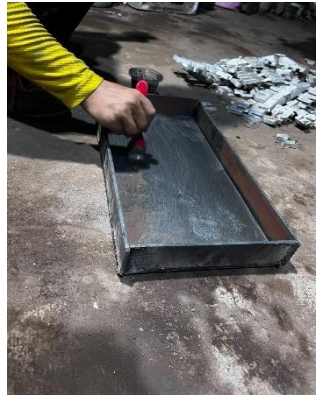


LAMPIRAN

Lampiran proses peleburan



Memasukkan aluminium ke dalam tungku krusibel



Melapisi permukaan dengan fluks



Memanaskan cetakan



Mengambil aluminium cair pada tungku krusibel



Proses penuangan aluminium ke dalam cetakan



Membongkar hasil aluminium cair yang sudah membeku

Lampiran proses pembuatan sampel



Menghaluskan
permukaan hasil coran



Pemotongan awal
menggunakan gerinda
duduk



Pemtongan ke 2 dengan
frais milling

Lampiran jumlah sampel



Lampiran perlakuan panas T6



Heat treatment/proses pelarutan



Heat treatment 540°C selama 1 jam



Proses *artificial aging*/penuaan buatan



Perlakuan panas T6, 165°C selama 1,5 jam



Perlakuan panas T6, 165°C selama 2,5 jam



Perlakuan panas T6, 165°C selama 3,5 jam



Perlakuan panas T6, 185°C selama 1,5 jam



Perlakuan panas T6, 185°C selama 2,5 jam



Perlakuan panas T6, 185°C selama 3,5 jam



Perlakuan panas T6,
205°C selama 1,5 jam



Perlakuan panas T6,
205°C selama 2,5 jam



Perlakuan panas T6, 205°C
selama 3,5 jam

Proses Pengujian Brinell



Meletakkan sampel uji
pada alas alat uji



Proses penataan titik
penekanan



Proses penekanan bola
indenter

Hasil uji kekerasan raw material

	LABORATORIUM UJI BAHAN	No. Dokumen	:	
	POLITEKNIK PERKAPALAN NEGERI SURABAYA	Tanggal	:	
	HARDNESS TEST - BRINELL	Revisi	:	

SPK No. : 10-V/PL19/BJP/2026
Customer : Sdr A. Yusuf Sya'ban
Project : -
Specimen : RAW
Material : Aluminium 6061
Dimension : as received
Test Method : ASTM E10

Weld. Process : -
Position : -
Welder : -
Reff. Code : -

Equipment

Name : Digital Brinell Tester
Brand/Type : TIME / TBH-3000D

Manufacturer : TIME - China
Serial Number : 155SHBW22406

Test Result:

Test Load : 125kgf		Indentor : Ball Ø5mm			Dwell time : 15 s	
No.	Sample Stamp	Position	Location	Hardness Value (BHN)	Average (BHN)	Remark
1	RAW	-	1	82,88	81,04	
2		-	2	78,87		
3		-	3	81,38		

Surabaya, May 29, 2026


(.....)

	LABORATORIUM UJI BAHAN		No. Dokumen	:	
	POLITEKNIK PERKAPALAN NEGERI SURABAYA		Tanggal	:	
	HARDNESS TEST - BRINELL		Revisi	:	

No	D(mm)	HB						
01	1.373	082.88						
02	1.407	078.87						
03	1.385	081.38						
MIN= 078.87			AV= 081.04		MAX= 082.88		P= 00	
HV			No. 03		2026/05/29_15:36:37			
Loading	Indenter	Dwell	Light	Change	Time			
125	5.0 mm	15S	10 %	HV	MIN			

Hasil Uji kekerasan T6

	LABORATORIUM UJI BAHAN	No. Dokumen	:	
	POLITEKNIK PERKAPALAN NEGERI SURABAYA	Tanggal	:	
	HARDNESS TEST - BRINELL	Revisi	:	

SPK No. : 74-V/PL19/BJP/2026
 Customer : Sdr. Muizur Rizal Ubaidillah
 Project : -
 Specimen : Cast
 Material : Aluminium 6061
 Dimension : as received
 Test Method : ASTM E10

Weld. Process : -
 Position : -
 Welder : -
 Reff. Code : -

Equipment

Name : Digital Brinell Tester
 Brand/Type : TIME / TBH-3000D

Manufacturer : TIME - China
 Serial Number : 15SSHBW22406

Test Result:

Test Load : 125kgf		Indentor : Ball Ø5mm			Dwell time : 15 s	
No.	Sample Stamp	Position	Location	Hardness Value (BHN)	Average (BHN)	Remark
1	Tanpa T6	-	1	58,58	51,34	
2		-	2	45,90		
3		-	3	49,55		
4	T6-16S-1.5	I1	1	58,40	58,95	
5			2	59,41		
6			3	59,03		
7		I2	1	54,11	54,36	
8			2	54,86		
9			3	54,11		
10		I3	1	22,88	22,44	
11			2	22,61		
12			3	21,82		
13		I1	1	67,63	61,14	
14			2	58,95		
15			3	56,84		
16	T6-16S-2.5	I2	1	61,05	58,13	
17			2	56,13		
18			3	57,22		
19		I3	1	60,85	64,78	
20			2	67,98		
21			3	65,52		

	LABORATORIUM UJI BAHAN		No. Dokumen	:	
	POLITEKNIK PERKAPALAN NEGERI SURABAYA		Tanggal	:	
	HARDNESS TEST - BRINELL		Revisi	:	

No.	Sample Stamp	Position	Location	Hardness Value (BHN)	Average (BHN)	Remark
22	T6-165-3.5	I1	1	56,57	57,63	
23			2	58,76		
24			3	57,57		
25		I2	1	59,14	59,25	
26			2	56,75		
27			3	61,86		
28		I3	1	58,21	59,10	
29			2	57,65		
30			3	61,45		
31	T6-185-1.5	I1	1	55,47	54,35	
32			2	51,95		
33			3	55,63		
34		I2	1	62,45	71,09	
35			2	75,41		
36			3	75,41		
37		I3	1	62,66	60,99	
38			2	58,76		
39			3	61,54		
40	T6-185-2.5	I1	1	63,08	67,41	
41			2	75,98		
42			3	63,18		
43		I2	1	71,44	68,49	
44			2	69,61		
45			3	64,42		
46		I3	1	73,46	68,57	
47			2	65,62		
48			3	66,63		
49	T6-185-3.5	I1	1	38,95	58,25	
50			2	64,11		
51			3	71,68		
52		I2	1	59,14	61,60	
53			2	67,07		
54			3	58,58		
55		I3	1	82,46	71,76	
56			2	67,63		
57			3	65,20		

	LABORATORIUM UJI BAHAN		No. Dokumen	:	
	POLITEKNIK PERKAPALAN NEGERI SURABAYA		Tanggal	:	
	HARDNESS TEST - BRINELL		Revisi	:	

No.	Sample Stamp	Position	Location	Hardness Value (BHN)	Average (BHN)	Remark
58	T6-205-1.5	I1	1	24,77	24,84	
59			2	18,87		
60			3	30,89		
61		I2	1	68,34	71,22	
62			2	69,73		
63			3	75,58		
64		I3	1	72,96	75,91	
65			2	79,89		
66			3	74,89		
67	T6-205-2.5	I1	1	31,49	31,22	
68			2	31,90		
69			3	30,27		
70		I2	1	61,54	56,44	
71			2	59,03		
72			3	48,75		
73		I3	1	65,62	67,41	
74			2	70,21		
75			3	66,39		
76	T6-205-3.5	I1	1	52,65	62,08	
77			2	65,62		
78			3	67,98		
79		I2	1	56,67	56,99	
80			2	59,03		
81			3	55,28		
82		I3	1	74,89	67,47	
83			2	62,87		
84			3	64,65		

Surabaya, May 26, 2026


 (.....)

	LABORATORIUM UJI BAHAN	No. Dokumen	:
	POLITEKNIK PERKAPALAN NEGERI SURABAYA	Tanggal	:
	HARDNESS TEST - BRINELL	Revisi	:

[illegible]

Tanpa T6

No	D(mm)	H ₀	07	2,545	022,08			
01	1,629	050,40	08	2,559	022,61			
02	1,616	059,41	09	2,602	021,02			
03	1,620	059,03						
04	1,690	054,11						
05	1,679	054,06						
06	1,690	054,11						
MIN=		021,02	RM=		045,25	PM0=		059,41
			P=		00			
HU		No.		08				
				2026/05/26_09:37:24				
Loadings	Indenter	Dwell	Light	Chance	Time			
125	5.0 mm	15S	10 %	HU	MIN			

T6-165-1.5

No	D(mm)	HB	07	1.597	060.85		
01	1.516	067.63	08	1.513	067.98		
02	1.621	058.95	09	1.540	065.52		
03	1.650	056.04					
04	1.594	061.05					
05	1.660	056.13					
06	1.645	057.22					
MIN= 056.13		HU= 061.35		H50= 067.98		P= 00	
HV		No. 09		2026/05/26_09:51:12			
Loading	Indenter	Duell	Liwh	Chanse	Time		
125	5.0 mm	155	10 %	HV	HV		

T6-165-2.5

No	D(mm)	HD	07	1.632	050.21			
01	1.653	056.57	00	1.629	057.65			
02	1.624	050.76	09	1.589	061.45			
03	1.640	057.57						
04	1.619	059.14						
05	1.652	056.75						
06	1.504	061.06						
HIN= 056.57		HUE= 050.66		HDI= 061.06		P= 00		
HV		No.		09 2026-05-26_10103100				
Loading	Indenter	Dwell	Light	Change	Time			
125	5.0 mm	150	10 %	HV	HIN			

T6-165-3.5

No	D(mm)	HB	07	1.574	062.66				
01	1.670	055.47	08	1.624	058.76				
02	1.724	051.95	09	1.587	061.54				
03	1.668	055.63							
04	1.577	062.45							
05	1.437	075.41							
06	1.438	075.41							
MIN= 051.95		RM= 062.14		MR0= 075.41		P= 00			
HV			No. 09		2026/05/26_10:12:51				
Loading	Indenter	Duell	Light	Change	Time				
125	5.0 mm	155	10 %	HV	RIN				

T6-185-1.5

No	D(mm)	HB	07	1.457	073.46				
01	1.568	063.00	08	1.539	065.62				
02	1.432	075.90	09	1.528	066.63				
03	1.568	065.18							
04	1.476	071.44							
05	1.495	069.61							
06	1.553	064.42							
H1H= 063.00		H2H= 068.16		H3H= 075.90		P= 00			
H4		No. 09		2026-05-26-10:23:17					
Loadings	Indenter	Dwell	Light	Chance	Time				
125	5.0 mm	155	10 %	H1	H1H				

T6-185-2.5

	LABORATORIUM UJI BAHAN		No. Dokumen :	
	POLITEKNIK PERKAPALAN NEGERI SURABAYA		Tanggal :	
	HARDNESS TEST - BRINELL		Revisi :	

No	D(mm)	HB	07	1.377	002.46				
01	1.900	030.95	08	1.517	067.63				
02	1.557	064.11	09	1.543	065.20				
03	1.474	071.60							
04	1.619	059.14							
05	1.522	067.07							
06	1.626	050.50							
MIN= 030.95		RUM= 063.87		HRC= 002.46		P= 00			
HU		No. 09		2026-05-26.10:33:16					
Loading	Indenter	Dwell	Light	Change	Time				
125	5.0 mm	15s	10 %	HU	MIN				

T6-185-3.5

No	D(mm)	HB	07	1.461	072.96				
01	2.453	024.77	08	1.397	079.89				
02	2.781	010.87	09	1.443	074.89				
03	2.212	030.89							
04	1.509	060.34							
05	1.494	069.73							
06	1.436	075.50							
MIN= 010.87		RUM= 057.32		HRC= 079.89		P= 00			
HU			No. 09		2026-05-26.10:48:41				
Loading	Indenter	Dwell	Light	Change	Time				
125	5.0 mm	15s	10 %	HU	MIN				

T6-205-1.5

No	D(mm)	HB	07	1.620	059.03				
01	2.191	031.49	08	1.777	040.75				
02			09	1.539	065.62				
03			10	1.409	070.21				
04	2.178	031.90	11	1.530	066.39				
05	2.233	030.27							
06	1.588	061.54							
MIN= 000.00		RUM= 044.09		HRC= 070.21		P= 00			
HU		No. 11		2026-05-26.11:03:00					
Loading	Indenter	Dwell	Light	Change	Time				
125	5.0 mm	15s	10 %	HU	MIN				

T6-205-2.5

No	D(mm)	HB	07	1.442	074.09				
01	1.713	052.65	08	1.572	062.07				
02	1.539	065.62	09	1.550	064.65				
03	1.513	067.90							
04	1.653	056.67							
05	1.621	059.03							
06	1.673	055.20							
MIN= 052.65		RUM= 062.10		HRC= 074.09		P= 00			
HU		No. 09		2026-05-26.11:13:40					
Loading	Indenter	Dwell	Light	Change	Time				
125	5.0 mm	15s	10 %	HU	MIN				

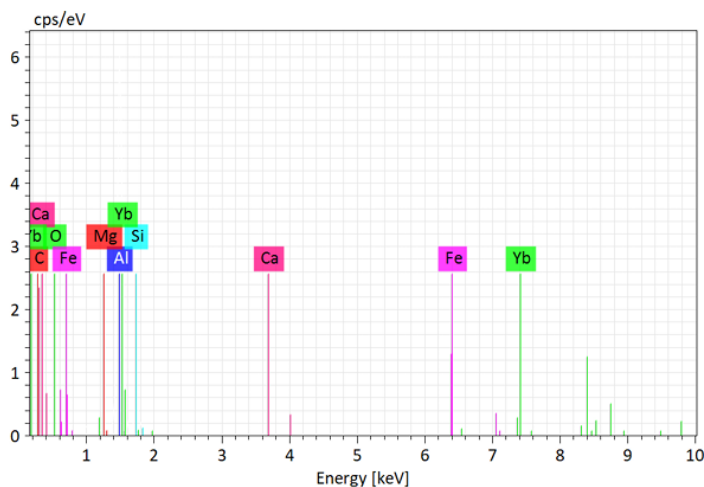
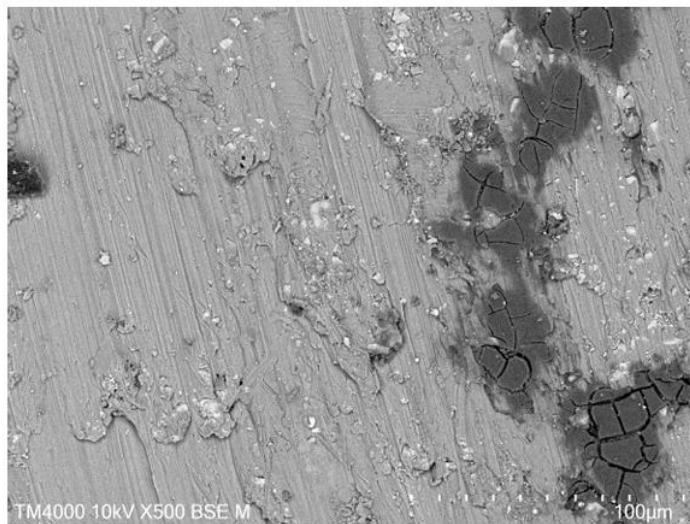
T6-205-3.5

Lampiran Proses pengamatan SEM-EDX



Lampiran hasil SEM-EDX

Sampel A1

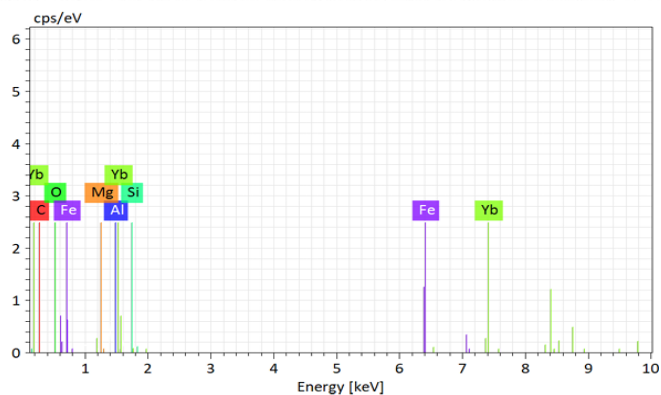
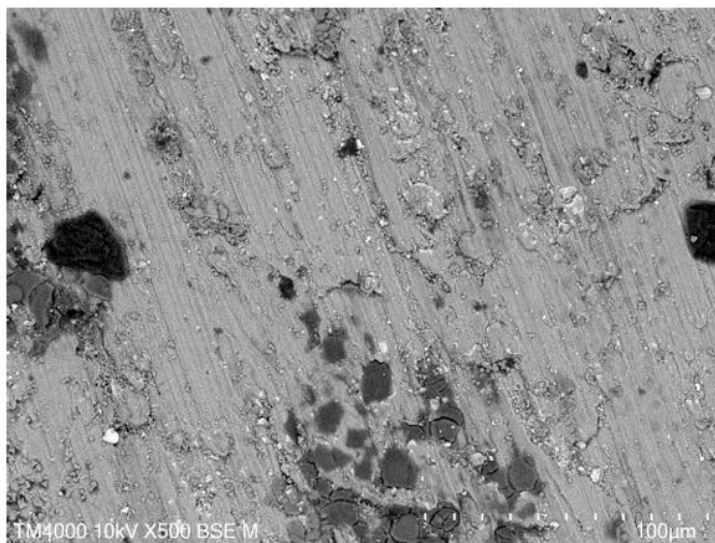


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	2535	26.17	17.76	33.76	4.60	17.23
O	8	4650	16.16	12.25	17.29	3.05	16.01
Mg	12	556	0.70	0.50	0.46	0.09	11.76
Al	13	48230	59.80	45.80	38.99	2.80	4.55
Si	14	4350	9.88	7.40	5.80	0.50	4.84
Ca	20	326	1.13	0.88	0.49	0.10	9.73
Fe	26	310	6.68	4.97	2.01	0.54	8.98
Yb	70	5535	12.66	9.49	1.22	0.60	5.15
		Sum	133.18	100.00	100.00		

Sampel A2

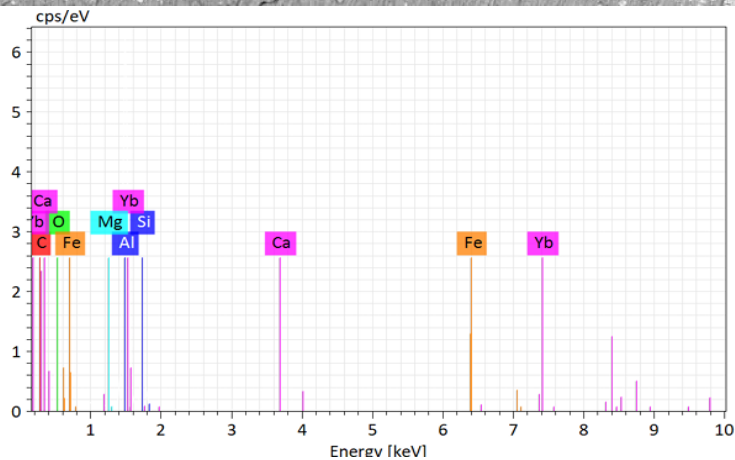
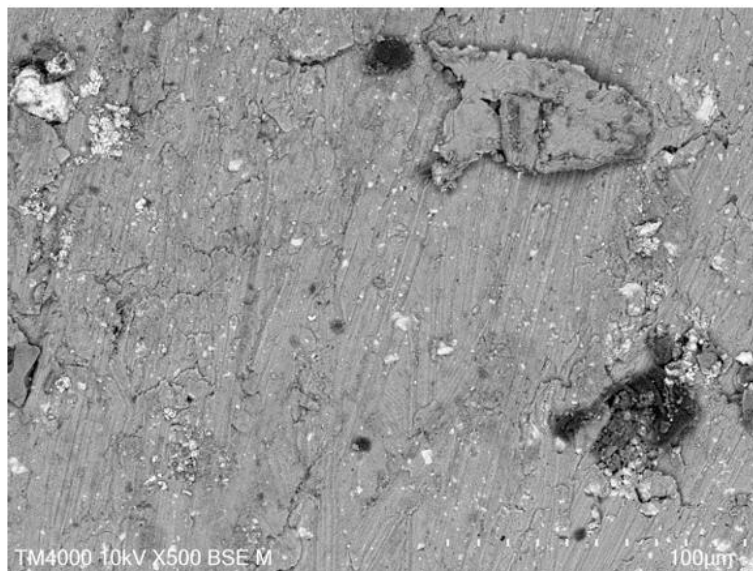


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	2180	17.81	13.52	28.06	3.71	18.71
O	8	3690	9.58	7.04	11.02	1.57	16.92
Mg	12	730	0.41	0.47	0.42	0.06	12.04
Al	13	91610	79.40	59.55	53.48	3.24	4.59
Si	14	3254	6.26	4.45	3.97	0.32	5.07
Fe	26	320	4.30	3.17	2.42	0.45	9.52
Yb	70	9771	16.01	12.05	1.75	0.70	4.63
		Sum	153.77	100.00	100.00		

Sampel A3

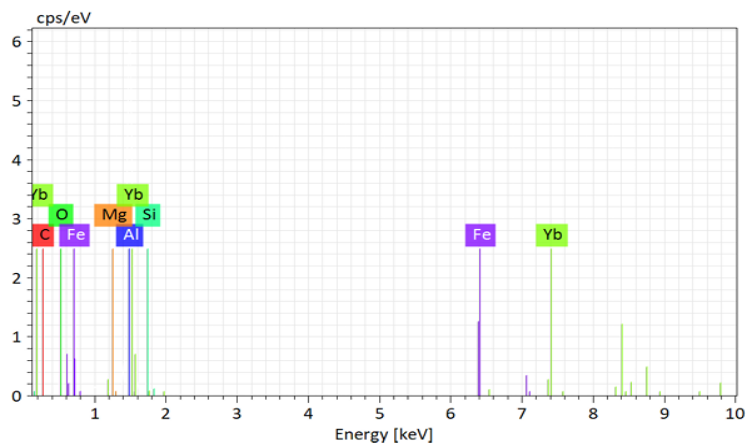
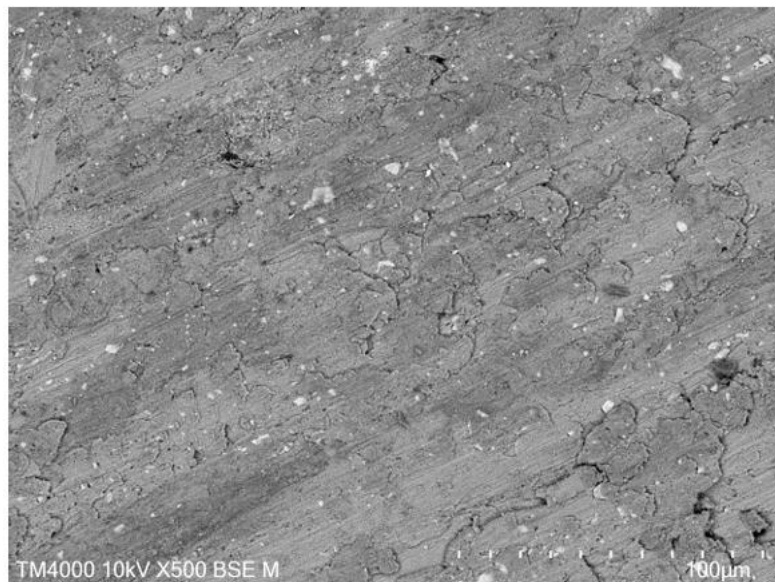


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	1421	21.54	15.81	28.45	4.40	16.70
O	8	4152	21.40	15.76	20.21	3.64	16.30
Mg	12	340	0.65	0.42	0.46	0.10	12.84
Al	13	32565	59.30	44.80	38.36	2.62	4.60
Si	14	4045	13.15	8.54	7.50	0.53	4.40
Ca	20	122	0.71	0.56	0.45	0.10	9.48
Fe	26	305	5.82	4.21	1.60	0.45	7.15
Yb	70	4100	12.59	9.49	1.29	0.69	4.55
		Sum	132.16	100.00	100.00		

Sampel B1

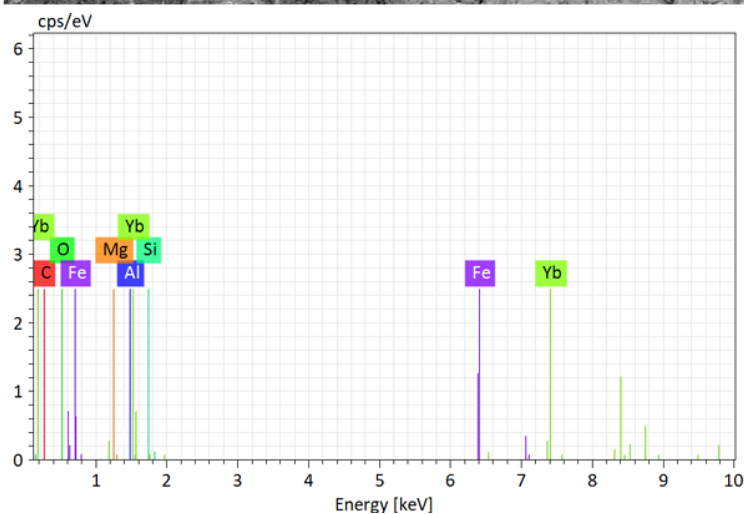


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	2180	17.81	13.52	28.06	3.71	18.71
O	8	3690	9.58	7.04	11.02	1.57	16.92
Mg	12	730	0.41	0.47	0.42	0.06	12.04
Al	13	91610	79.40	59.55	53.48	3.24	4.59
Si	14	3254	6.26	4.45	3.97	0.32	5.07
Fe	26	320	4.30	3.17	2.42	0.45	9.52
Yb	70	9771	16.01	12.05	1.75	0.70	4.63
		Sum	153.77	100.00	100.00		

Sampel B2

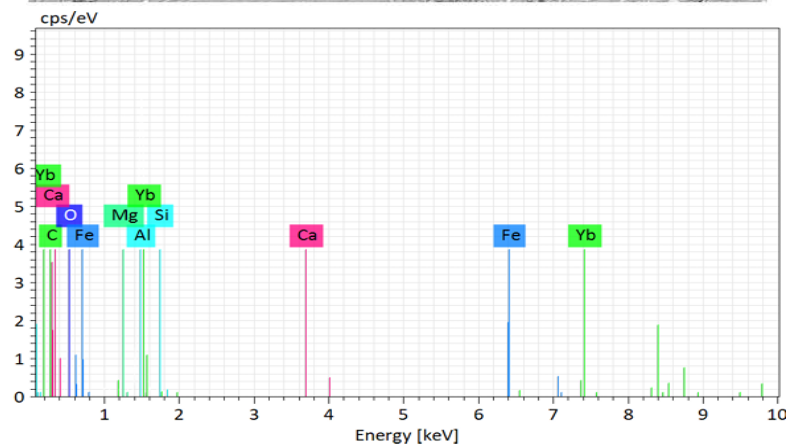
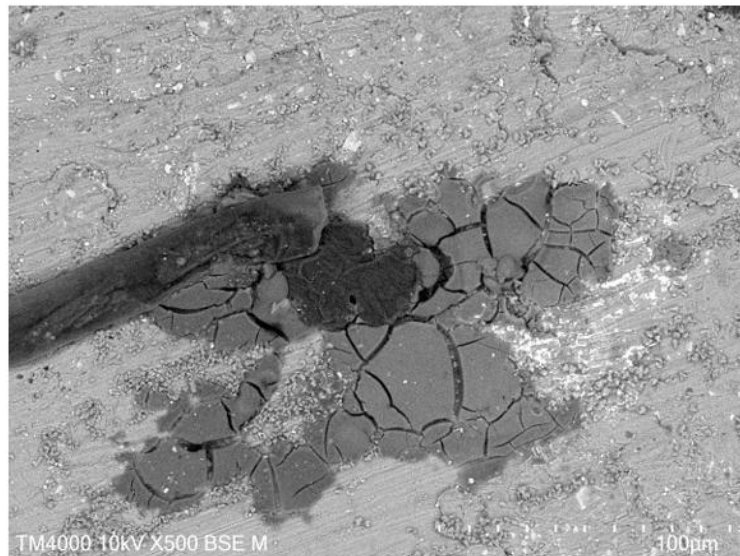


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	2180	17.81	13.52	28.06	3.71	18.71
O	8	3690	9.58	7.04	11.02	1.57	16.92
Mg	12	730	0.41	0.47	0.42	0.06	12.04
Al	13	91610	79.40	59.55	53.48	3.24	4.59
Si	14	3254	6.26	4.45	3.97	0.32	5.07
Fe	26	320	4.30	3.17	2.42	0.45	9.52
Yb	70	9771	16.01	12.05	1.75	0.70	4.63
		Sum	153.77	100.00	100.00		

Sampel B3

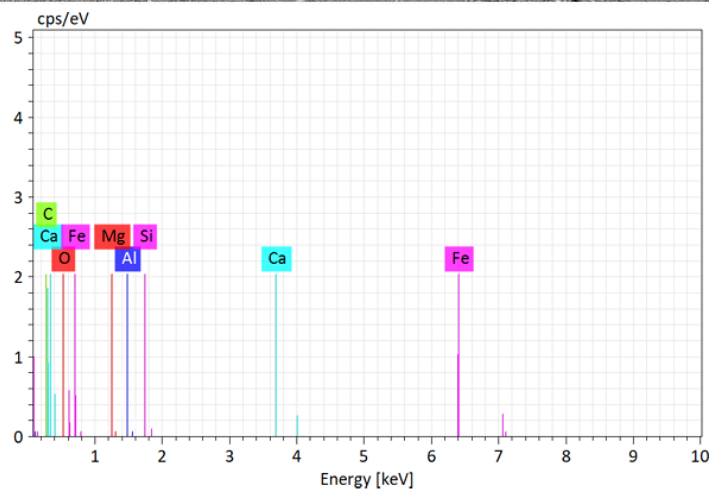
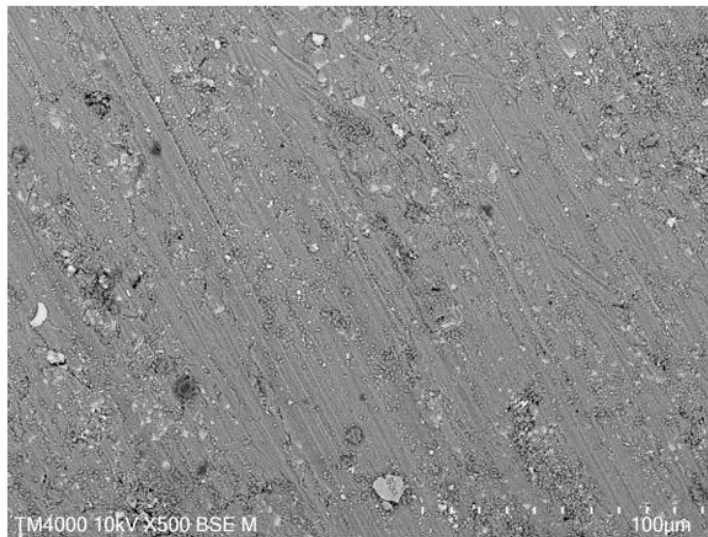


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	823	14.57	11.20	28.99	3.60	19.82
O	8	4132	25.14	16.43	26.57	3.93	16.29
Mg	12	1133	2.55	1.81	1.81	0.12	7.41
Al	13	29542	65.40	49.88	42.84	2.98	4.42
Si	14	1020	4.15	3.15	3.05	0.37	6.30
Ca	20	260	1.60	1.42	0.81	0.14	9.25
Fe	26	123	4.20	3.11	1.31	0.47	10.50
Yb	70	1245	13.59	11.01	1.40	0.69	5.21
		Sum	137.2	100.00	100.00		

Sampel C1

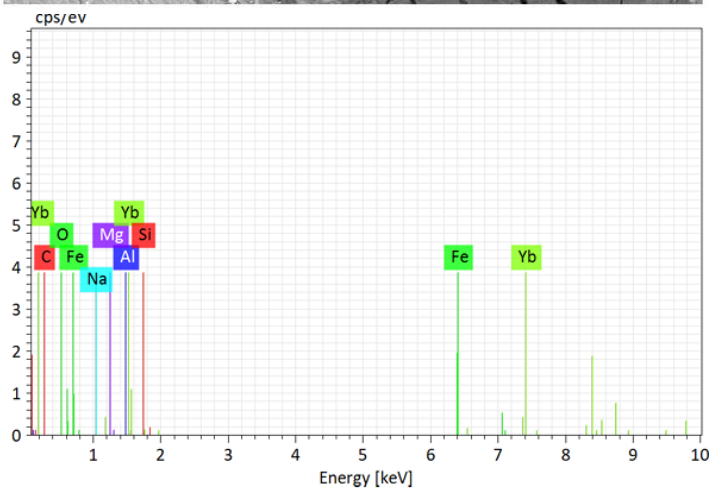
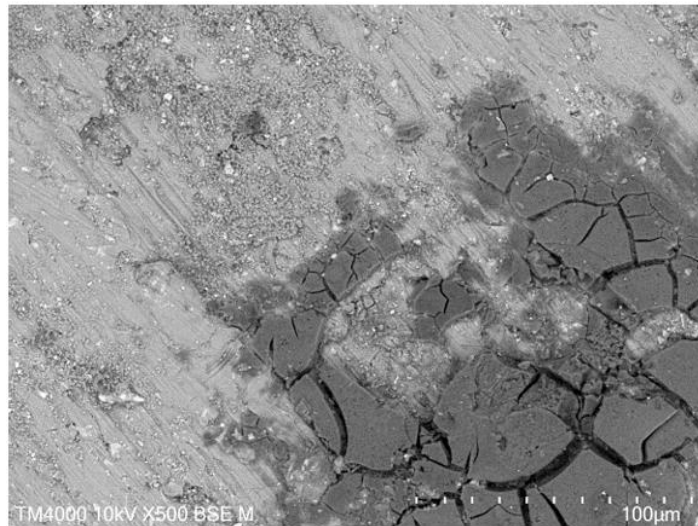


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	1321	11.91	10.63	18.76	2.60	20.98
O	8	10530	23.20	21.88	28.01	3.45	14.00
Mg	12	3402	2.70	2.39	2.10	0.12	6.62
Al	13	83702	67.30	59.90	47.30	3.05	4.50
Si	14	1541	2.22	2.02	1.52	0.14	6.42
Ca	20	636	1.60	1.50	0.73	0.12	6.42
Fe	26	144	1.88	1.68	0.53	0.28	12.30
		Sum	124.53	100.00	100.00		

Sampel C2

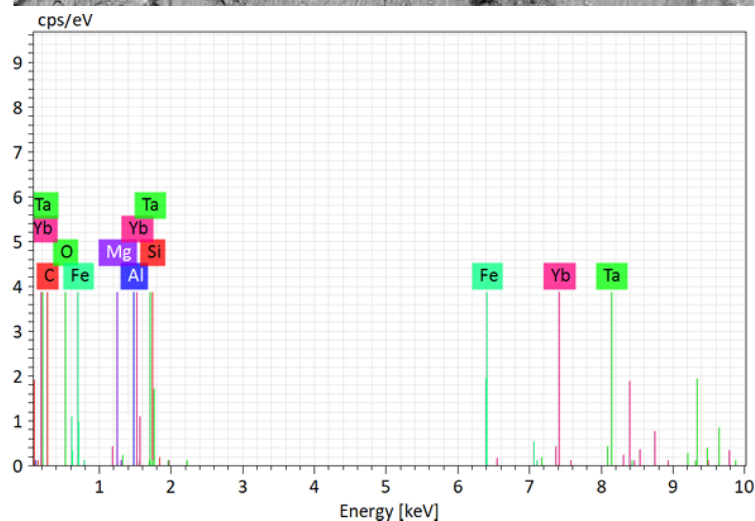
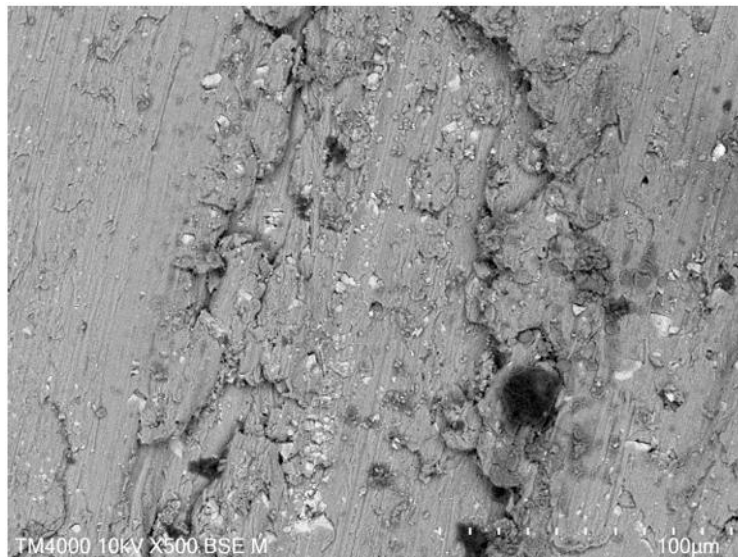


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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	1283	14.59	11.89	25.78	3.25	19.98
O	8	2973	10.95	9.35	14.10	1.90	17.58
Na	11	708	1.0	0.86	0.92	0.12	10.40
Mg	12	395	0.48	0.42	0.42	0.07	12.60
Al	13	53793	66.84	56.30	50.37	3.11	4.50
Si	14	2727	6.70	5.62	4.90	0.36	5.60
Fe	26	110	2.47	1.90	0.90	0.34	13.15
Yb	70	5660	13.20	11.08	1.48	0.69	5.15
		Sum	116.23	100.00	100.00		

Sampel C3



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Element	At. No.	Netto	Mass [%]	Mass Norm [%]	Atom [%]	abs. error [%] (1 sigma)	Rel. error [%] (1 sigma)
C	6	3160	14.81	12.30	25.97	2.80	16.97
O	8	5851	10.02	8.83	11.80	1.50	16.50
Mg	12	926	0.48	0.42	0.42	0.05	12.04
Al	13	13301	68.79	56.30	52.98	3.15	4.55
Si	14	5403	6.03	4.50	4.11	0.32	5.05
Fe	26	501	5.70	4.20	2.05	0.45	7.50
Yb	70	16370	16.50	12.74	1.77	0.70	4.30
Ta	73	1435	2.20	1.55	0.25	0.18	6.75
		Sum	124.53	100.00	100.00		