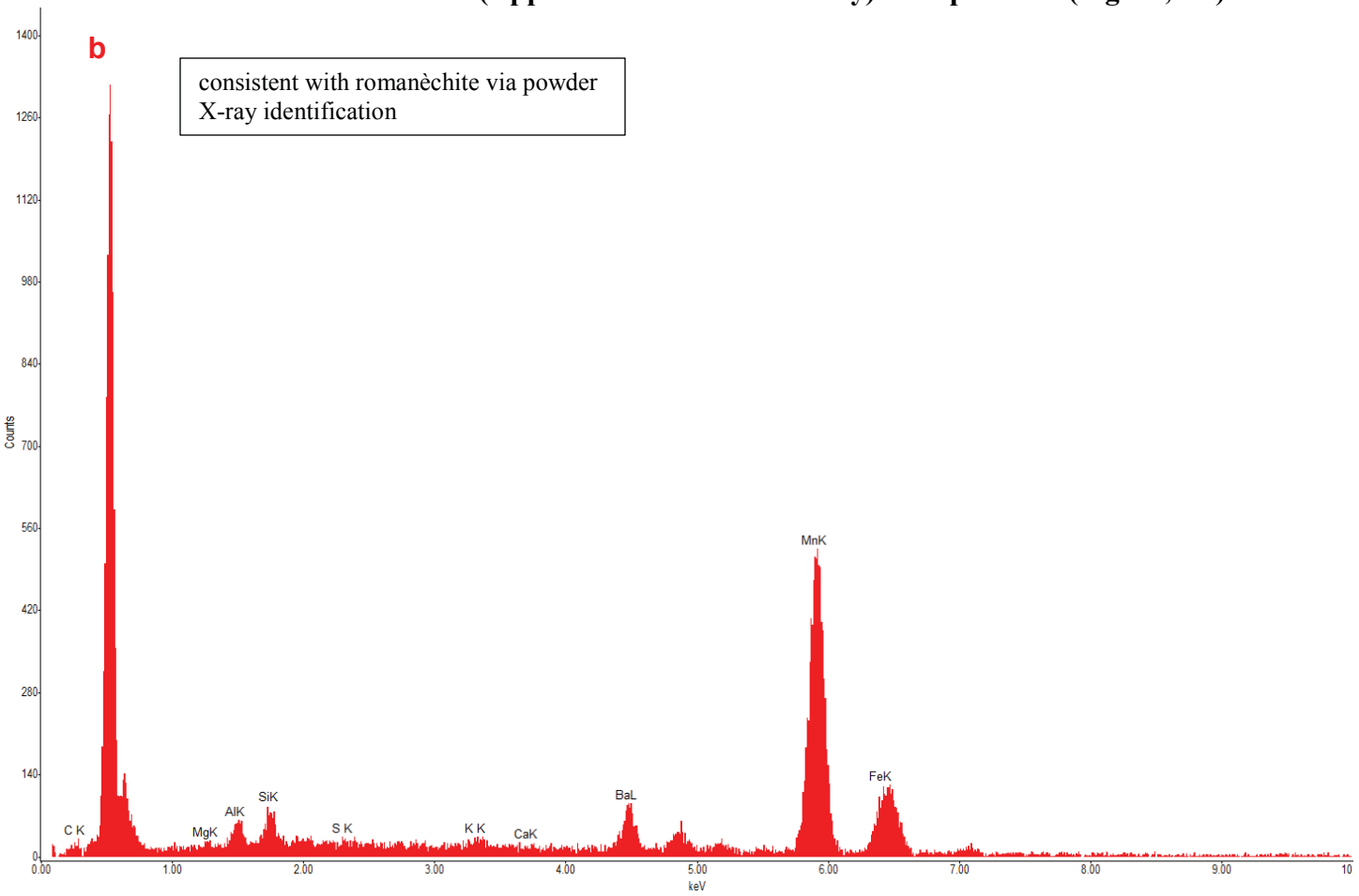
Associated SEM-EDS data (Appalachian State University): Sample SH-2 (Fig 9C, 9D)



Associated SEM-EDS data (Appalachian State University): Sample SH-2 (Fig 9C, 9D)



Associated SEM-EDS data (Appalachian State University): Sample SH-2 (Fig 9C, 9D)



Energy-dispersive X-ray spectroscopy data for Figures 10A, 10D, 11A, 11C, 11F

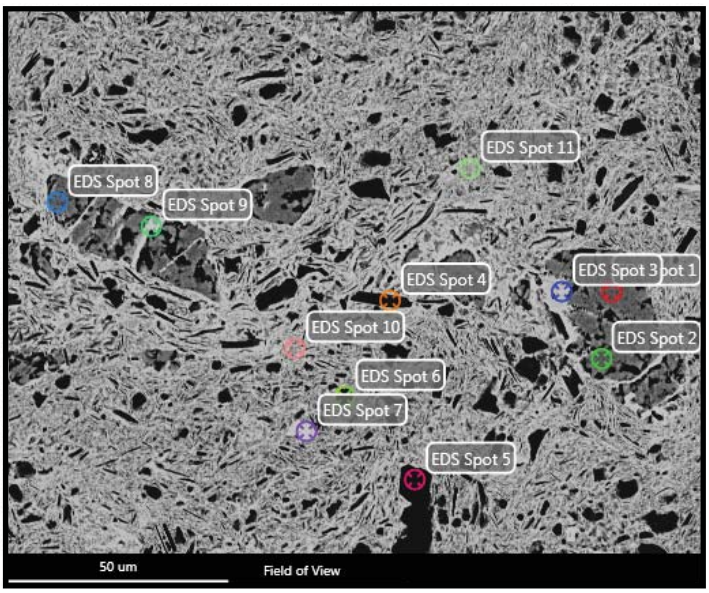
All energy-dispersive X-ray spectroscopy (EDS) data were collected at the U.S. Geological Survey in Reston, VA on a Hitachi SU-5000 field emission SEM equipped with an EDAX silicon drift detector (SDD) (30 mm^2). The polished thin sections were carbon coated and examined under high vacuum at an accelerating voltage of 15kV and a working distance of ~10 mm (working distance for maximum collection efficiency on the SDD).

Initial peak identification was done by the EDAX-TEAM software. Spurious peak identifications were removed manually. EDS analyses were used in a qualitative capacity for phase identification and to document major element variations (e.g. Ba vs. K) that resulted in observed brightness variations in manganese oxide minerals in backscatter electron images.

Provided here is a subset of EDS analyses with annotation. We emphasize that these spectra were used in a qualitative capacity only.

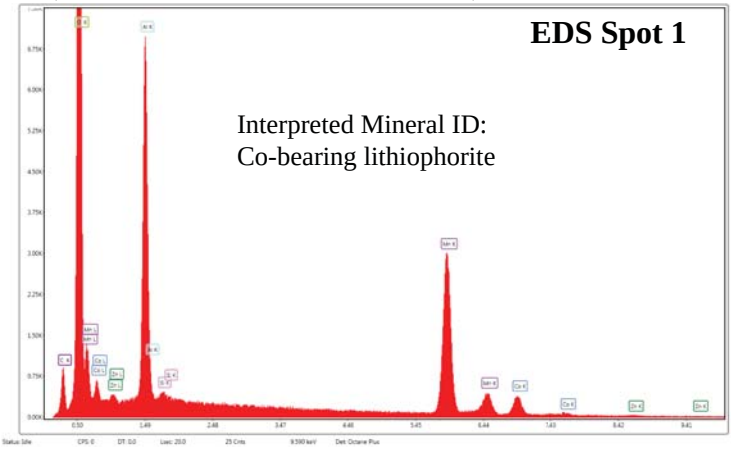
*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

EDS spectra for Figure 10A
(K13-07-12B2-nodule)



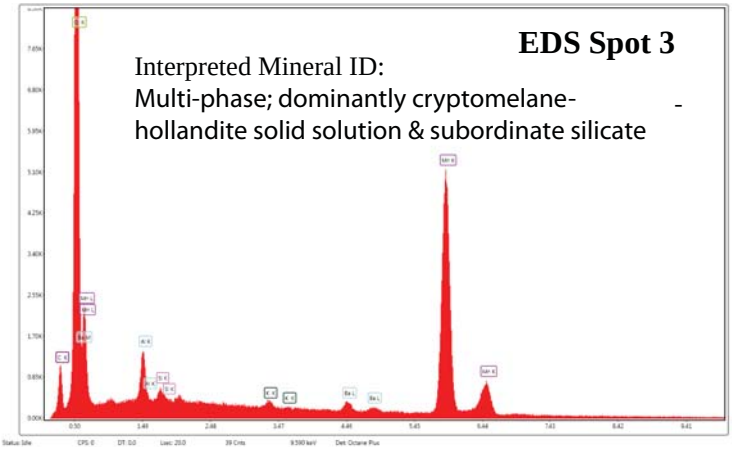
EDS Spot 1

Interpreted Mineral ID:
Co-bearing lithiophorite



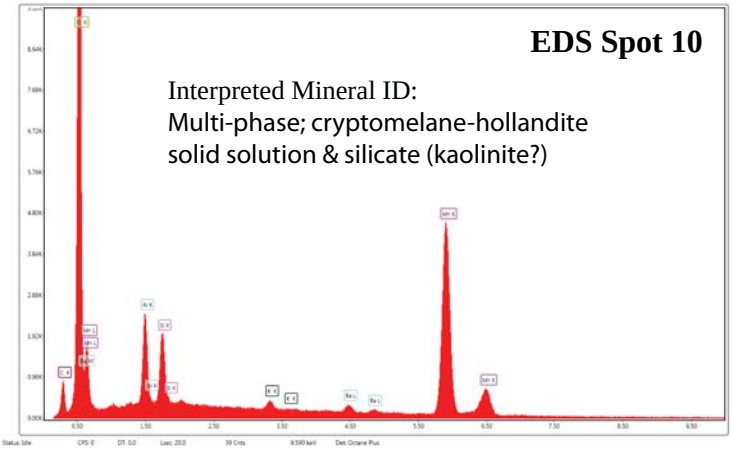
EDS Spot 3

Interpreted Mineral ID:
Multi-phase; dominantly cryptomelane-hollandite solid solution & subordinate silicate



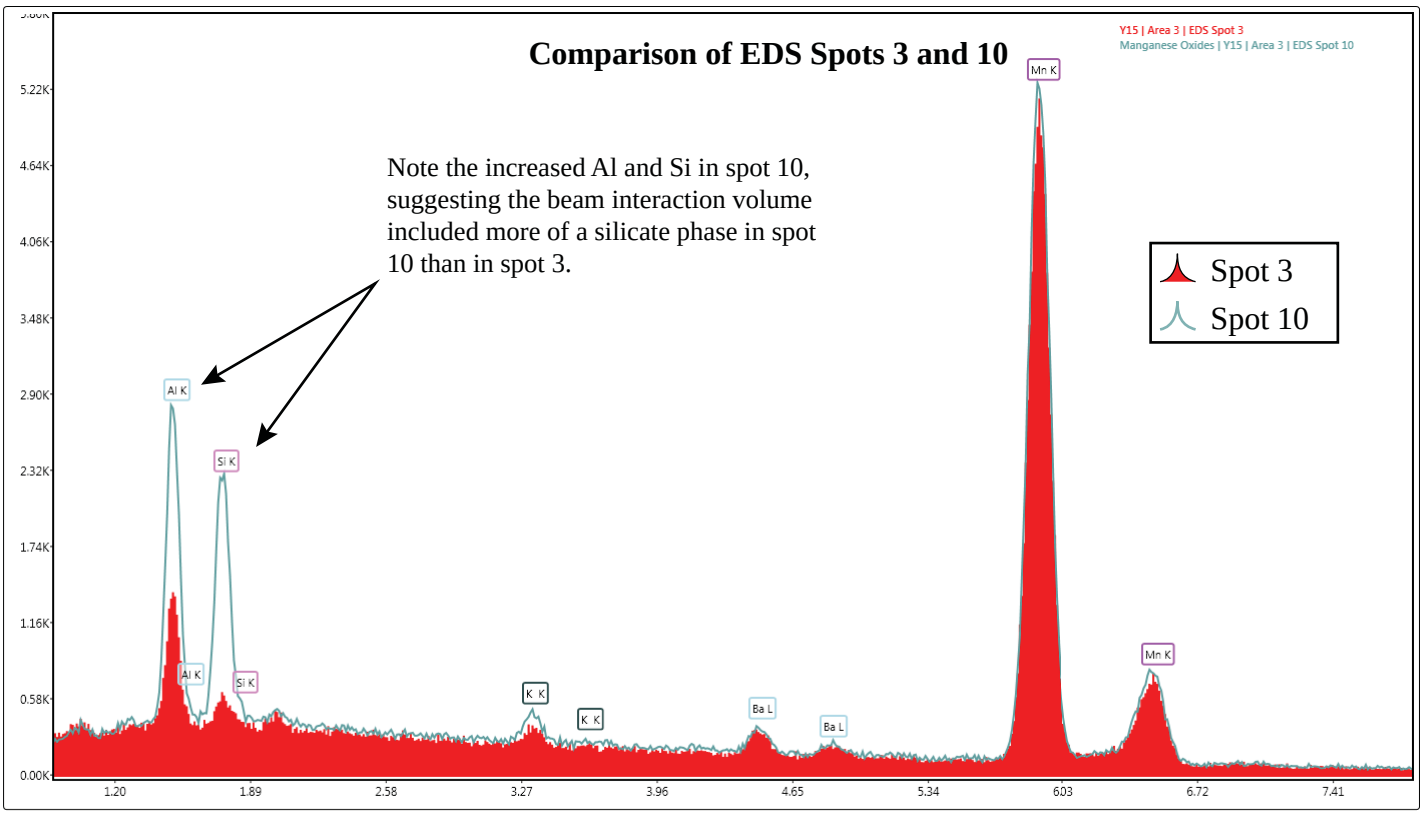
EDS Spot 10

Interpreted Mineral ID:
Multi-phase; cryptomelane-hollandite solid solution & silicate (kaolinite?)



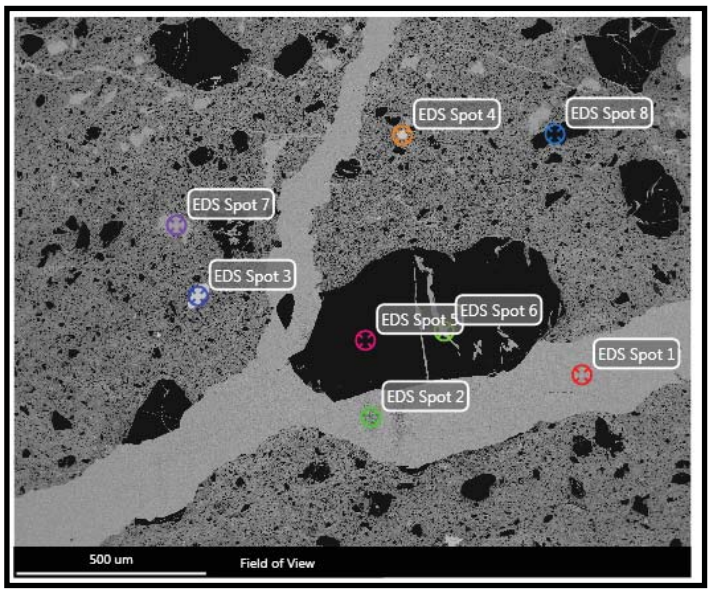
Comparison of EDS Spots 3 and 10

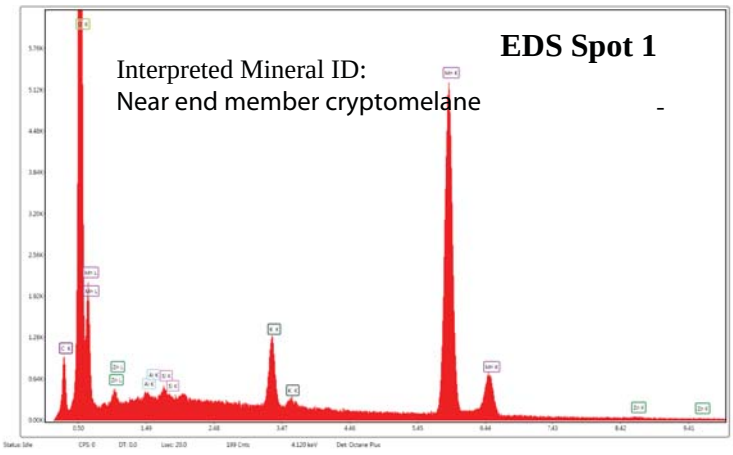
Note the increased Al and Si in spot 10, suggesting the beam interaction volume included more of a silicate phase in spot 10 than in spot 3.

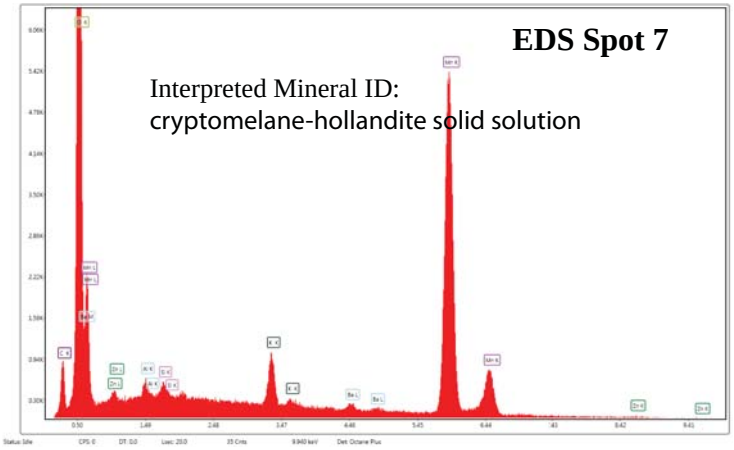


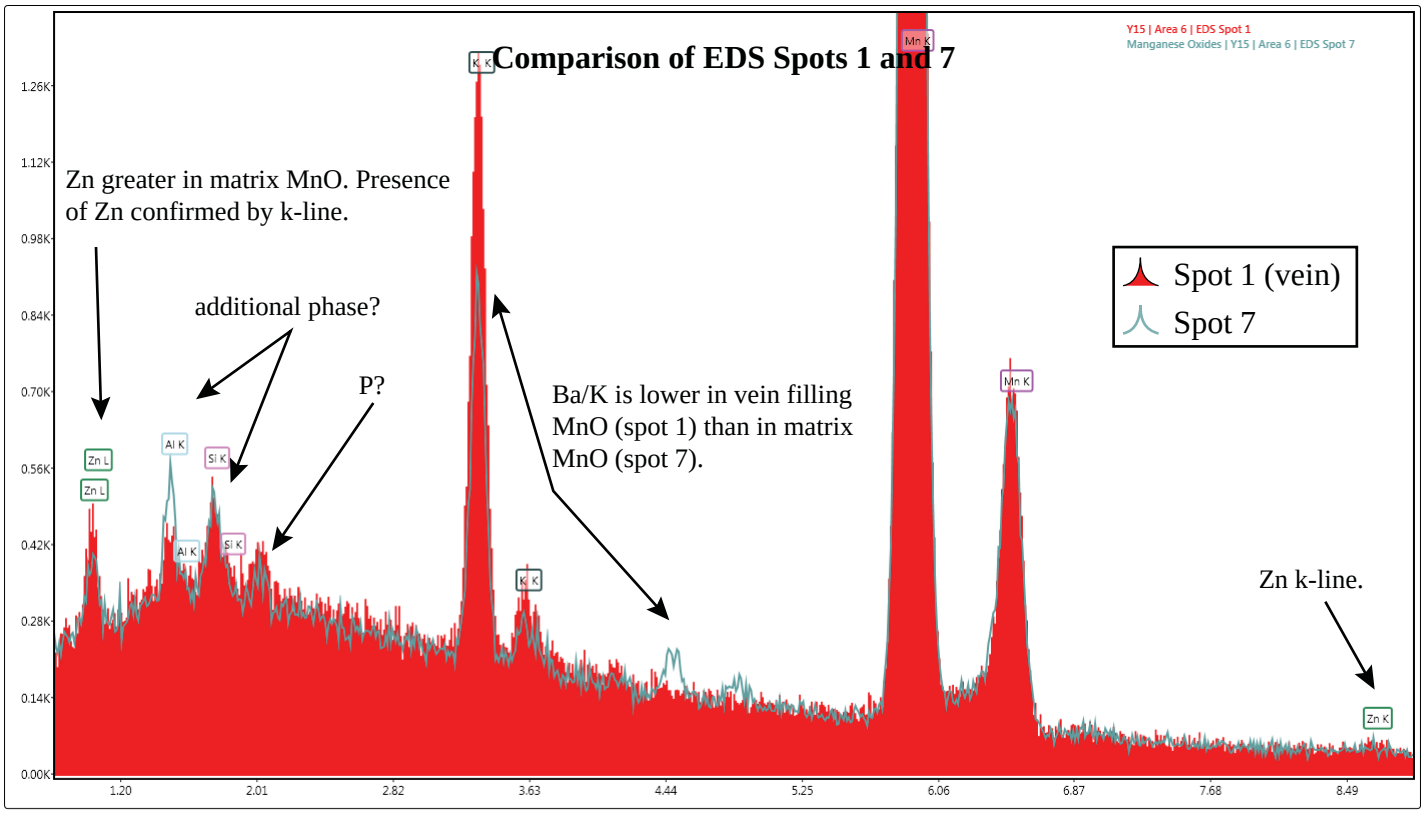
Status: Idle CPS: 0 DT: 0.0 Lsec: 20.0 39 Cnts 9.590 keV Det: Octane Plus

EDS spectra for Figure 10D
(K13-07-12B2-nodule)





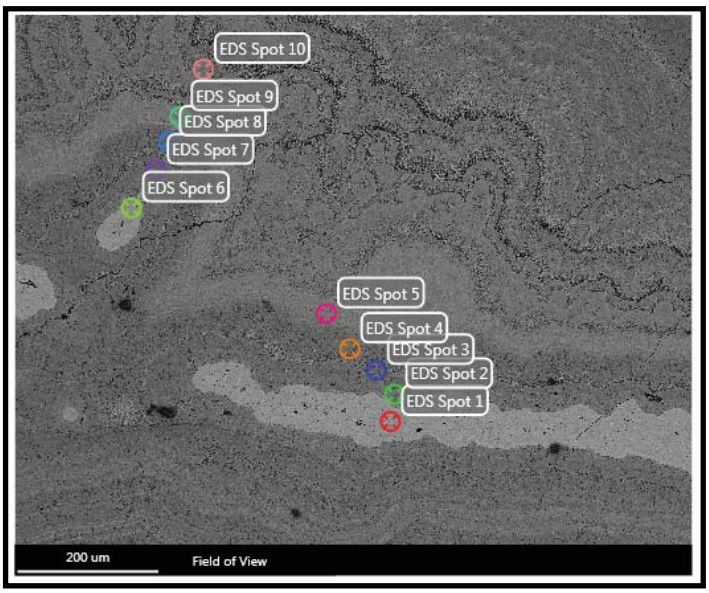




Status: Idle CPS: 0 DT: 0.0 Lsec: 20.0 428 Cnts 2.010 keV Det: Octane Plus

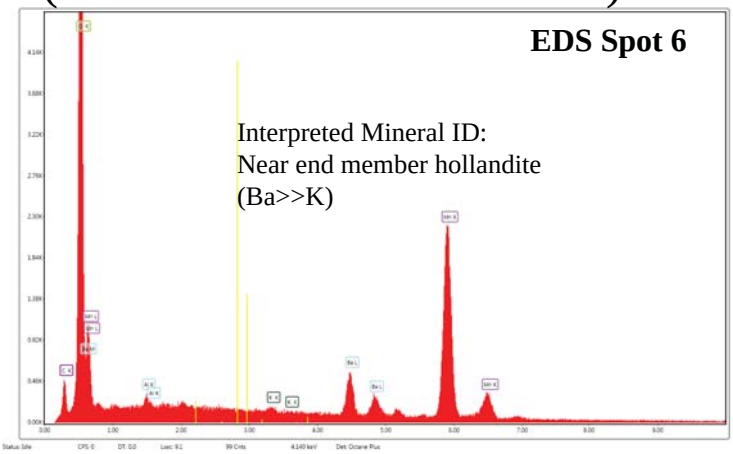
EDS spectra for Figure 11A

(K13-06-18B-breccia cement)



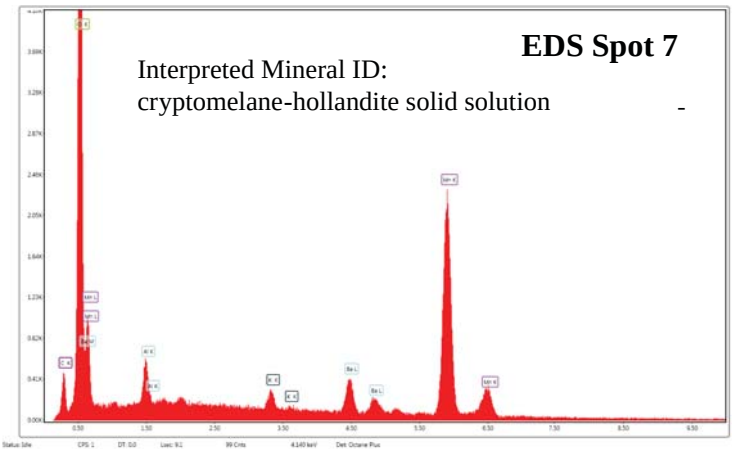
EDS Spot 6

Interpreted Mineral ID:
Near end member hollandite
(Ba>>K)



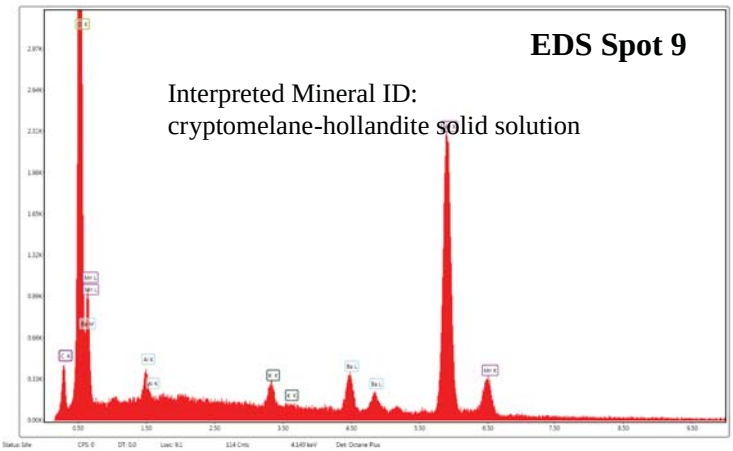
EDS Spot 7

Interpreted Mineral ID:
cryptomelane-hollandite solid solution

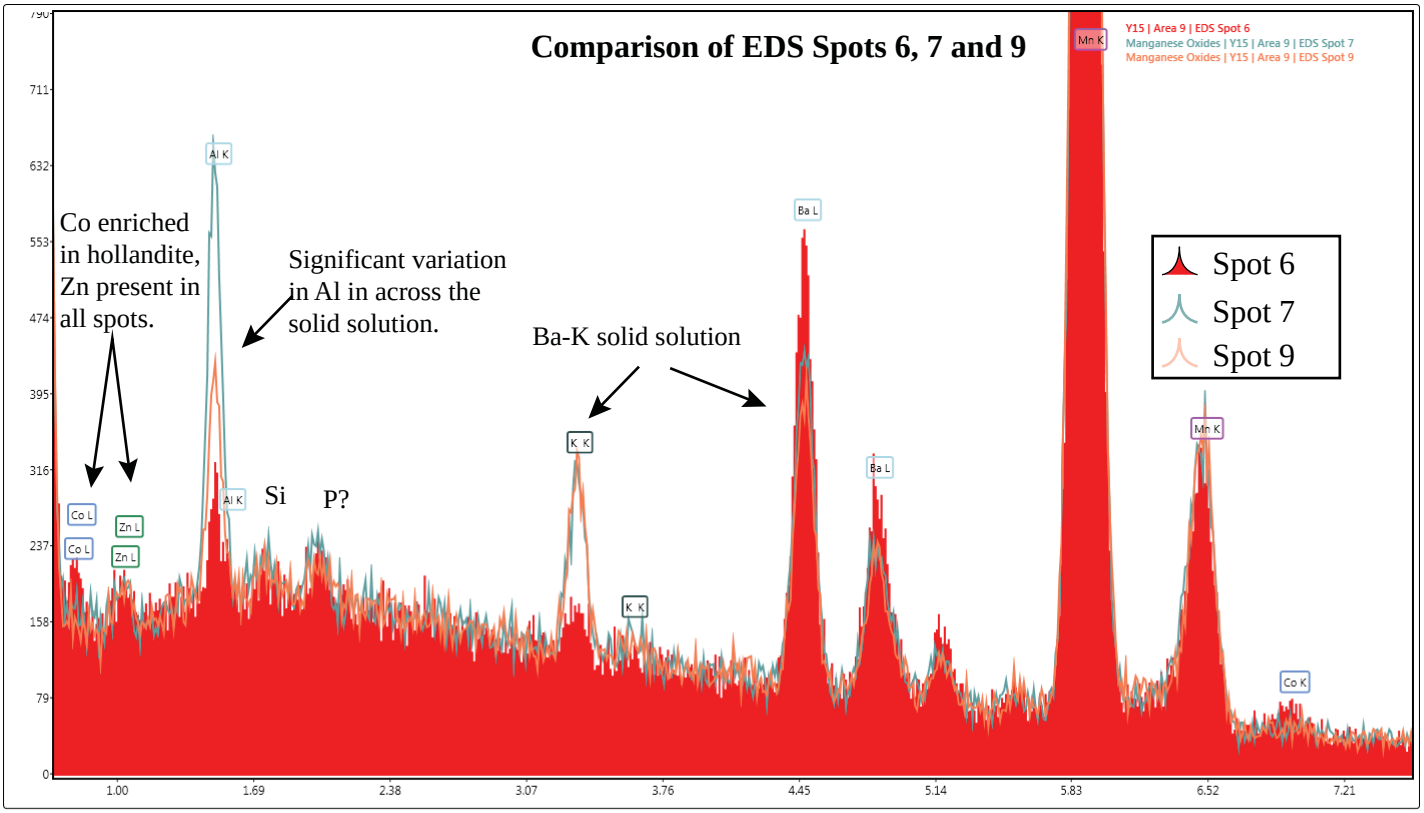


EDS Spot 9

Interpreted Mineral ID:
cryptomelane-hollandite solid solution

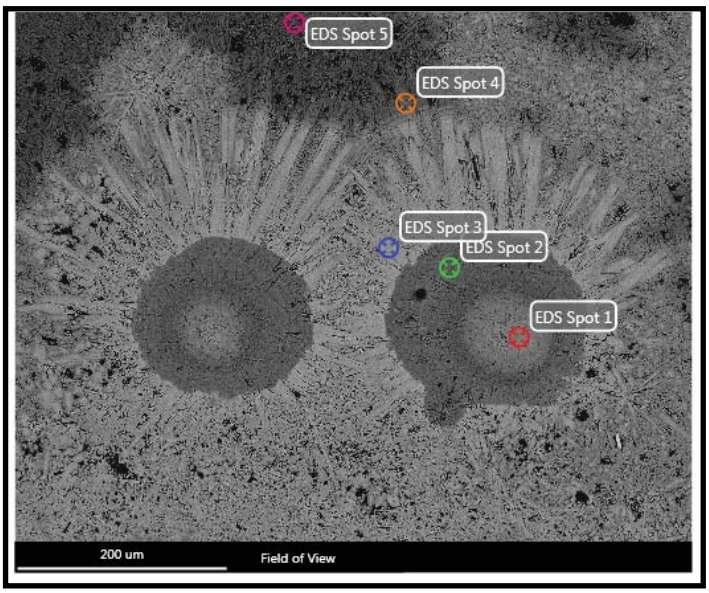


Comparison of EDS Spots 6, 7 and 9



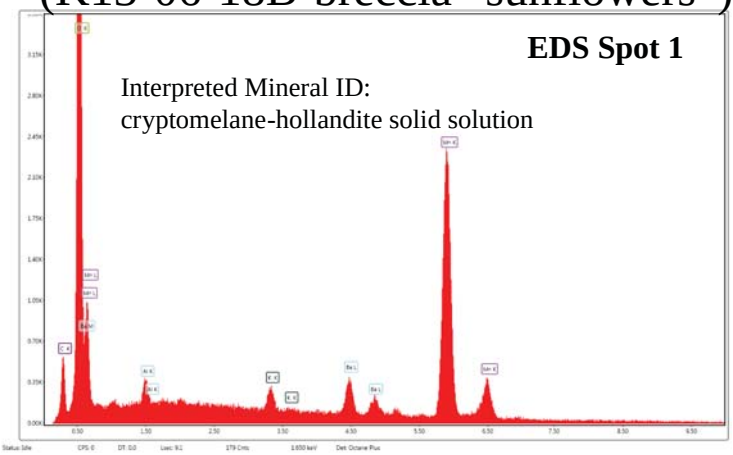
Status: Idle CPS: 0 DT: 0.0 Lsec: 9.1 200 Cnts 1.650 keV Det: Octane Plus

EDS spectra for Figure 11C
(K13-06-18B-breccia “sunflowers”)



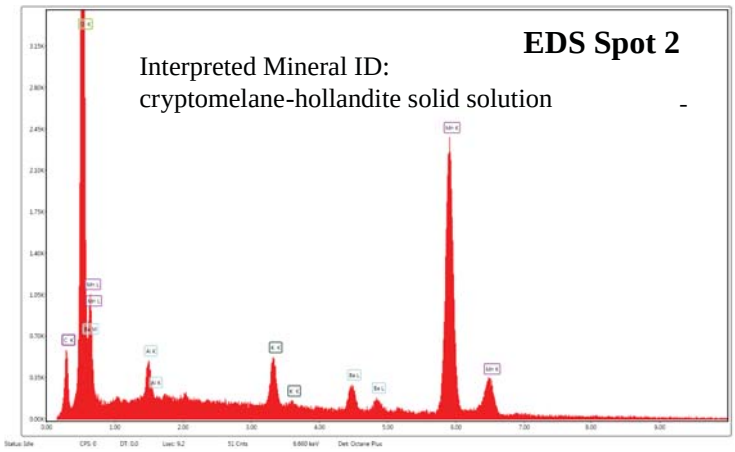
EDS Spot 1

Interpreted Mineral ID:
cryptomelane-hollandite solid solution



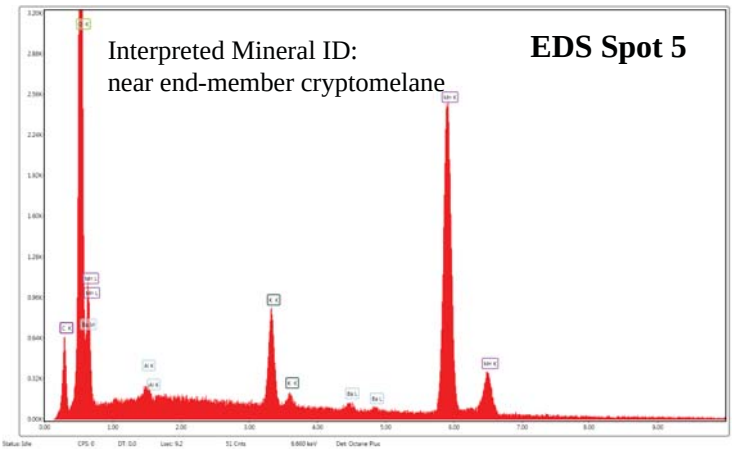
EDS Spot 2

Interpreted Mineral ID:
cryptomelane-hollandite solid solution

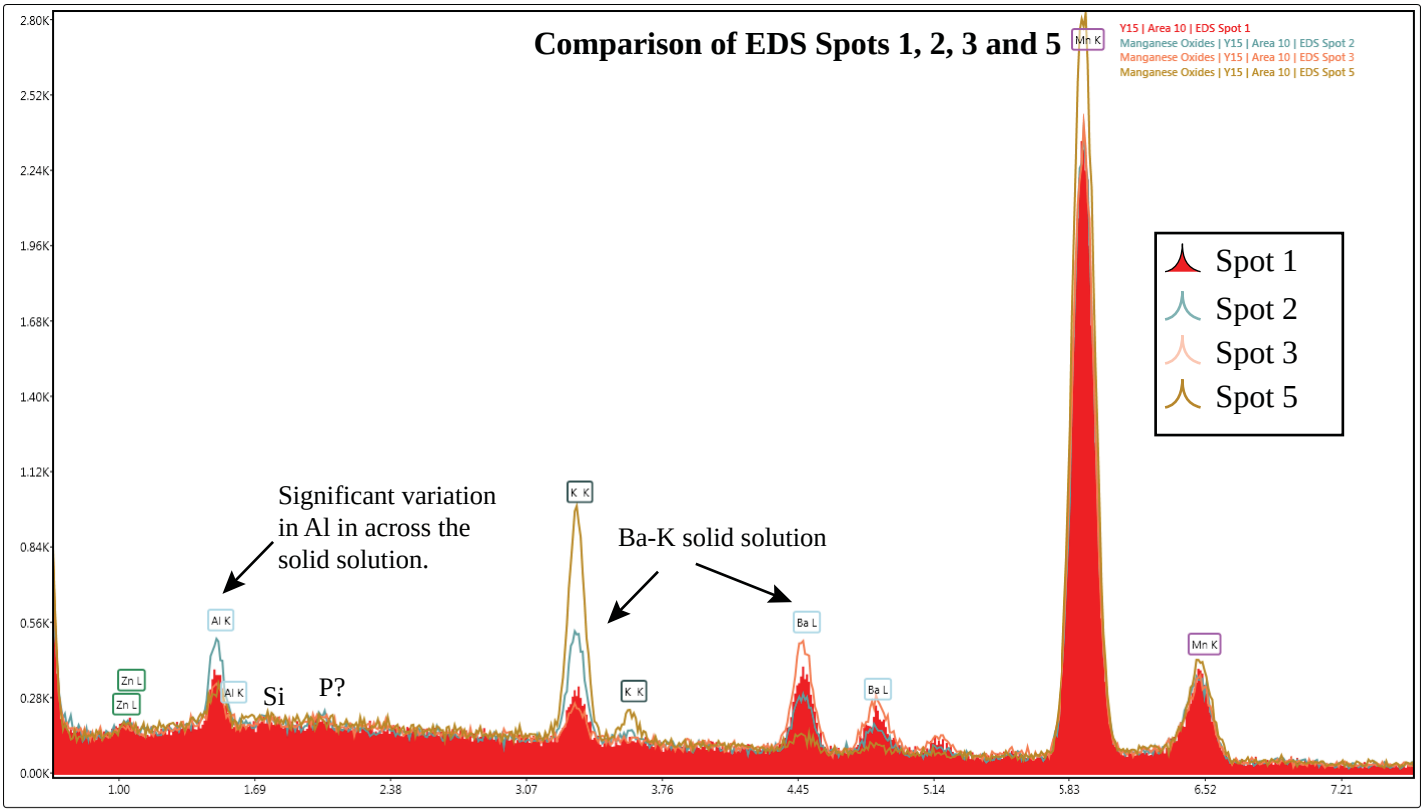


EDS Spot 5

Interpreted Mineral ID:
near end-member cryptomelane



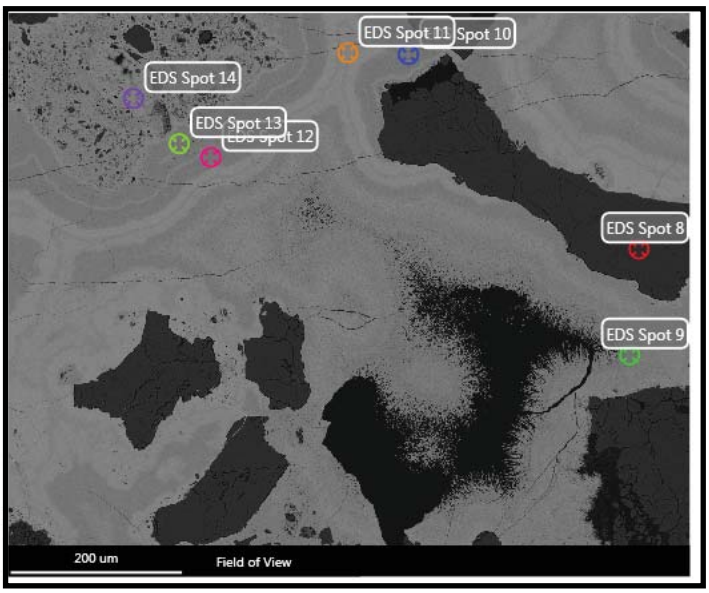
Comparison of EDS Spots 1, 2, 3 and 5



Status: Idle CPS: 1 DT: 0.0 Lsec: 9.2 52 Cnts 6.660 keV Det: Octane Plus

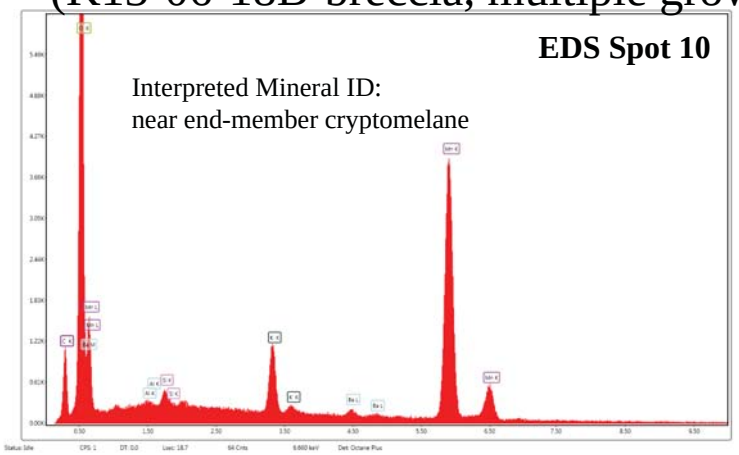
EDS spectra for Figure 11F

(K13-06-18B-breccia, multiple growth)



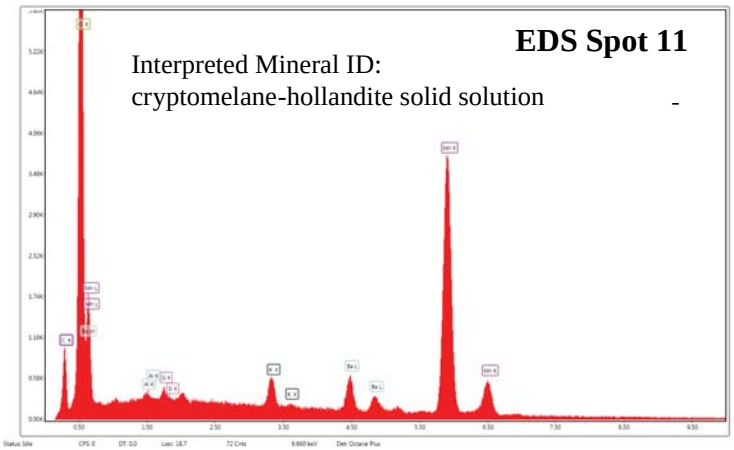
EDS Spot 10

Interpreted Mineral ID:
near end-member cryptomelane



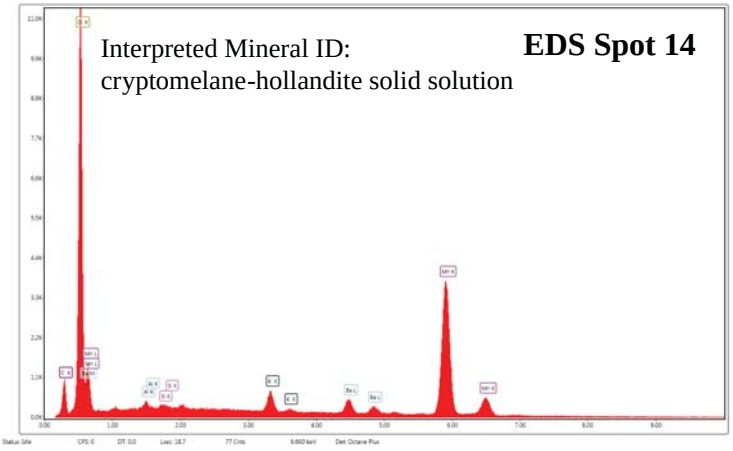
EDS Spot 11

Interpreted Mineral ID:
cryptomelane-hollandite solid solution

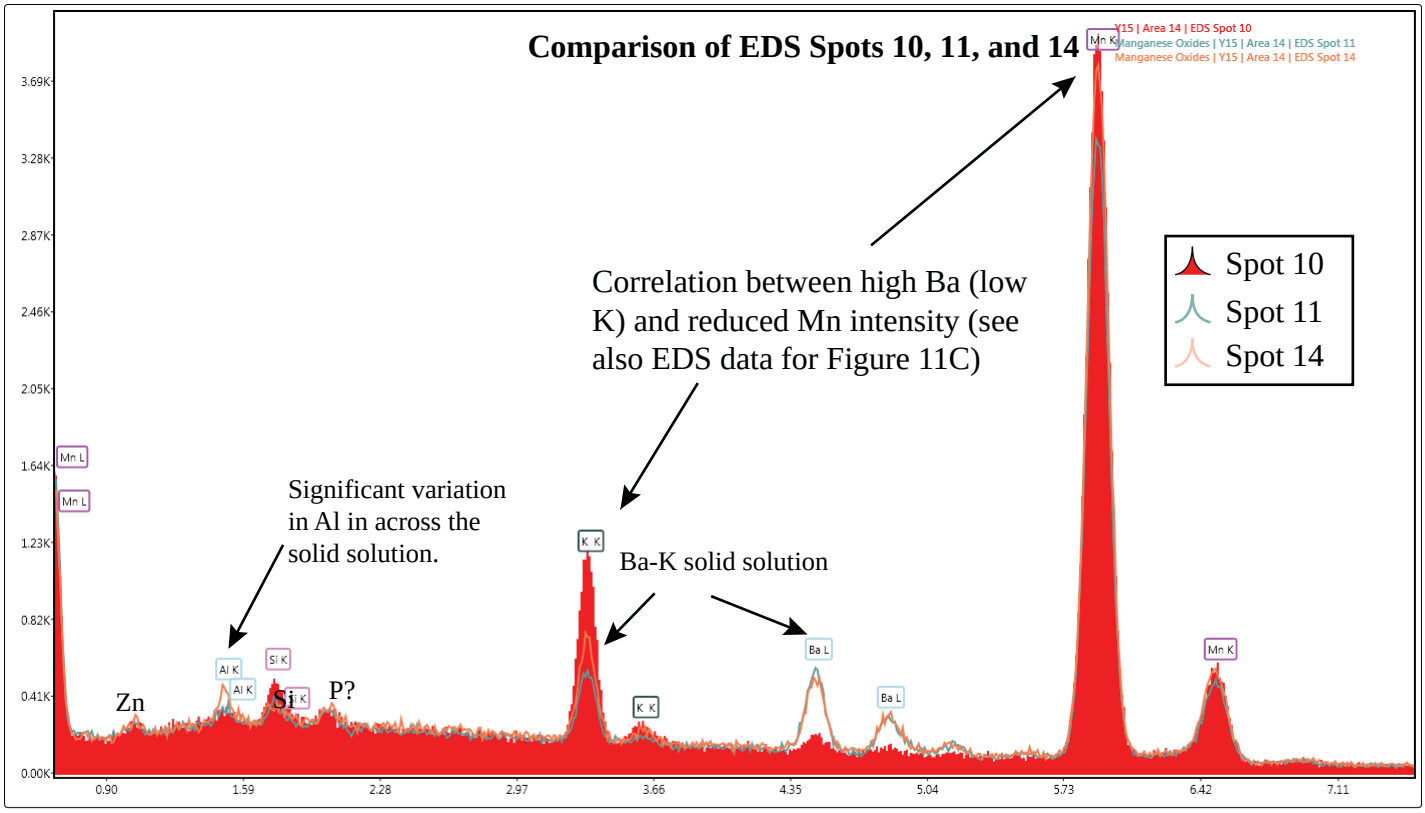


EDS Spot 14

Interpreted Mineral ID:
cryptomelane-hollandite solid solution



Comparison of EDS Spots 10, 11, and 14



Status: Idle CPS: 0 DT: 0.0 Lsec: 18.7 64 Cnts 6.660 keV Det: Octane Plus

DR File 3
Final Report: Activation Laboratories

Sample #	description	details	SiO2	Al2O3	Fe2O3(T)	MnO	MgO	CaO	Na2O	K2O	TiO2	P2O5
AM-01	nodule	Merschat nodule sample	28.03	9.47	3.38	36.54	0.32	0.11	0.12	5.88	0.365	0.15
DR150124-B	nodule	Mt City platy Mn-oxide nodule	28.5	9.00	2.79	36.56	0.33	0.05	0.14	6.70	0.376	0.16
K130712-A	nodule	Stanley nodule; Mick's sample A	5.24	2.81	0.59	69.6	0.11	0.33	0.23	2.16	0.064	0.38
K130712-B	nodule	Stanley nodule; Mick's sample B	12.89	4.66	2.11	62.32	0.19	0.12	0.09	1.70	0.223	0.38
K130712-B2	nodule	Stanley nodule; Mick's sample B-rep	19.86	5.88	2.23	54.69	0.18	0.11	0.07	1.34	0.303	0.34
DR150417-A	quartzite breccia matrix	Lyndhurst breccia; MnO ore float sample, has mixed age, mixed phases	1.35	2.38	0.30	75.69	0.02	0.20	0.28	1.74	0.013	0.51
DRBYC-646	quartzite breccia matrix	Larry's place breccia; xstlln cryptomelane - clean cryptomelane	6.05	1.67	0.19	68.22	< 0.01	0.16	0.28	1.08	0.005	0.11
K130618-A	quartzite breccia matrix	Larry's place breccia; Mick's sample, dated - clean cryptomelane	3.02	2.79	5.09	63.74	< 0.01	0.15	0.2	0.95	0.006	0.35
K130618-B	quartzite breccia matrix	Larry's place breccia; Mick's sample, dated - clean cryptomelane	1.48	1.14	0.39	73.91	< 0.01	0.19	0.16	0.59	0.008	0.29
K130618-C	quartzite breccia matrix	Linden quad breccia; corner quarry, Mick's sample-dated - clean cryptomelane	2.2	0.73	0.47	70.55	< 0.01	0.07	0.06	0.35	0.003	0.35
K130712-C1	quartzite breccia matrix	Compton mine breccia; Mick's sample, dated	1.34	0.79	0.13	71.76	< 0.01	0.08	0.07	0.37	0.009	0.28
DR150124-A2	silicified shady dolomite CLAST	Mt City breccia; clast of mostly chert	94.78	1.03	2.12	0.201	0.09	0.06	0.03	0.30	0.041	0.06
DR150124-A1	silicified shady dolomite matrix	Mt City breccia; fracture fill-dendrites	24.9	4.81	2.66	49.71	0.1	0.11	0.13	2.64	0.24	0.56
JC-7c	shrub	Mtn City breccia; cryptomelane-hollandite	2.71	2.3	4.71	70.49	0.03	0.16	0.18	2	0.022	0.92
JC-7b	nodule	Mtn City breccia; romanechite, microcline	29.36	8.1	5.9	35.97	0.41	0.09	0.12	5.44	0.335	0.2
JC-10	frothy layered stromatolite	from Tina Delahunty's garage pit	2.7	1.35	81.83	0.232	0.05	< 0.01	0.02	0.1	0.037	2.47
SH-2	silicified shady dolomite matrix	float piece from Steve Hageman	22.1	1.64	26.94	32.61	0.02	0.06	0.05	0.21	0.02	0.35

DR File 3
Final Report: Activation Laboratories

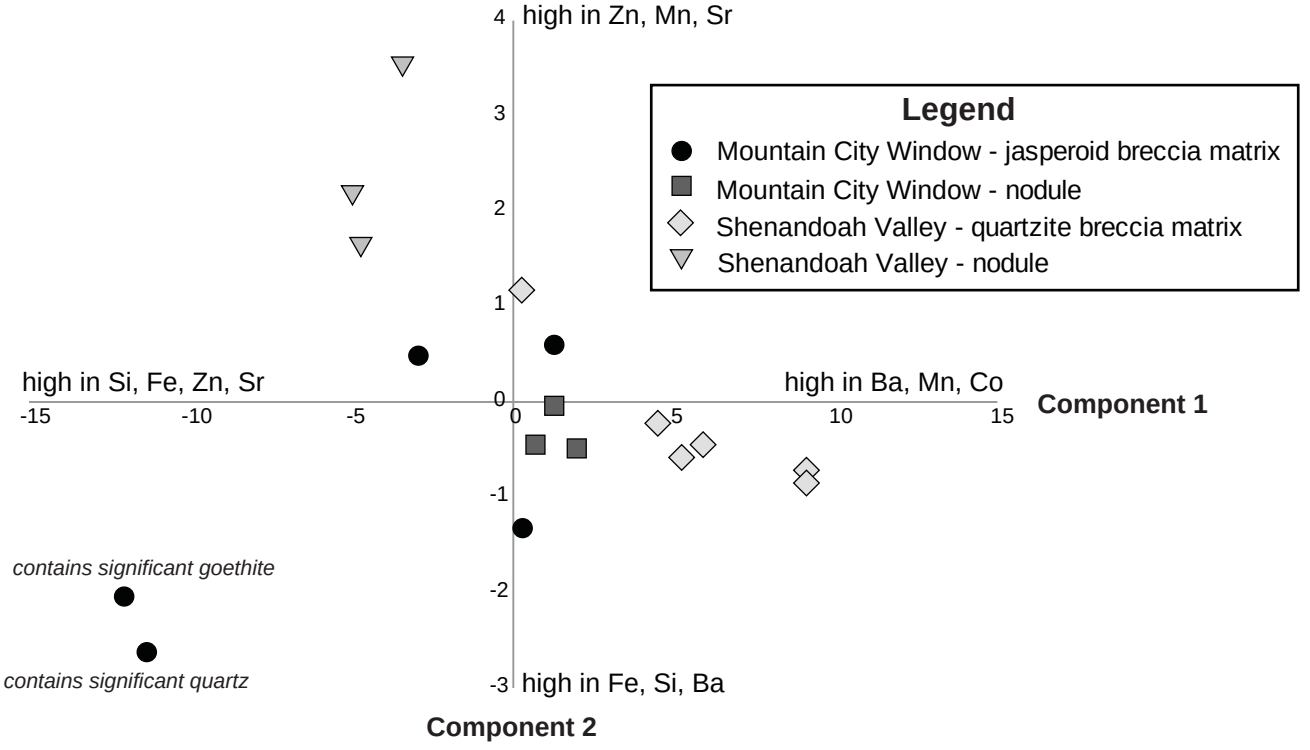
Sample #	BaO	CoO	ZnO	LOI	Total	Li	Sc	Be	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Rb	Sr	Y	Zr	Nb	Mo	Ag	In	Sn	Sb	Cs	Ba	La	Ce	Pr
AM-01	6.152	1.008	0.154	8.75	99.27	530	16	13	90	40	> 1000	670	370	1240	45	1.0	11	62	78	104	89	5.8	7	< 0.5	< 0.1	6	< 0.2	2.6	55080	27.8	291	10.1
DR150124-B	6.561	0.144	0.105	7.81	98.98	130	13	8	87	40	> 1000	250	160	840	39	0.8	8	72	39	49.8	85	4.4	< 2	< 0.5	< 0.1	< 1	0.2	2.4	58740	24	83.1	5.7
K130712-A	2.519	0.137	0.798	13.43	97.46	20	17	327	41	440	> 1000	270	170	6410	50	1.5	8	29	2175	55.2	66	1.4	< 2	< 0.5	< 0.1	< 1	1.5	0.6	22550	28.5	353	13
K130712-B	1.684	0.123	0.433	12.14	98.51	60	13	212	55	120	965	150	190	3480	51	1.6	8	25	985	82.5	63	3.3	< 2	0.5	< 0.1	1	0.7	1.7	15080	26.7	215	10.3
K130712-B2	1.802	0.099	0.326	11.67	98.47	40	14	158	48	140	781	160	200	2620	50	1.1	11	23	787	74.8	99	4.6	< 2	0.7	< 0.1	< 1	0.6	1.7	16130	27.5	186	10.5
DR150417-A	4.890	1.156	0.128	11.95	99.32	190	5	13	33	30	> 1000	350	550	1030	49	1.3	12	11	390	276	104	0.2	12	< 0.5	< 0.1	< 1	< 0.2	< 0.1	43780	11.7	55	11.3
DRBYC-646	8.871	0.198	0.045	11.62	98.26	< 10	2	4	< 5	70	> 1000	40	570	360	35	1.6	< 5	10	35	66.3	193	3.7	< 2	< 0.5	< 0.1	4	< 0.2	< 0.1	79430	26.9	59.5	8.37
K130618-A	9.710	0.261	0.039	12.35	98.36	20	10	9	26	30	> 1000	40	670	310	39	2.2	9	7	19	93	80	9.3	2	< 0.5	< 0.1	< 1	0.3	< 0.1	86940	16.8	77.8	6.9
K130618-B	10.383	0.200	0.042	10.51	99.05	< 10	2	8	13	< 20	> 1000	< 20	80	340	44	1.2	< 5	3	19	17.1	111	0.6	< 2	< 0.5	< 0.1	3	0.2	< 0.1	92960	11.6	21.5	2.46
K130618-C	14.598	0.337	0.036	9.93	99.31	< 10	2	5	15	< 20	> 1000	40	60	290	43	0.8	11	3	17	5.8	38	0.7	3	< 0.5	< 0.1	< 1	1.5	< 0.1	130700	6.88	14.1	1.39
K130712-C1	14.508	0.398	0.036	10.02	99.36	10	3	6	16	< 20	> 1000	40	90	290	47	0.9	8	3	11	20	39	< 0.2	4	< 0.5	< 0.1	< 1	< 0.2	< 0.1	129900	20.4	32.2	4.99
DR150124-A2	0.037	0.004	0.014	1.33	100.08	70	2	2	18	< 20	32	30	10	110	29	0.7	8	7	24	12.9	21	1.0	< 2	< 0.5	< 0.1	< 1	< 0.2	0.2	333	6.24	15.1	1.19
DR150124-A1	2.813	0.446	0.142	9.81	98.48	150	9	19	77	20	> 1000	440	200	1140	50	0.9	10	31	312	146	206	2.8	< 2	< 0.5	< 0.1	< 1	0.2	1.1	25190	11.8	47.5	3.05
JC-7c				11.55	95.08		4	23	97	< 20	> 1000	230	340	1300	43	1.2	26	16	353	101	6	< 0.2	6	< 0.5	< 0.1	< 1	0.5	< 0.1	51840	2.95	8.06	0.74
JC-7b				7.41	93.34		14	12	85	40	> 1000	190	370	950	43	1.4	13	57	74	63.8	50	3.8	4	< 0.5	< 0.1	2	0.7	3	50090	26	80.9	6.05
JC-10				12.17	101		2	9	20	< 20	146	260	70	1830	7	0.8	43	3	7	10.7	10	0.3	< 2	< 0.5	< 0.1	3	< 0.2	0.2	82	6.91	14.9	1.69
SH-2				10.77	94.78		2	7	28	30	970	80	280	620	27	< 0.5	35	4	35	104	5	< 0.2	6	< 0.5	< 0.1	5	0.9	< 0.1	47930	4.34	22.2	2.41

DR File 3
Final Report: Activation Laboratories

Sample #	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Tl	Pb	Bi	Th	U	Co
AM-01	48.2	16.7	4.55	19.1	3.96	26.8	5.55	16	2.4	14.7	2.21	1.8	0.28	11.4	0.07	298	< 0.1	6.25	2.45	0.793
DR150124-B	23.8	7.48	2.15	8.2	1.78	12.6	2.58	7.37	1.07	6.83	1.04	2.4	0.34	155	0.08	80	< 0.1	7.14	1.86	0.113
K130712-A	63.5	28.1	6.97	27.5	4.06	21.9	3.34	8.46	1.15	7.73	1.18	1.8	< 0.01	53.4	< 0.05	14	< 0.1	2.04	8.88	0.108
K130712-B	56	31.9	8.19	36.1	6.05	32	4.9	12.4	1.76	11.1	1.65	2.3	0.04	5.5	< 0.05	106	< 0.1	5.45	4.79	
K130712-B2	66.1	39.2	10.3	40	6.59	34.5	5.15	13.1	1.84	12.1	1.78	4.0	0.19	6.2	0.15	112	< 0.1	5.99	5.45	
DR150417-A	80.4	41.3	13.5	67.4	10.2	58.1	11.3	31.8	4.74	31.4	5.22	3.3	< 0.01	4.3	< 0.05	< 5	< 0.1	0.78	7.23	0.909
DRBYC-646	41	18	6.39	21.3	3.28	19.4	3.68	10.1	1.39	8.44	1.3	4.6	< 0.01	3.1	< 0.05	66	0.2	1.59	1.79	0.156
K130618-A	36.9	20.6	7.48	26.6	4.41	27	5.31	14.9	2.33	14.8	2.28	3.8	< 0.01	6	< 0.05	14	< 0.1	1.29	5.97	0.205
K130618-B	9.78	4.36	2.32	5.64	0.76	4	0.73	1.93	0.276	1.91	0.301	3.0	0.12	1.6	< 0.05	< 5	< 0.1	1.15	1.26	0.157
K130618-C	7.11	4.79	2.38	3.92	0.39	1.72	0.3	0.79	0.112	0.77	0.141	1.1	0.19	4.9	< 0.05	17	< 0.1	0.51	1.48	0.265
K130712-C1	22.2	10.3	3.67	10.1	1.11	5.12	0.89	2.29	0.301	2.02	0.321	1.0	0.19	2.3	< 0.05	10	< 0.1	7.65	3.36	0.313
DR150124-A2	4.69	0.81	0.196	0.77	0.18	1.23	0.32	0.95	0.152	0.99	0.155	0.3	0.09	0.7	0.06	14	< 0.1	0.91	0.64	
DR150124-A1	15.6	5.46	1.67	7.93	1.66	14	3.66	12.9	2.11	13.6	2.35	5.1	0.15	50.1	0.08	46	< 0.1	3.00	3.77	0.351
JC-7c	3.46	1.19	0.509	2.4	0.55	5.43	1.85	6.94	1.19	7.96	1.21	0.4	0.18	1.2	< 0.05	8	< 0.1	0.35	6.04	
JC-7b	23.8	5.99	1.71	8.03	1.76	13.1	2.86	8.41	1.26	8.12	1.15	2.2	0.45	3.6	< 0.05	32	< 0.1	6.28	2.46	
JC-10	6.05	1.27	0.261	1.38	0.27	1.8	0.35	1.03	0.173	1.2	0.176	0.3	0.17	< 0.5	0.1	26	< 0.1	0.92	4.89	
SH-2	13.7	5.07	1.42	7.73	1.64	12.7	3.05	9.69	1.53	10.2	1.59	0.4	0.22	12.3	0.56	143	0.5	0.57	11.7	

a

PC1 vs. PC2



b

Loadings Plots