



Supplement of

Fossilization of Precambrian microfossils in the Volyn pegmatite, Ukraine

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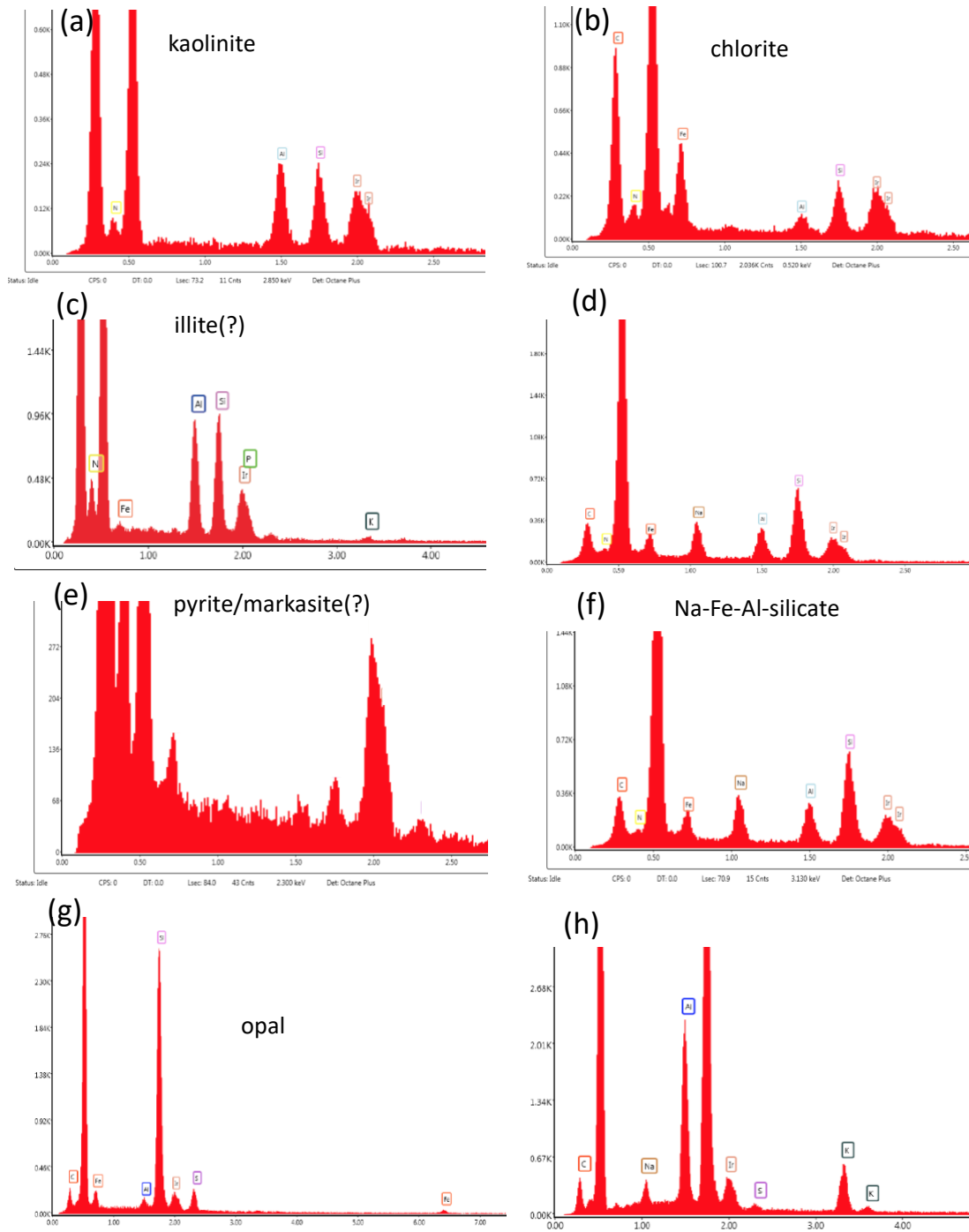
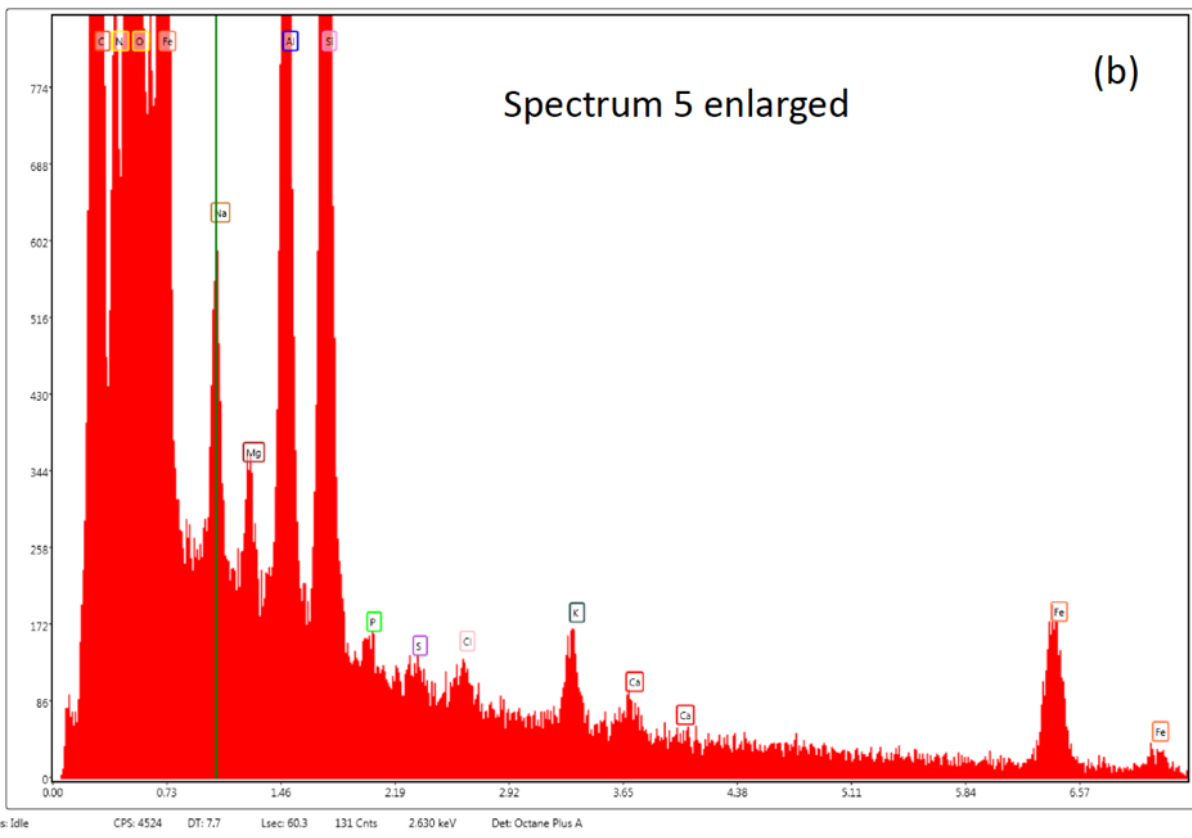
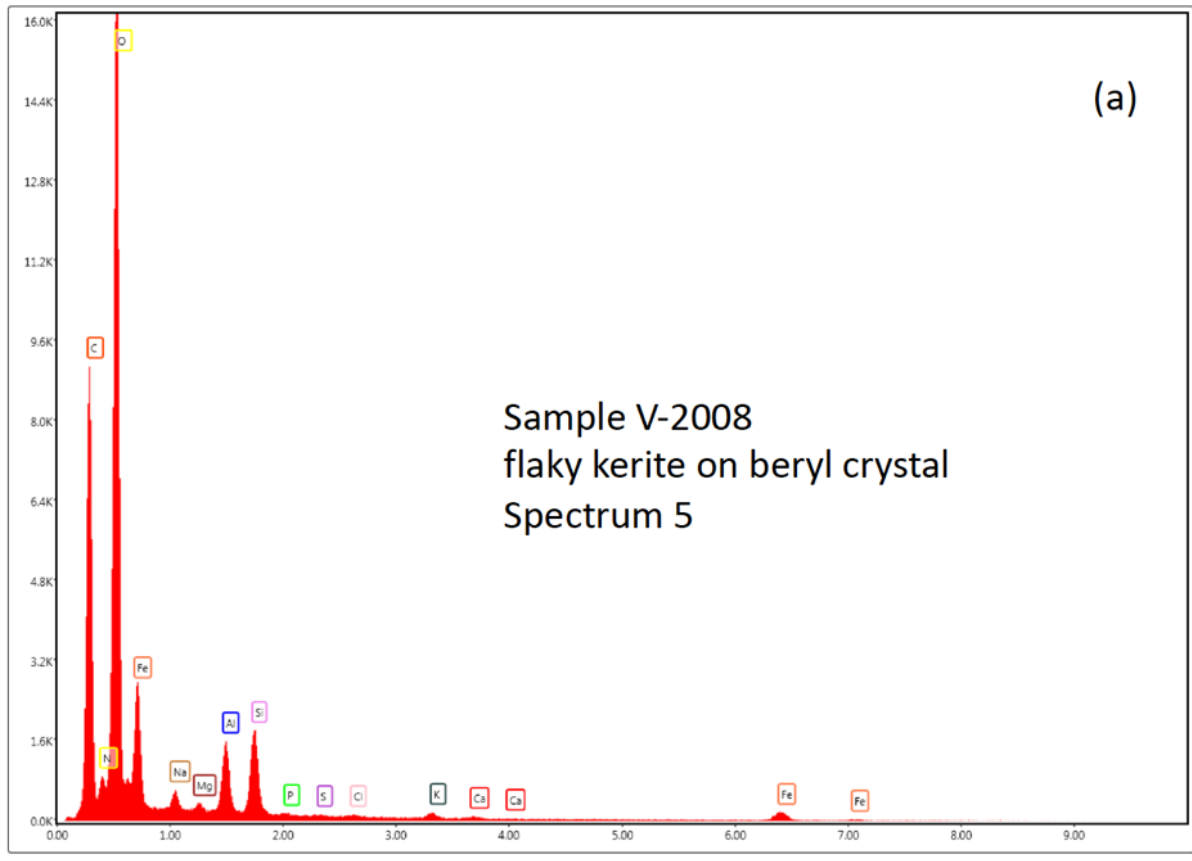
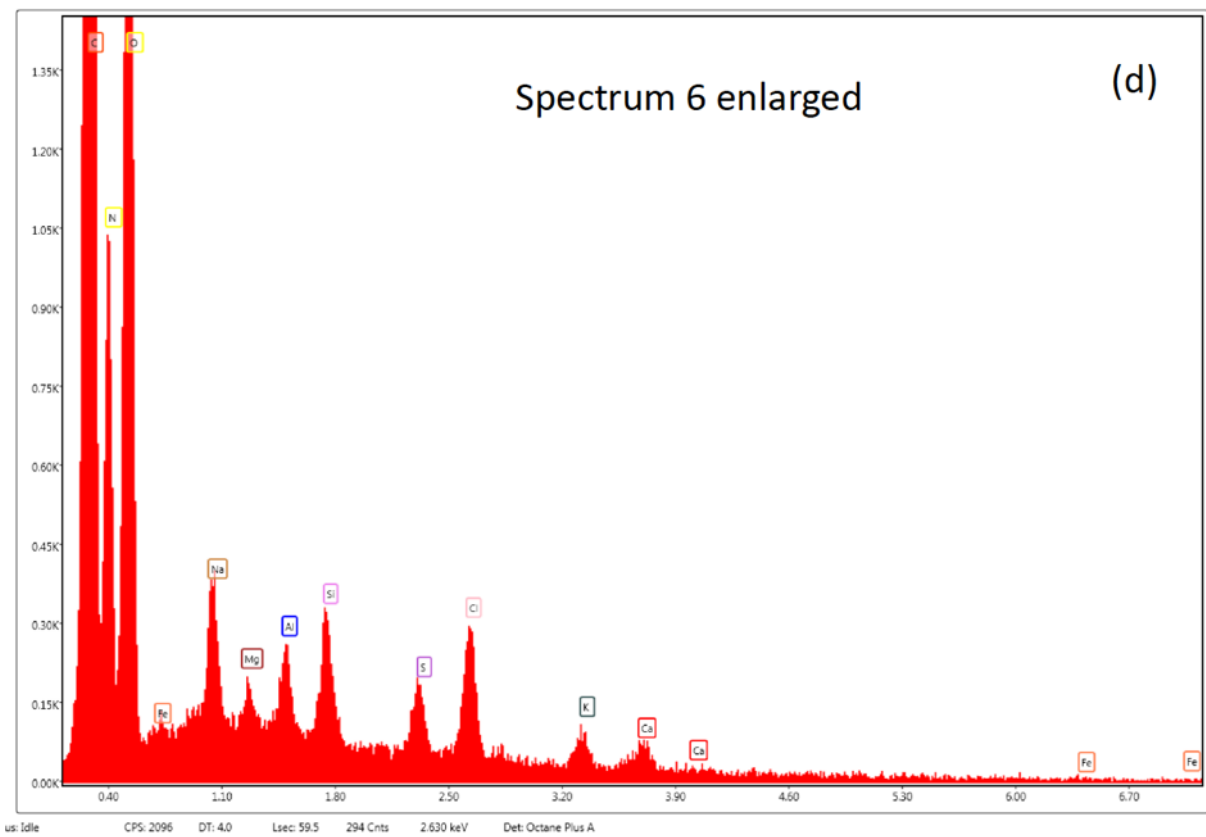
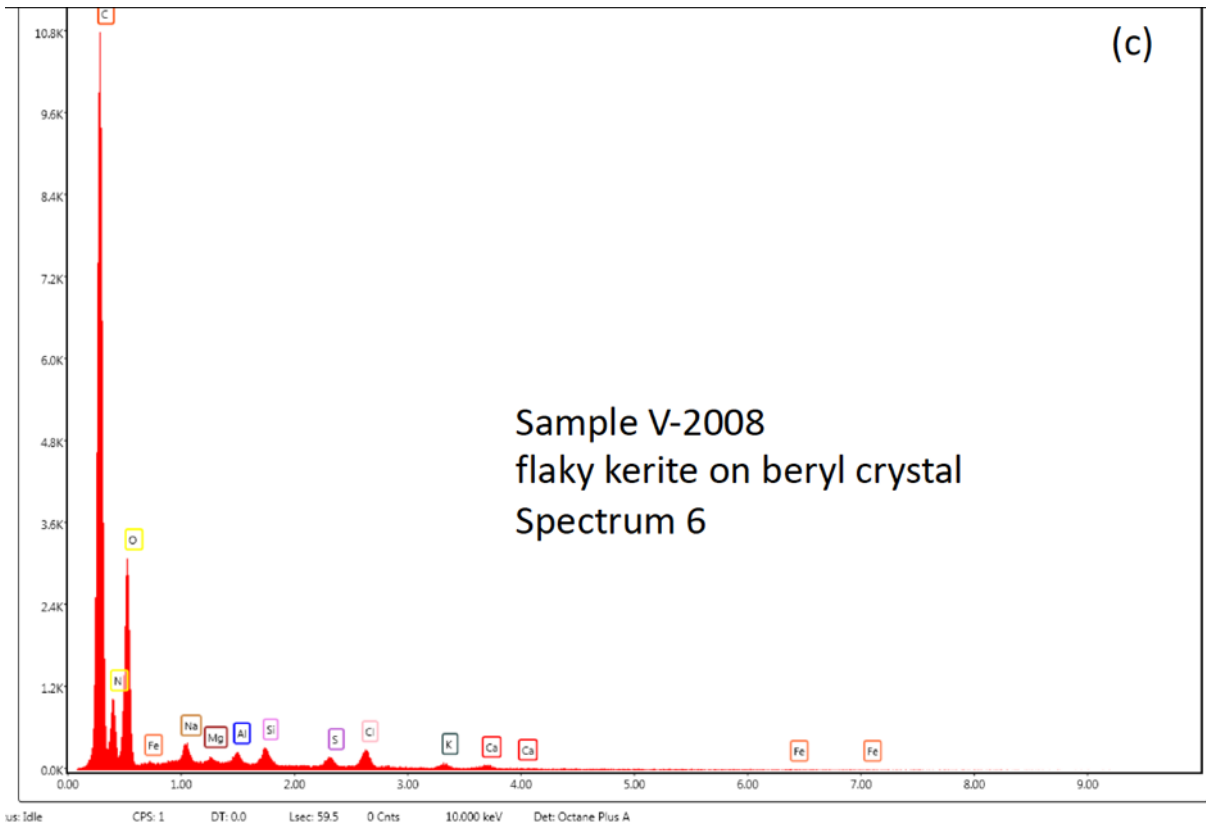


Fig. S1: EDS spectra of minerals and encrustations of filamentous kerite. All mineral identifications were made on the basis of the spectra and morphology, not verified by XRD. (a,b,c) Information to Fig. 3a; (d) to Fig. 3b; (e) to Fig. 3c; (f) to Fig. 3e; (g) to Fig. 3f; (h) to Fig. 3h.





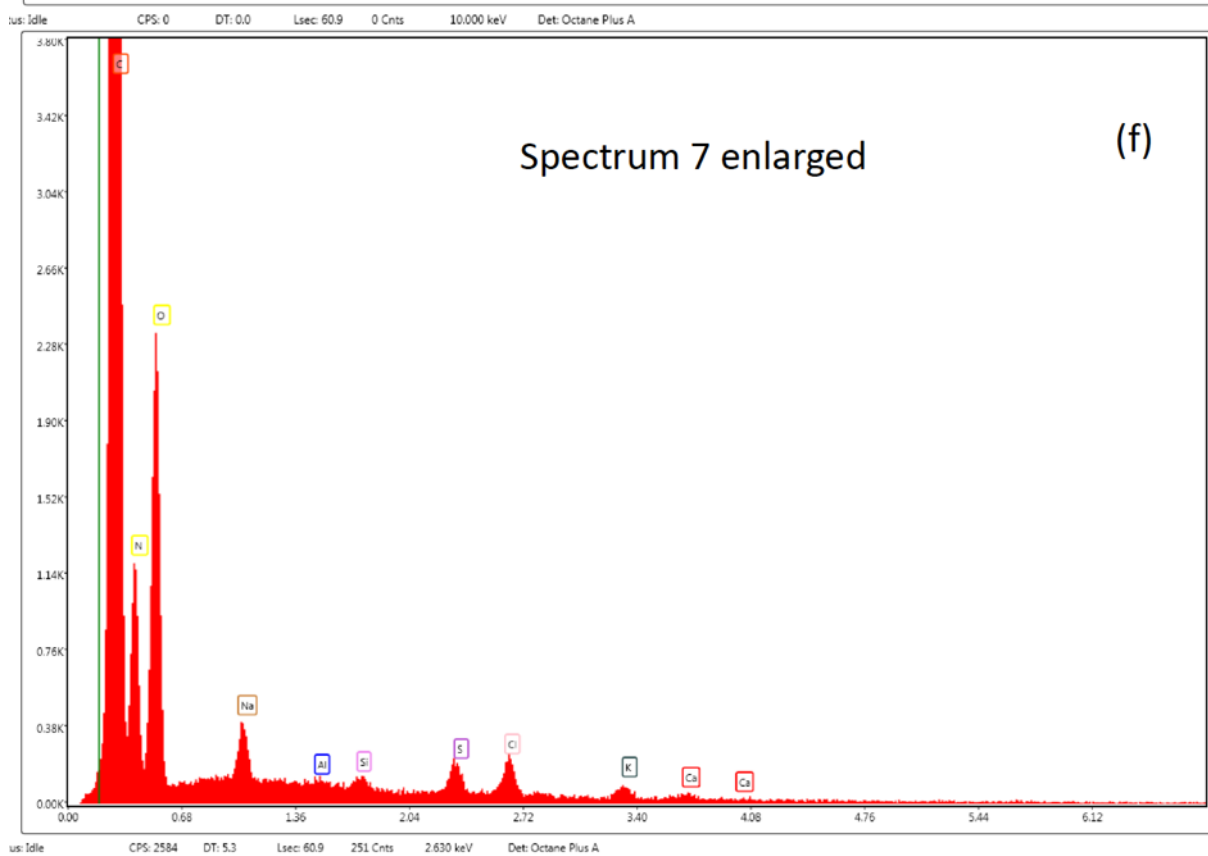
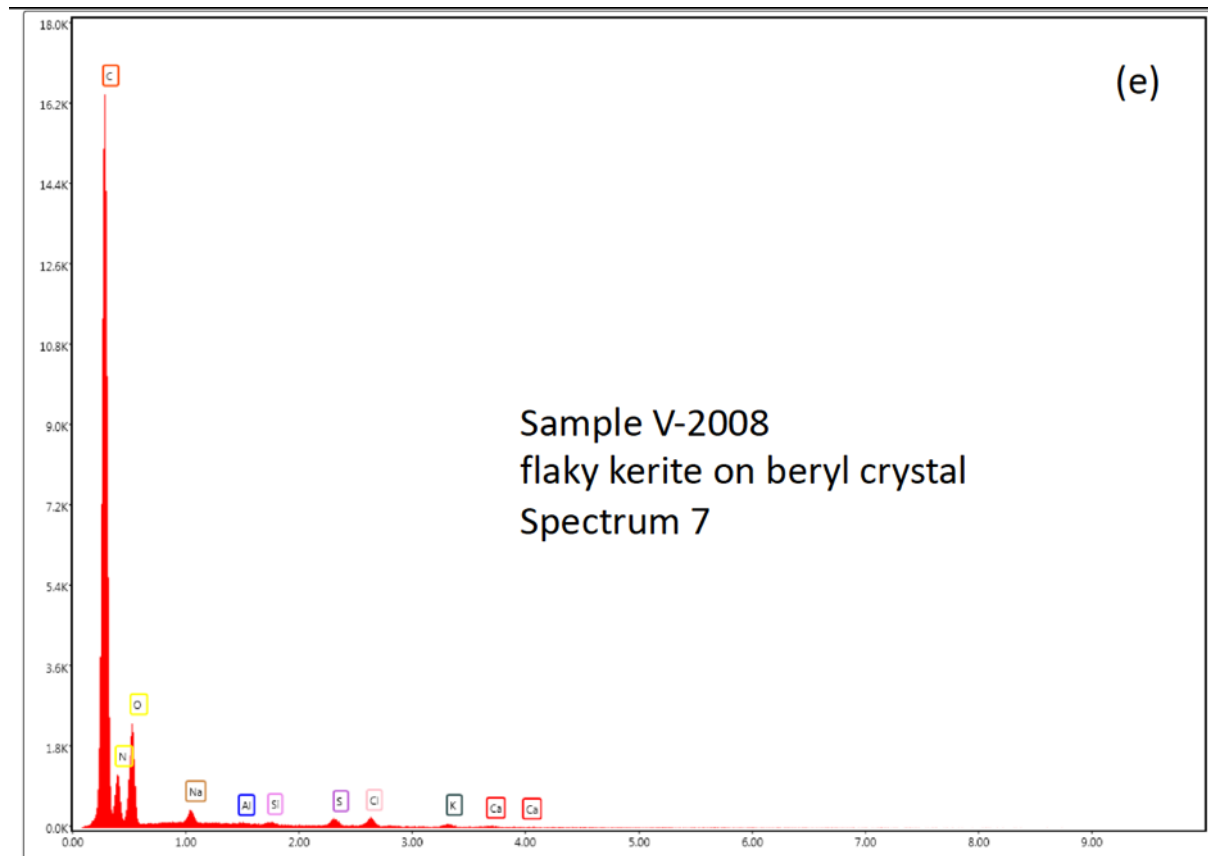
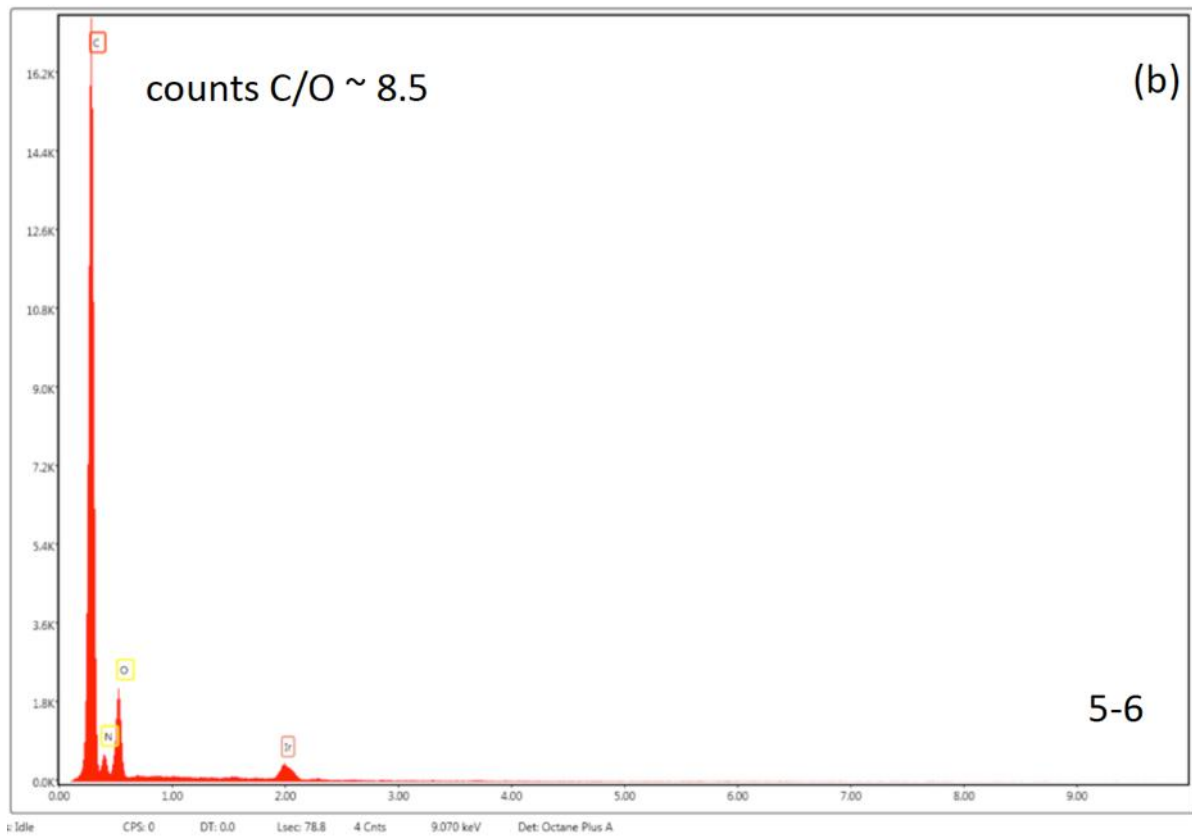
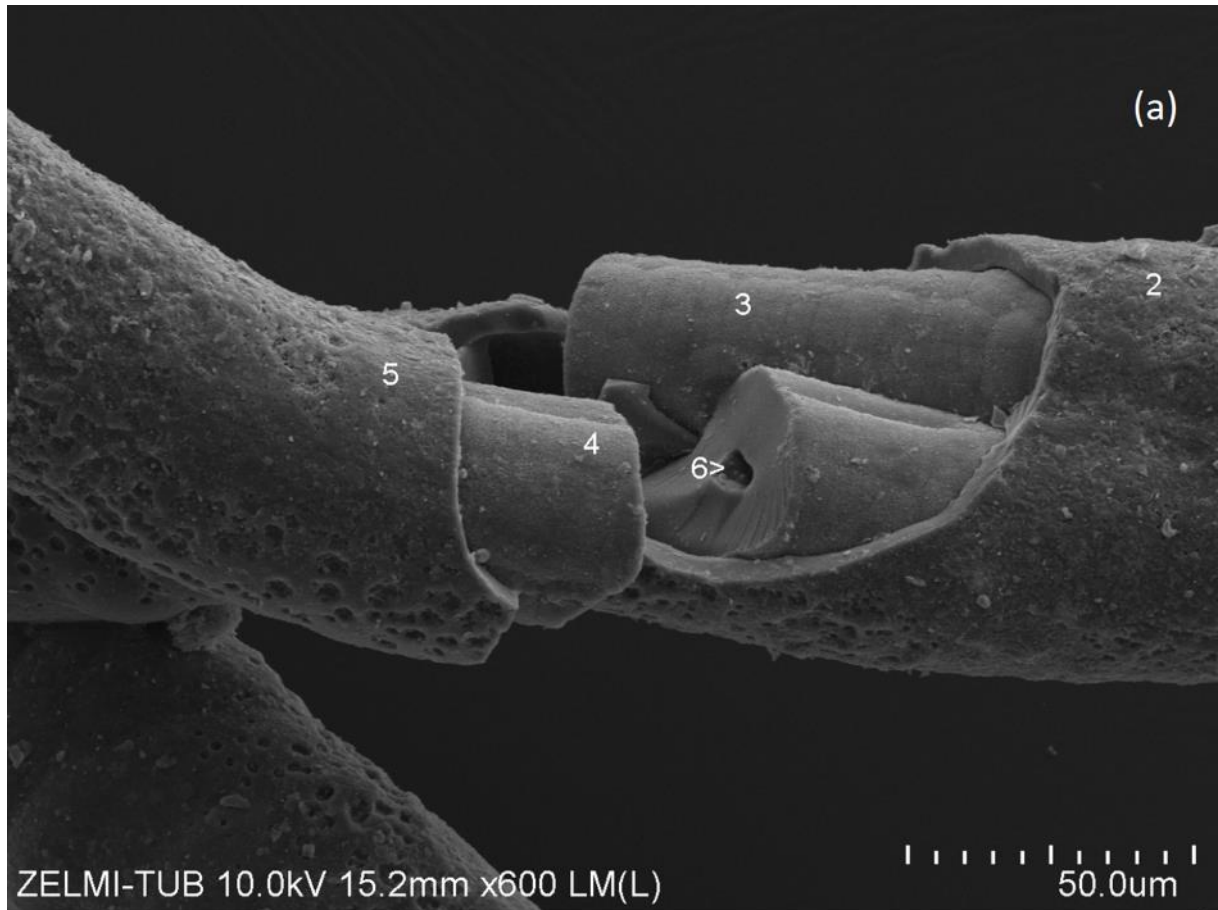
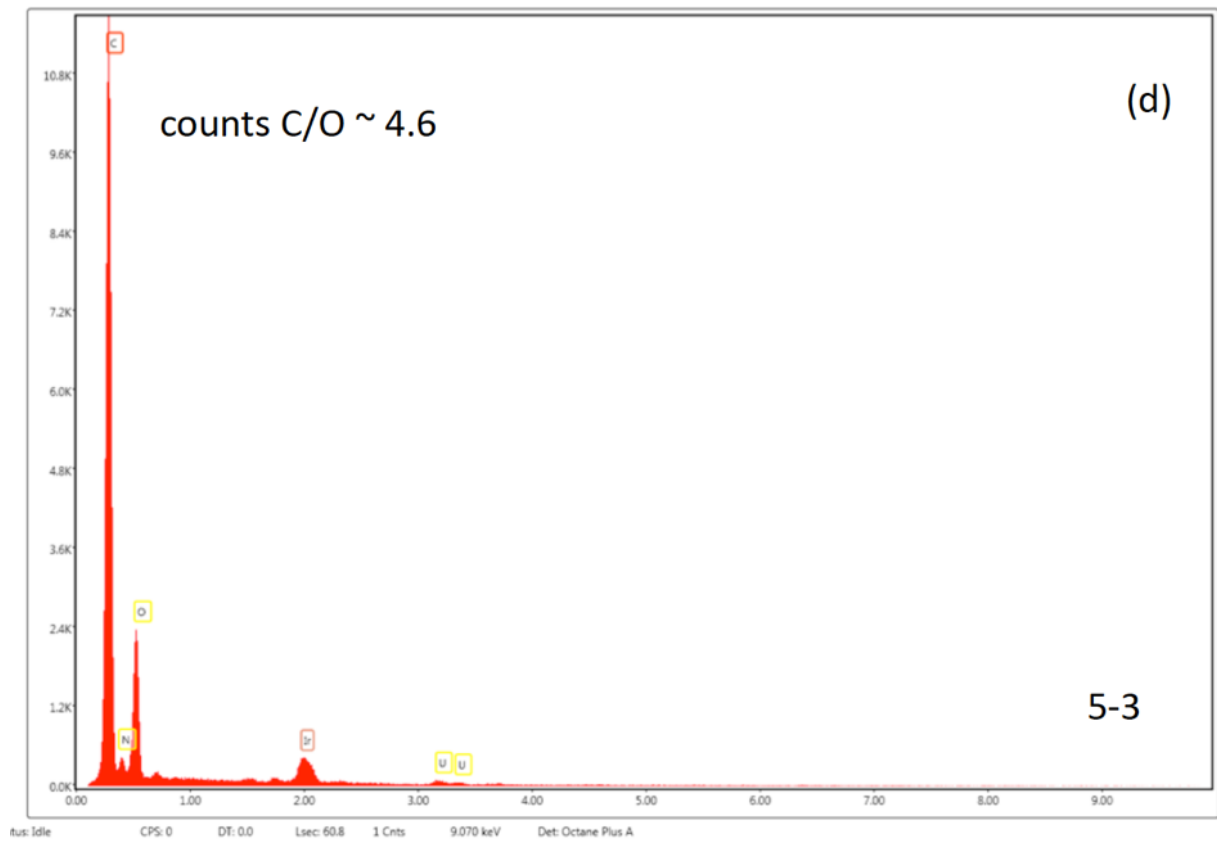
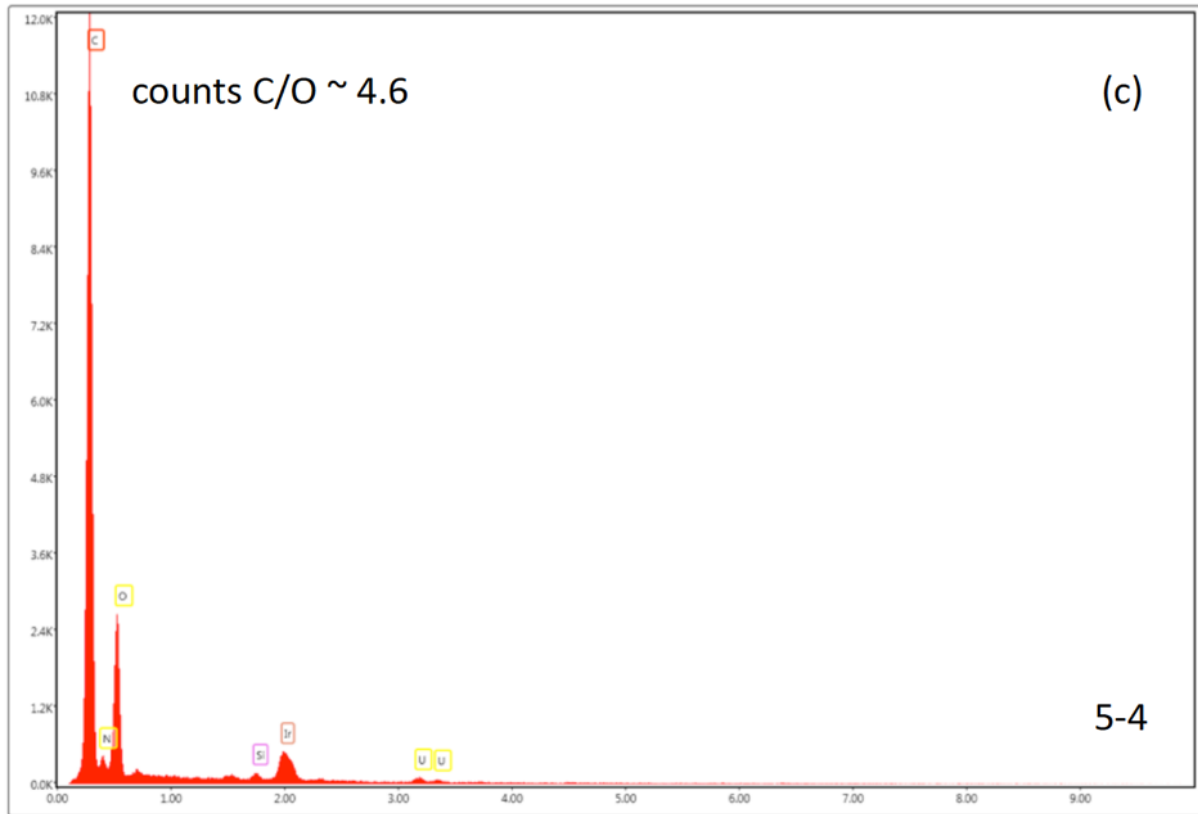


Fig. S2(a-f): EDS spectra 5,6, and 7 of flaky kerite in etch pits of beryl. The sample V-2008 was coated with C (in contrast to the other kerite samples, which were coated with Ir).





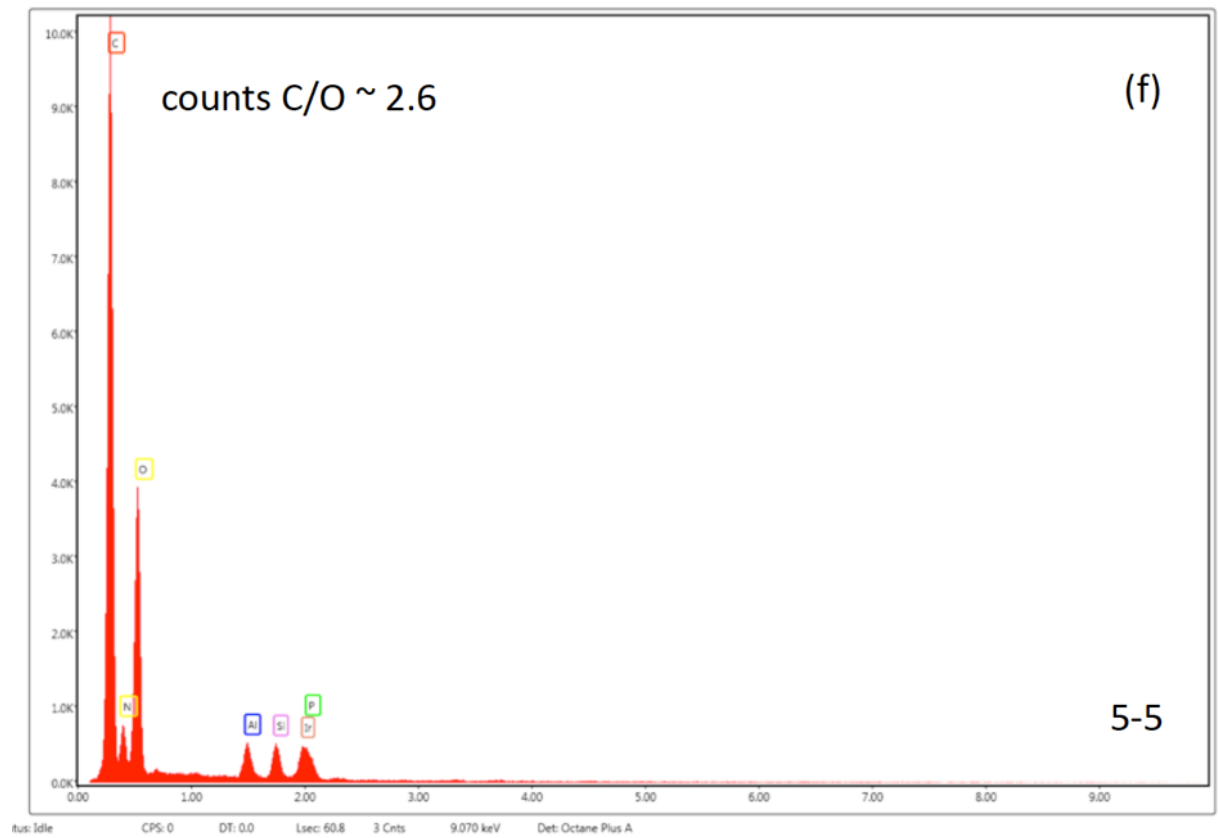
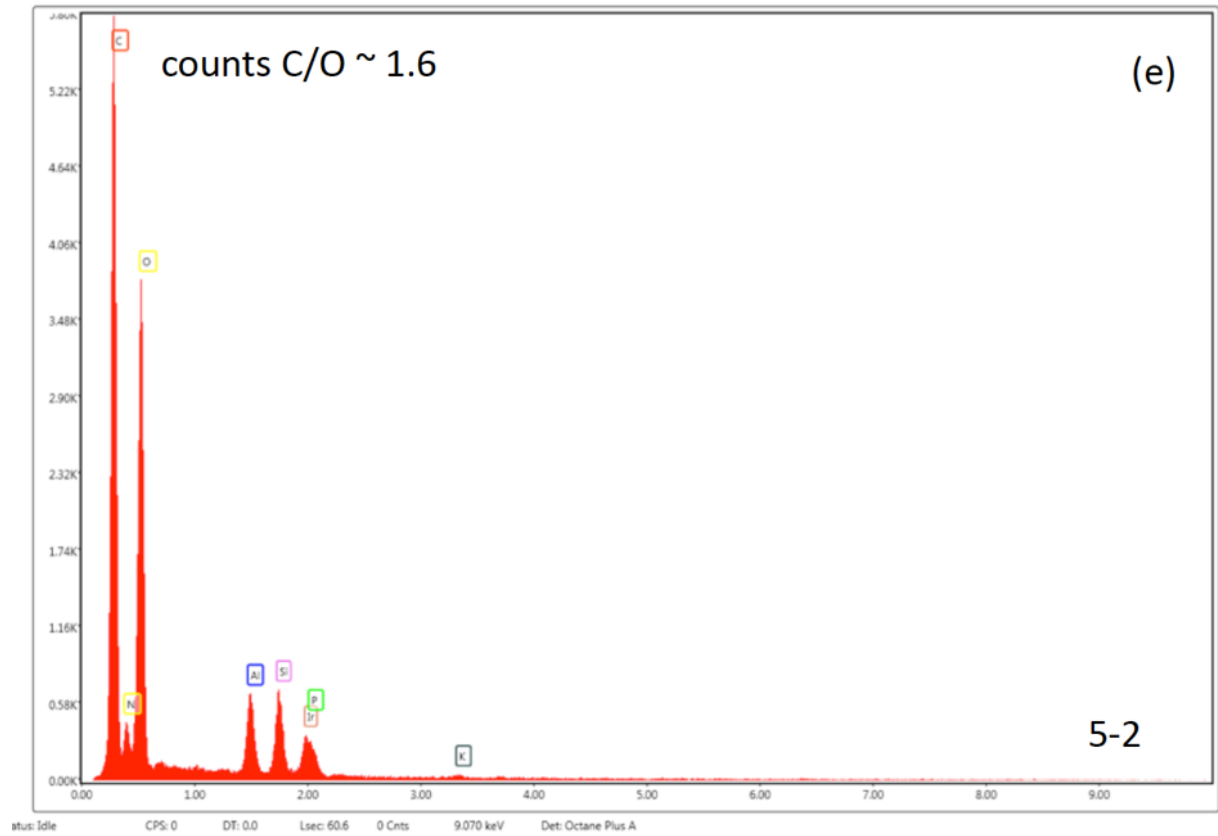


Fig. S3: BSE image (a) and corresponding EDS analyses (b-f), labeled 5-2 to 5-6, of filamentous kerite with sheath-like structure. The peak count ratio for C/O decreases from the central (analysis 6) to the outer part (analyses 5 & 2).

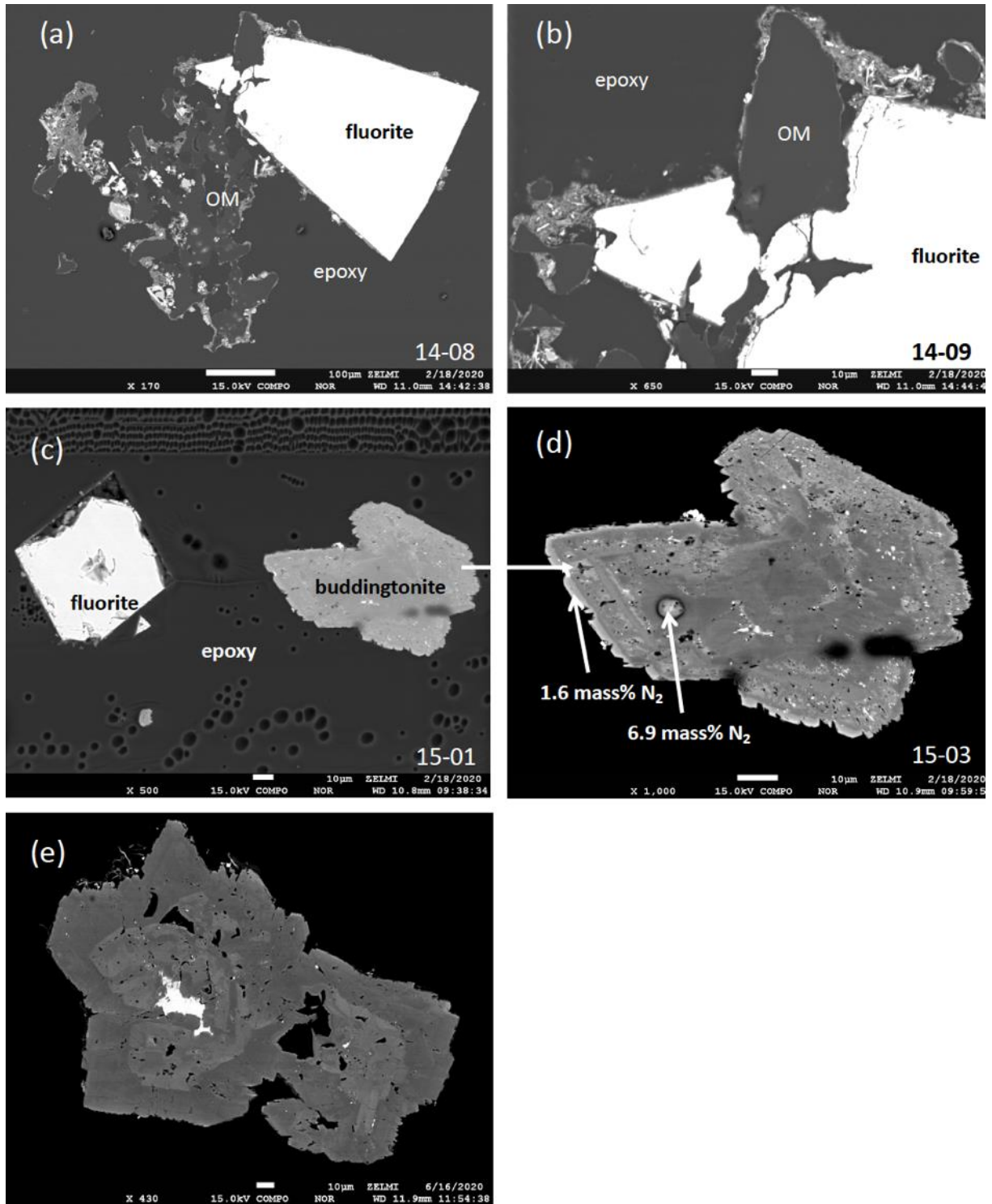


Fig. S4: BSE images of grain mounts in epoxy, showing fluorite, closely intergrown with kerite (OM), and zoned buddingtonite
 (a,b) Kerite 14
 (c,d) Kerite 15; inclusions with high contrast are Fe-oxide
 (e) Kerite 11; outer zones with high contrast are rich in K, poor in NH₄. Inner, irregular white grain is relict, igneous K-feldspar.

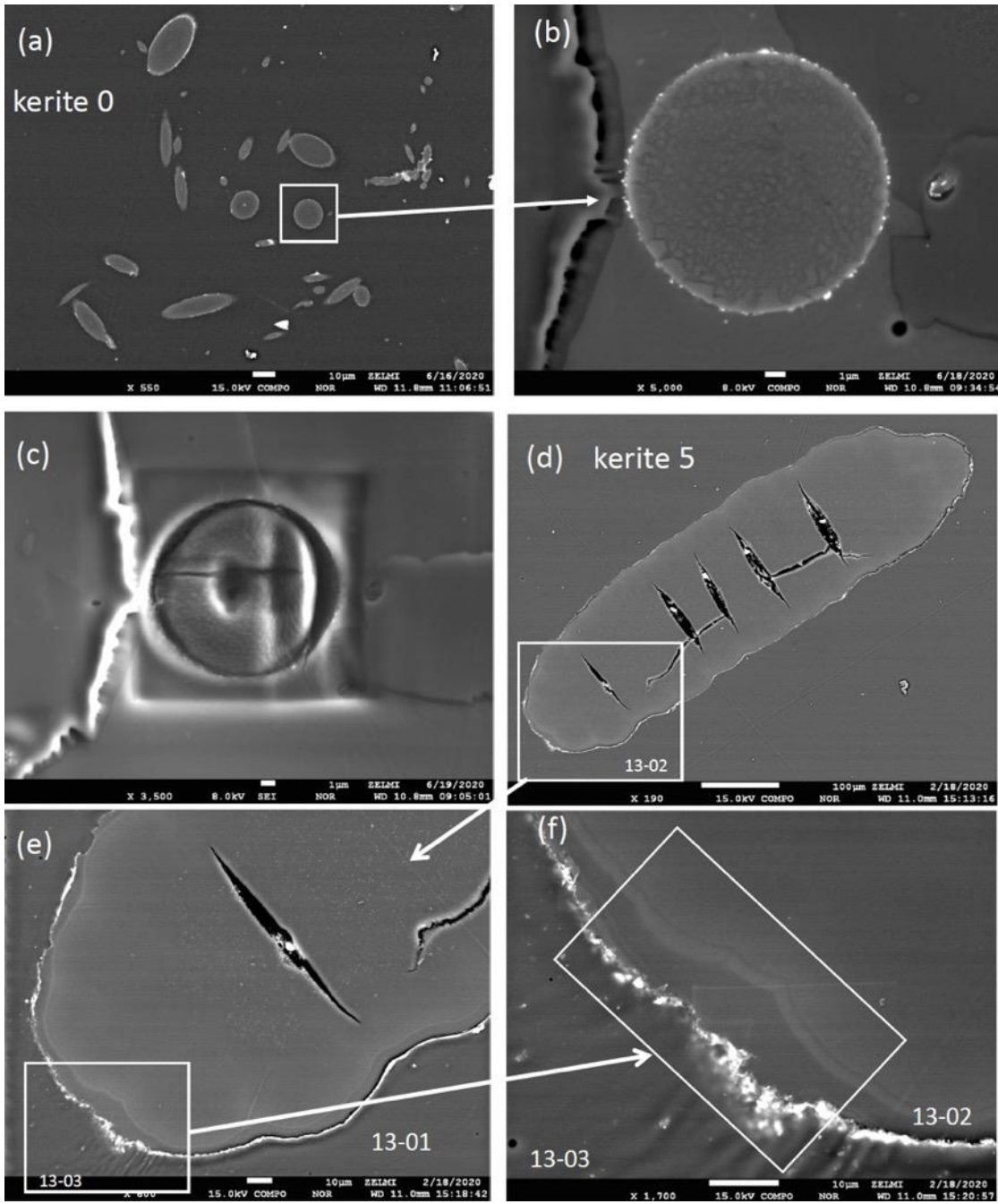


Fig. S5: BSE images of selected areas for element mapping (a, b, e, f); (c) is combined SEM/BSE after mapping. (a,b) are for element distribution maps in Fig. S5.

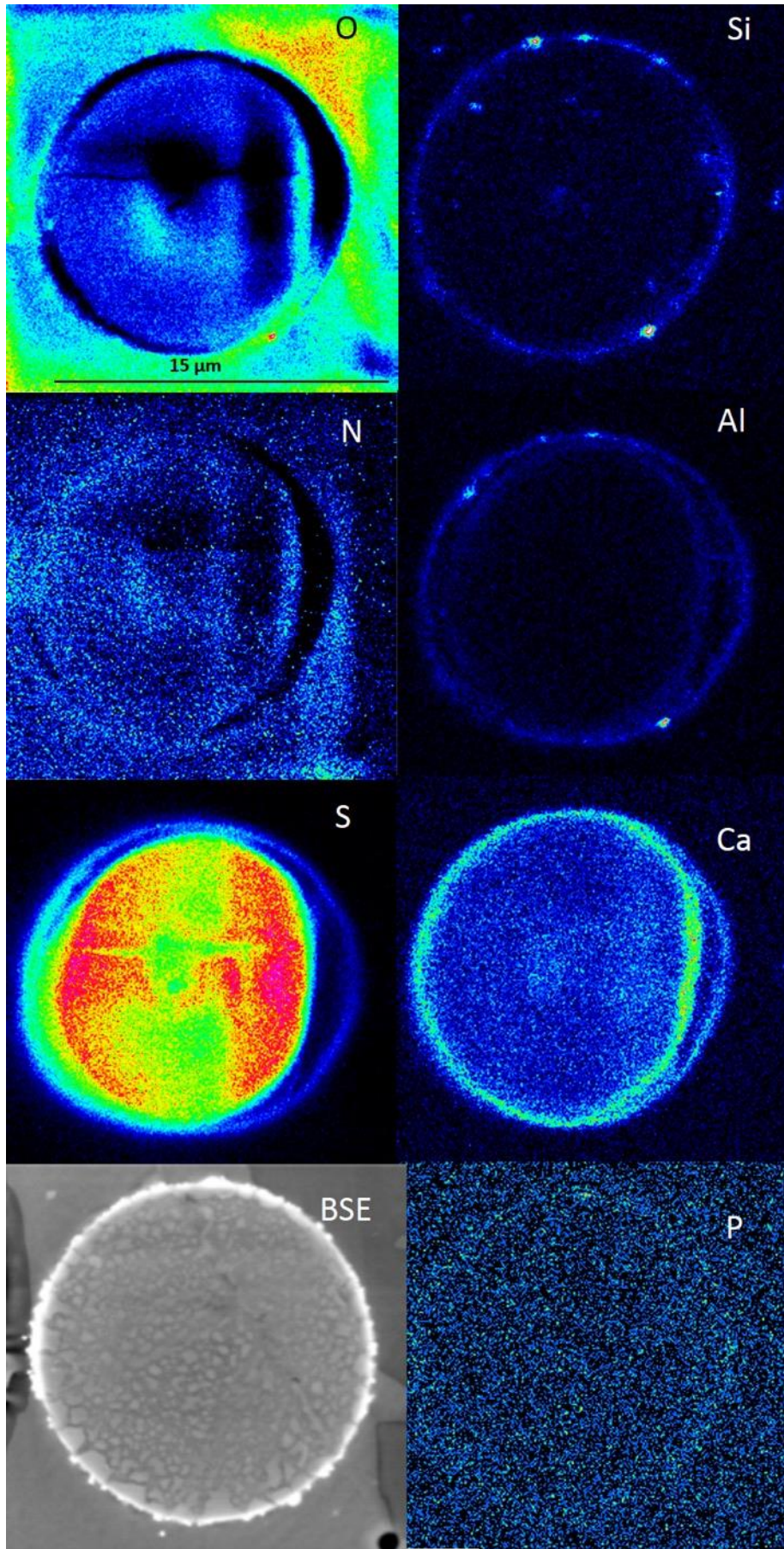


Fig. S6: Element distribution of cross section of filament, sample kerite 0.

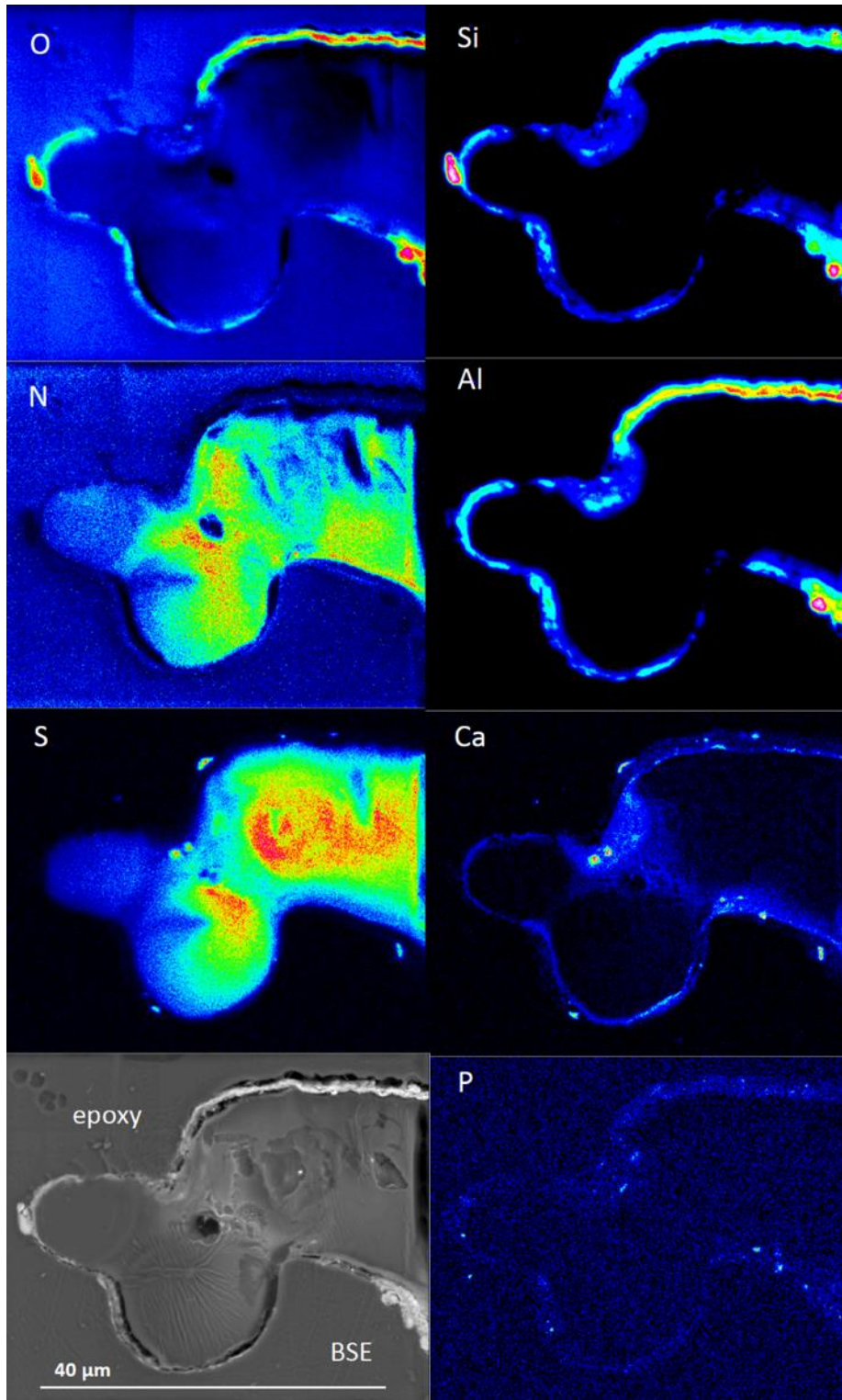


Fig. S7: Element distribution of globular-flaky object of kerite (sample 11). Note clearly visible phosphatization.

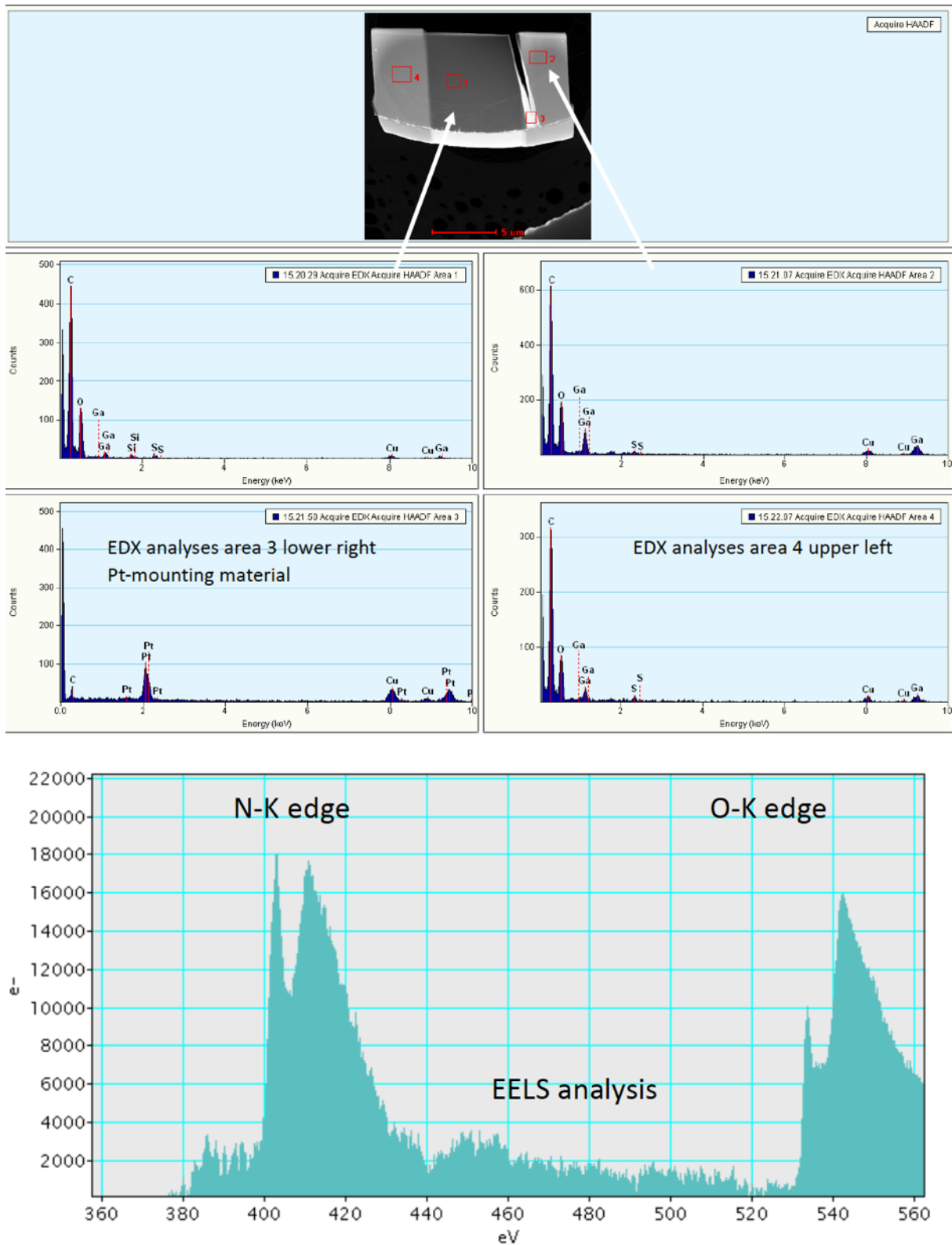
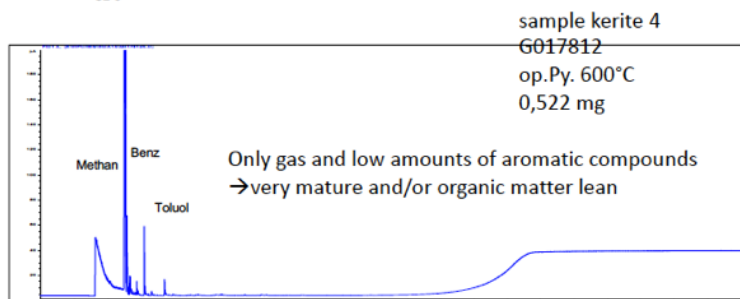
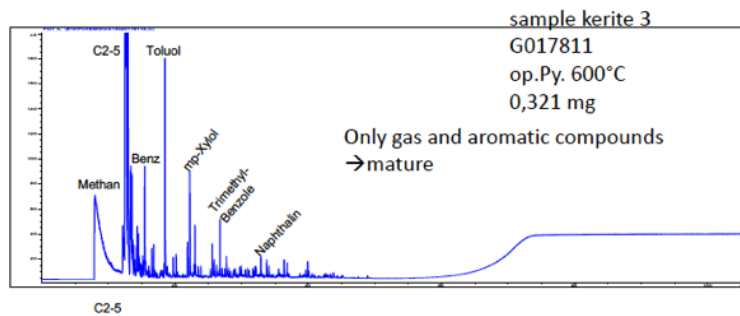
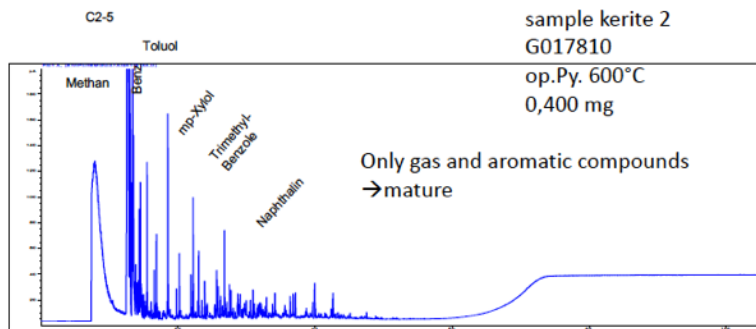
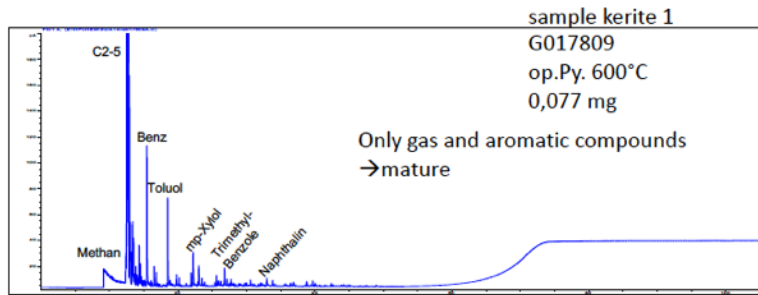


Fig. S8: Analytical TEM investigation, sample kerite 0; FIB foil #5047

Results of open system pyrolysis

kerite 1	G017809	mature
kerite 2	G017810	mature
kerite 3	G017811	mature
kerite 4	G017812	very mature/OM lean
kerite 5	G017813	mature
kerite 6	G017814	mature
kerite 7	G017815	mature
9 topaz with OM	G017816	very mature/OM lean



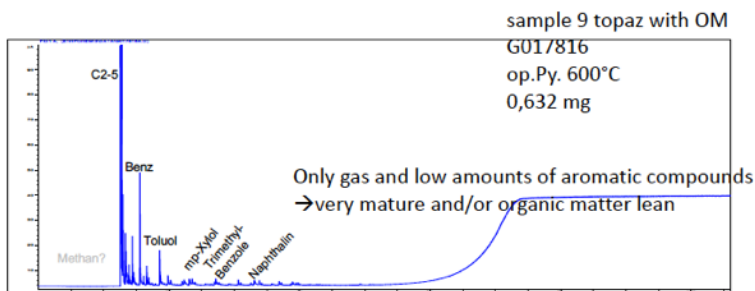
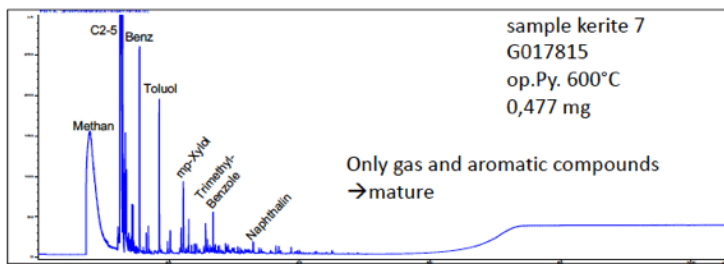
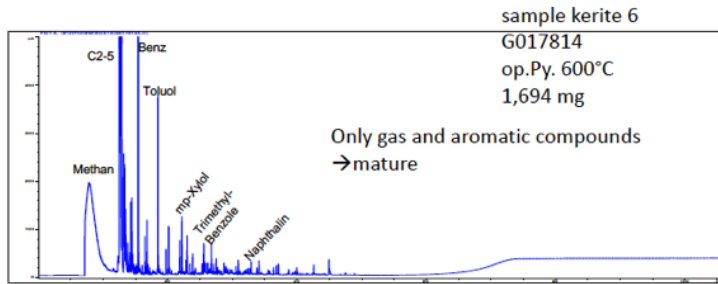
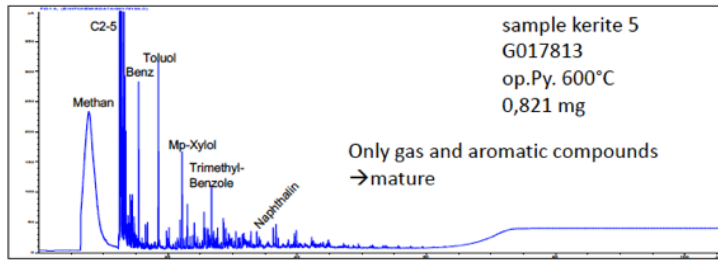


Fig. S9: Pyrolysis results of samples kerite 1 to 7, and OM sample 9.

Table S1: Trace and major elements of black opal; samples BO31, 41 and 72 were used for U-Pb age determination

Element	Signal	BO31 µg/g	BO41 µg/g	BO72 µg/g
As	As75(HR)	0.04	0.17	0.05
Ba	Ba137(LR)	0.10	16.27	6.71
Be	Be9(MR)	0.07	5.82	8.24
Cd	Cd114(LR)	0.00	0.02	0.01
Co	Co59(MR)	0.02	0.74	0.47
Cr	Cr52(MR)	0.13	1.79	3.04
Cs	Cs133(MR)	0.01	0.79	0.02
Cu	Cu63(MR)	0.49	0.89	0.21
Ga	Ga69(MR)	0.02	0.84	0.29
Hf	Hf178(LR)	0.00	1.18	0.60
Li	Li7(LR)	5.13	79.13	0.24
Mo	Mo98(MR)	0.03	0.62	0.50
Nb	Nb93(MR)	0.16	0.72	0.77
Ni	Ni60(MR)	0.12	0.85	0.64
Pb	tot	0.92	2.06	0.08
Rb	Rb85(MR)	0.07	24.68	1.23
Sc	Sc45(MR)	0.01	2.94	2.50
Sn	Sn118(LR)	0.06	0.41	0.22
Sr	Sr86(MR)	0.07	4.26	4.30
Ta	Ta181(LR)	0.01	0.12	0.04
Th	Th232(LR)	0.00	9.88	0.66
U	U238(LR)	0.01	11.48	3.60
V	V51 (HR)	0.02	5.68	10.40
W	W182(HR)	0.02	0.54	0.13
Zn	Zn66(MR)	0.50	29.53	4.95
Zr	Zr90(MR)	0.11	72.17	73.01

Analysis No.	Sample V-2008 EMPA			
	1	2	3	4
Oxide	wt%	wt%	wt%	wt%
SiO2	95.84	96.8	95.32	95.43
TiO2	0.009	bd	0.013	0.003
Al2O3	0.75	0.61	0.71	1.01
Cr2O3	0.01	0.01	0.01	0.02
V2O3	bd	bd	bd	0.02
MgO	0.07	0.06	0.08	0.08
FeO	0.18	0.10	0.16	0.31
MnO	0.01	0.02	bd	bd
CaO	0.26	0.23	0.28	0.33
Na2O	0.03	0.02	0.02	0.15
K2O	0.06	0.05	0.05	0.10
Total	97.21	97.9	96.64	97.44
bd below detection				

Table S2: U-Th isotope data

Material	g sample weight	g sample solution	g spike (U-Th)	235U/238U	SD (%)	230Th/232Th	SD (%)	238U (pmol)	2ε (%)	235U (pmol)	2ε (%)	232Th (pmol)	2ε (%)	238U/232Th	238U/204Pb	1ε (% est.)	232Th/204Pb	1ε (% est.)
UKR1	0.00253	0.1006	0.03704	1.782	0.33	4.272	7.2	1.088	0.66	0.007888	0.66	0.09913	14.4	10.97	29425	5	2682	5
UKR2	0.0009	0.1002	0.03029	4.104	0.41	6.485	3.73	0.3847	0.82	0.00279	0.82	0.03578	7.46	10.75	790	5	73.4	5
UKR3	0.00101	0.1	0.03088	3.496	0.64	6.304	2.78	0.4608	1.28	0.003342	1.28	0.03903	5.56	11.8	16765	5	1420	5
UKR4	0.00038	0.0974	0.03053	6.226	0.43	1.335	2.61	0.2551	0.86	0.00185	0.86	0.3758	5.22	0.6787	235	5	34.5	5
UKR5	0.00043	0.0989	0.02973	3.782	0.68	1.621	2.12	0.4098	1.36	0.002972	1.36	0.2925	4.24	1.401	137	5	97.98	5
UKR6	0.00067	0.0987	0.03078	7.544	0.64	2.844	1.9	0.212	1.28	0.001538	1.28	0.15	3.8	1.413	130	5	92	5

Table S3: Pb-isotope data black opal

Sample	weight (g)	ppm U	ppm Th	ppm Pb tot.	206Pb/204Pb	SD (%)	207Pb/204Pb	SD (%)	208Pb/204Pb	SD (%)	232Th/204Pb	SD (%)	238U/204Pb	SD (%)
BO 1-1 black opal	0.00633	7.490	2.181	0.743	66.57	0.34	18.02	0.50	70.19	0.21	405.9	1.46	1394.68	3.82
BO 1-2 black opal	0.01036	19.40	11.812	1.537	62.08	0.42	17.93	0.79	66.51	0.40	1005	1.60	1654.77	6.15
BO 2-1 feldspar	0.00488	0.378	0.701	13.148	16.46	0.69	15.58	0.26	36.22	0.40	1.625	0.59	0.88	7.43
BO 2-2 black opal	0.00621	37.17	18.685	5.142	61.2	0.16	18.81	0.40	70.92	0.55	489.7	0.55	974.20	3.11
BO 3-1 black opal	0.02216	0.014	0.004	0.861	19.35	0.51	15.69	0.49	38.94	0.42	0.329	20.70	1.06	1.4
BO 3-2 black opal	0.00802	0.067	0.019	0.727	25.25	0.64	16.12	0.18	43.18	0.63	1.932	6.97	6.91	1.41
BO 4-1 black opal	0.01392	13.00	9.618	1.916	104.2	1.13	19.36	0.83	68.48	0.96	860.8	2.22	1163.12	4.92
BO 4-2 black opal	0.0269	0.065	0.042	0.376	18.85	0.37	15.75	0.54	38.64	0.49	7.229	13.40	11.35	0.62
BO 5-1 black opal	0.01289	7.527	0.300	0.145	44.89	0.57	16.69	0.70	41.74	1.02	191.1	1.83	4800.48	0.71
BO 5-2 black opal	0.01489	7.586	0.327	0.094	69.09	0.53	16.86	0.14	41.77	0.27	398.8	2.20	9241.76	3.46
BO 6-1 black opal	0.00894	5.672	0.641	0.116	152.3	5.81	21.11	5.46	53.02	5.25	1.114	6.74	9866.42	2.39
BO 7-1 black opal	0.01646	3.786	0.617	0.076	302.2	4.61	20.7	5.49	54.99	3.65	2722	4.96	16700.50	1.88
BO 7-2 black opal	0.02329	4.400	0.659	0.079	167.1	2.20	18.29	3.13	45.86	2.79	1713	1.35	11450.34	4.69