Offsetting anthropogenic carbon emissions from biomass waste and mineralised carbon dioxide

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Table S1: Equivalent oxide composition of raw biomass (%w/w)

Biomass	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	ZnO	SrO	ZrO_2	WO_3	PbO
Poplar bark	0	0.16	0	0.03	0.15	0.09	0	0.3	2.57	0	0.03	0.04	0	0.02	0	0	0
Straw	0	0	0	0	0	0	0.38	1.94	0.93	0	0.01	0.07	0.01	0	0	0.11	0
Cassava peel	0	0.02	0.02	0	0	0.08	0.06	0.55	0.67	0.07	0.06	0.25	0	0	0.02	0.03	0
Almond shell	0	0.03	0	0.07	0.04	0.03	0.01	0.38	0.34	0	0.01	0.23	0	0	0	0	0
Orange peel	0	0.04	0	0.05	0.07	0.09	0.03	0.95	1.26	0	0.01	0.02	0	0.03	0	0	0
Mixed wood chip	0	0.04	0	0	0.16	0	0.03	0.28	3.4	0	0.19	0.21	0.04	0	0	0.22	0.02
Hemp	0	0	0	0	0	0.02	0.07	0.65	1.24	0	0.01	0.03	0	0	0	0.05	0
Chestnut dust	0	0.02	0.01	0.13	0.01	0.03	0	0.04	0.26	0.01	0.02	0.2	0	0	0	0	0
Cobnut shell	0	0.04	0	0.1	0.03	0.05	0.01	0.42	0.5	0	0.02	0.06	0	0	0	0	0
Pomegranate shell	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table S2: Oxide composition of cement and biomass ashes (% w/w)

Type of biomass	Cement/Bio-mass Ash	K_2O	CaO	SO_3	MgO	SiO_2	P_2O_5	Al_2O_3	Na_2O	Fe_2O_3	Cl	SrO	MnO	TiO_2	ZnO
	Cement (CEM1)	0.86	55.22	4.28	0.66	12.7	0.13	2.91	0.26	2.74	0.074	0.09	0.05	0.20	0.04
Wood	Mixed wood chip	6.00	53.6	3.75	5.49	10.08	8.52	0.96	0.27	0.65	-	0.07	1.16	0.06	0.10
	Poplar shavings	4.14	75.02	1.04	2.88	1.07	0.93	0.14	0.36	0.19	0.09	0.09	0.04	-	0.32
	Chestnut saw dust	6.28	45.37	2.0	3.2	12.1	1.52	1.5	0.21	2.80	-	0.075	0.88	0.165	0.32
Shell	Hazelnut shell	21.16	18.14	1.1	3.63	8.81	2.77	1.07	0.40	1.51	0.12	0.045	0.44	0.114	0.027
	Almond shell	24.43	24.13	14.38	3.4	4.17	3.82	1.15	0.98	0.68	-	0.48	0.08	0.04	0.02
Fibre	Jute fibre	10.21	45.38	2.55	2.64	5.21	2.14	0.66	0.25	1.16	-	0.099	0.09	-	0.04
	Straw (wheat)	23.67	11.22	3.1	1.26	26.01	1.78	1.11	1.12	0.42	0.39	0.034	0.14	-	0.03
	Pomegranate	23.57	15.59	6.27	3.73	1.63	1.36	0.54	0.50	0.38	0.24	0.196	0.04	0.041	0.03
	Orange	21.78	38.83	3.92	3.7	3.15	4.35	0.81	1.14	0.29	-	0.22	0.05	-	0.032
	Cassava peel	6.37	37.77	3.35	16.35	4.42	2.69	0.28	0.78	0.48	-	0.20	0.53	-	0.12

Table S3: CO_2 uptake in biomass ashes after 4 carbonation cycles

Type	Biomass ash	CO_2 uptake (g/kg)				Total CO_2 uptake (% w/w)
		1 hr	1 hr	1 hr	24 hrs	
Wood	Mixed wood chip	26.2	248.7	260.8	262.7	26.3
	Poplar shavings	70.6	87.5	254.1	414.0	41.4
	Chestnut saw dust	92.1	94.9	109.9	186.3	18.6
Shell	Hazelnut shell	62.35	64.4	82.9	113.7	11.4
	Almond shell	69.7	82.22	84.11	155.6	15.6
Fibre	Jute fibre	188.0	216.6	218.5	294.5	29.4
	Straw (wheat)	17.0	36.3	37.0	48.6	4.9
Fruit peel	Cassava	86.7	99.9	103.1	127.2	12.7
	Pomegranate	87.4	87.4	101	135.8	13.6
	Orange	67.3	104.9	149.6	150.0	15.0

Fig. S1 (a)

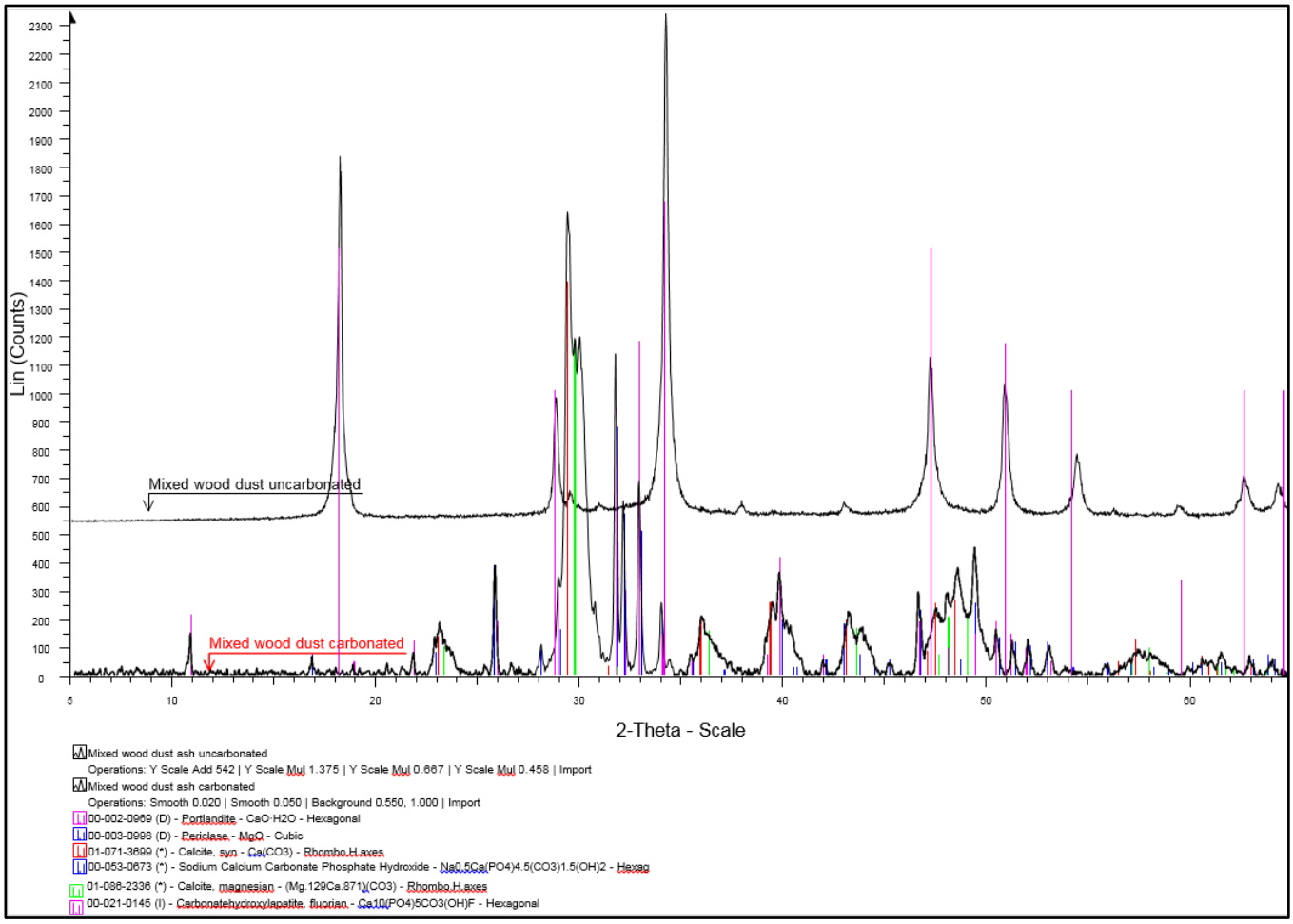

Lin (Counts)
2-Theta - Scale
Mixed wood dust uncarbonated
Mixed wood dust carbonated
Mixed wood dust ash uncarbonated
Operations: Y Scale Add 542 | Y Scale Mul 1.375 | Y Scale Mul 0.667 | Y Scale Mul 0.458 | Import
Mixed wood dust ash carbonated
Operations: Smooth 0.020 | Smooth 0.050 | Background 0.550, 1.000 | Import
00-002-0969 (D) - Portlandite - CaO·H2O - Hexagonal
00-003-0998 (D) - Periclase - MgO - Cubic
01-071-3699 (*) - Calcite, syn - Ca(CO3) - Rhombo.H.axes
00-053-0673 (*) - Sodium Calcium Carbonate Phosphate Hydroxide - Na0.5Ca(PO4)4.5(CO3)1.5(OH)2 - Hexag
01-086-2336 (*) - Calcite, magnesian - (Mg.129Ca.871)(CO3) - Rhombo.H.axes
00-021-0145 (I) - Carbonatehydroxylapatite, fluorian - Ca10(PO4)5CO3(OH)F - Hexagonal

Fig. S1(b)

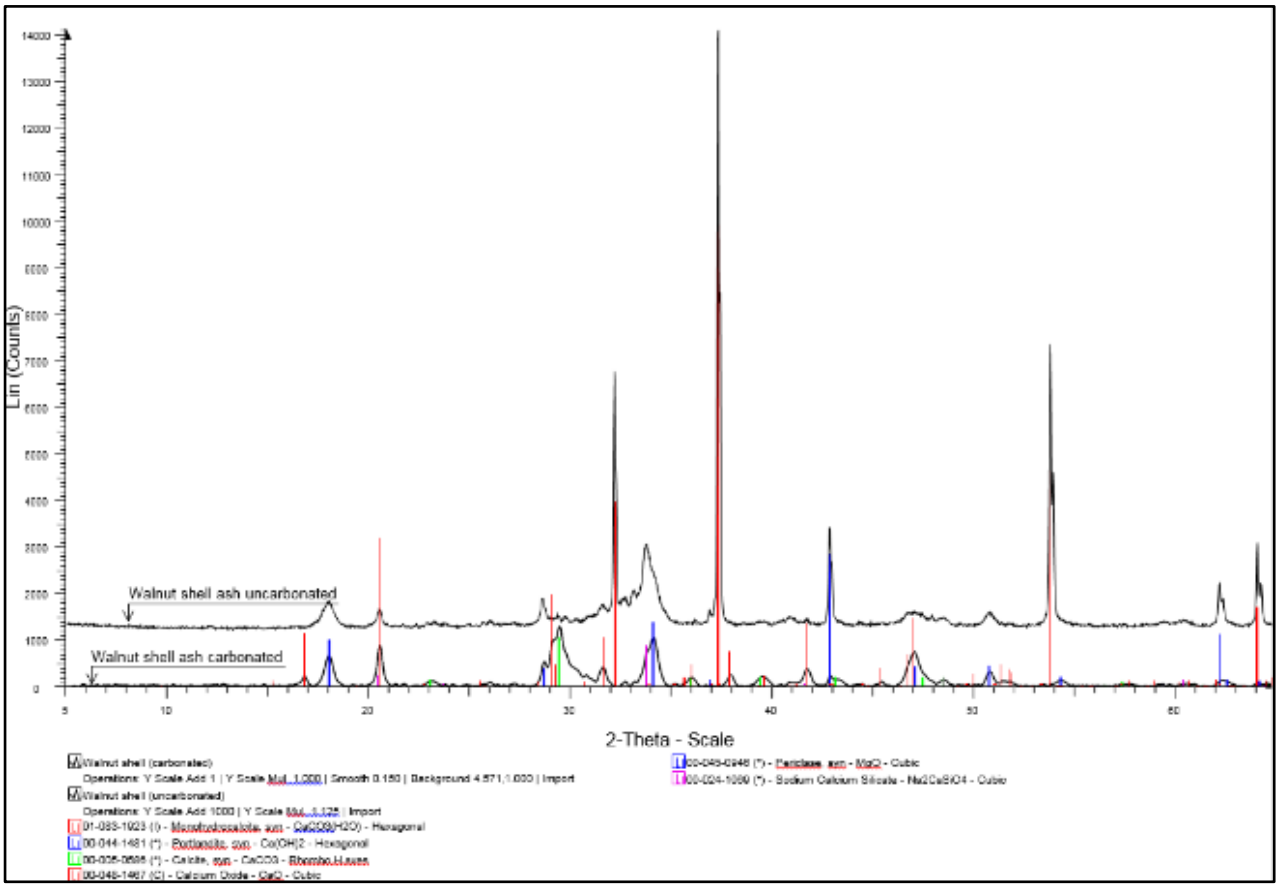

Lin (Counts)
2-Theta - Scale
Walnut shell ash uncarbonated
Walnut shell ash carbonated

Fig. S1(c)

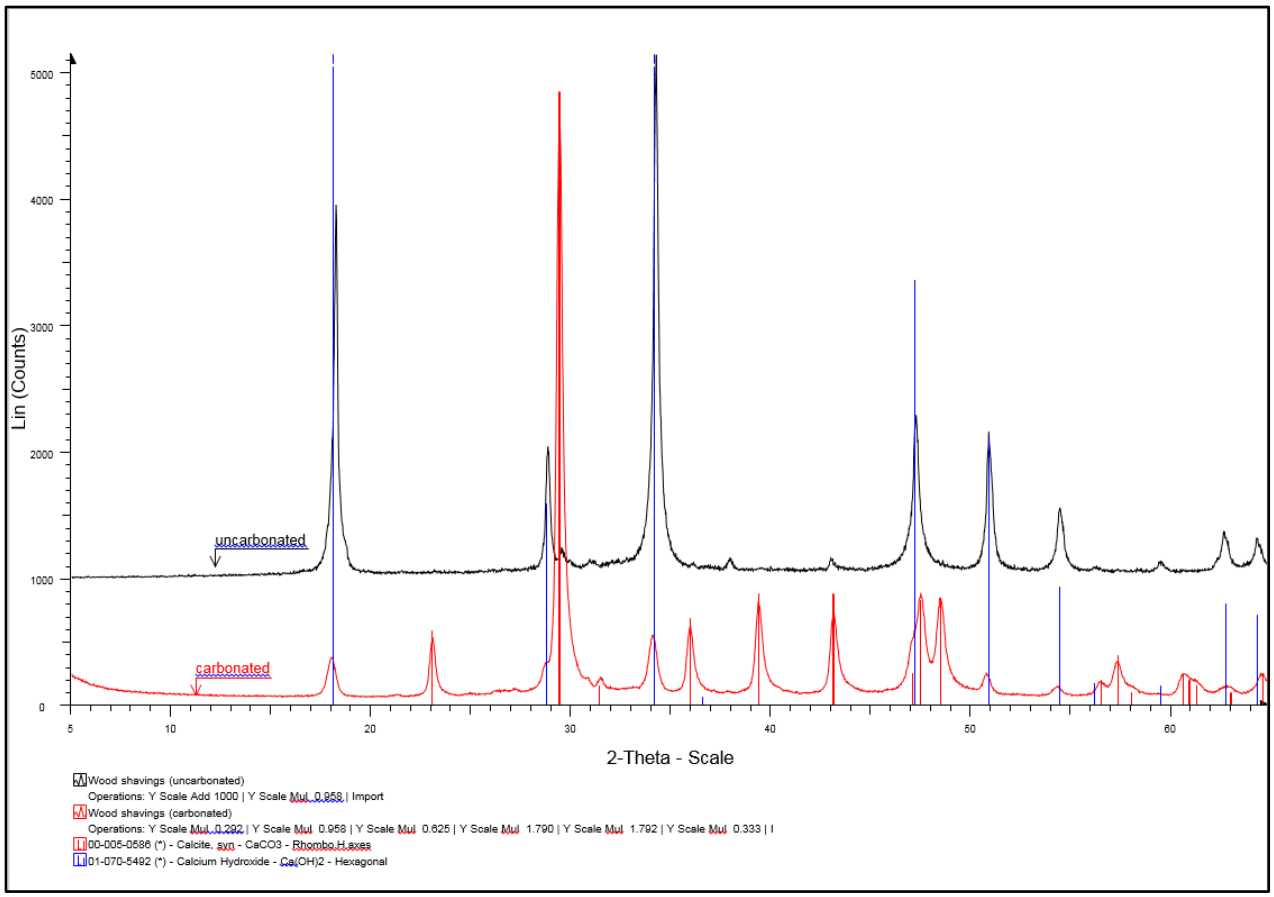


Fig. S1: X-ray diffractograms of biomass ash residues before and after carbonation: (a) mixed wood dust, (b) nut shell, (c) wood shavings. Calcium oxide, portlandite, and calcite are indicated.

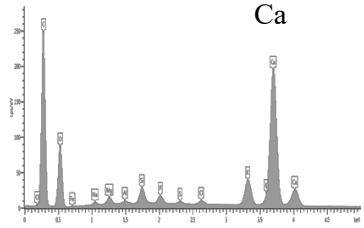
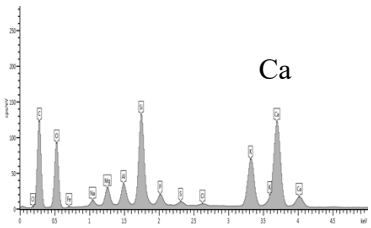
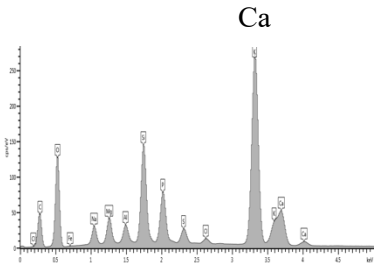
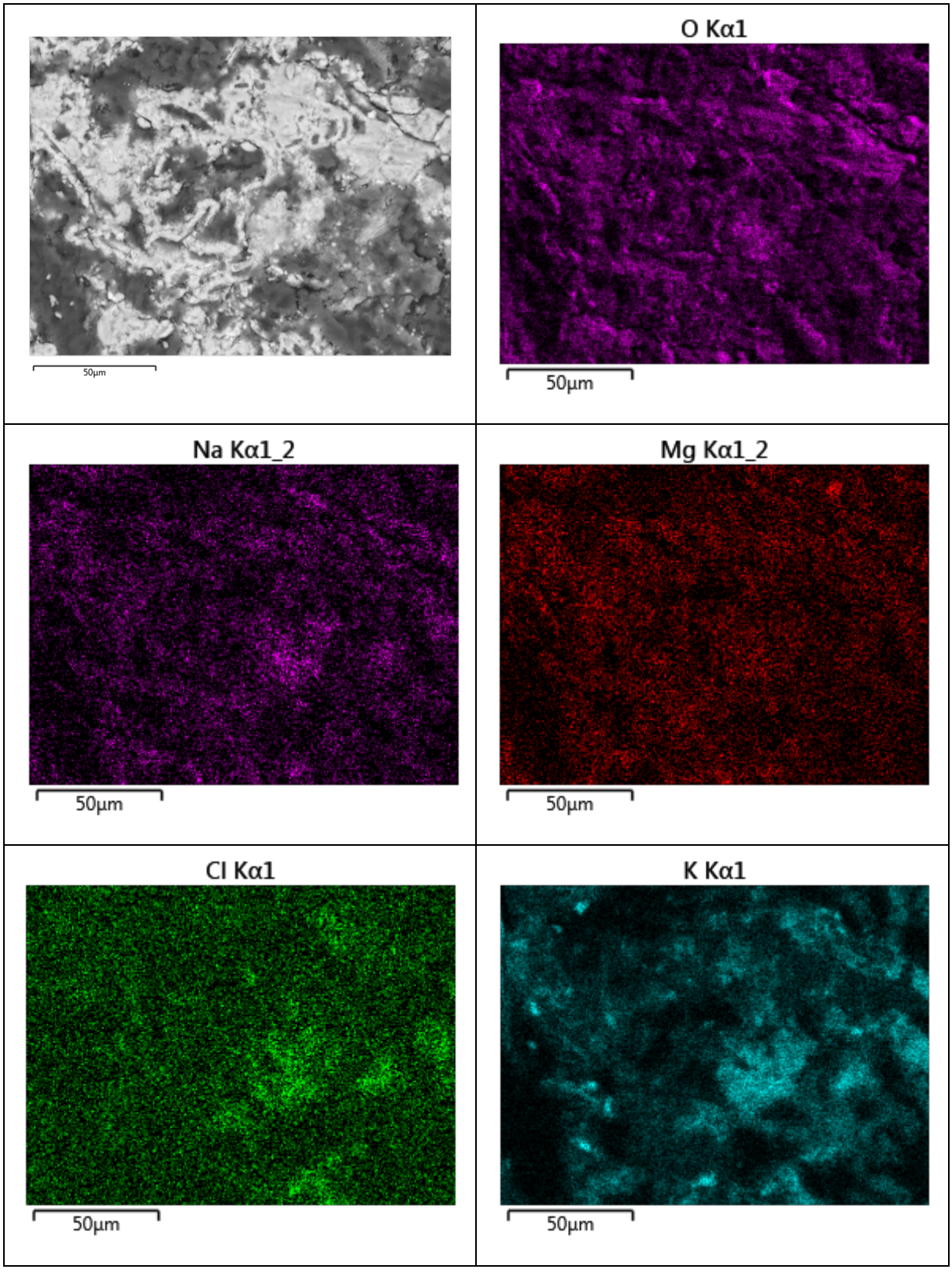
Type (i)	Type (ii)	Type (iii)
		

Fig. S2: EDS Spectra of carbonated biomass ash cylinders highlighting calcium (shown in Fig. 2 in MSS)

Fig. S3 (a)



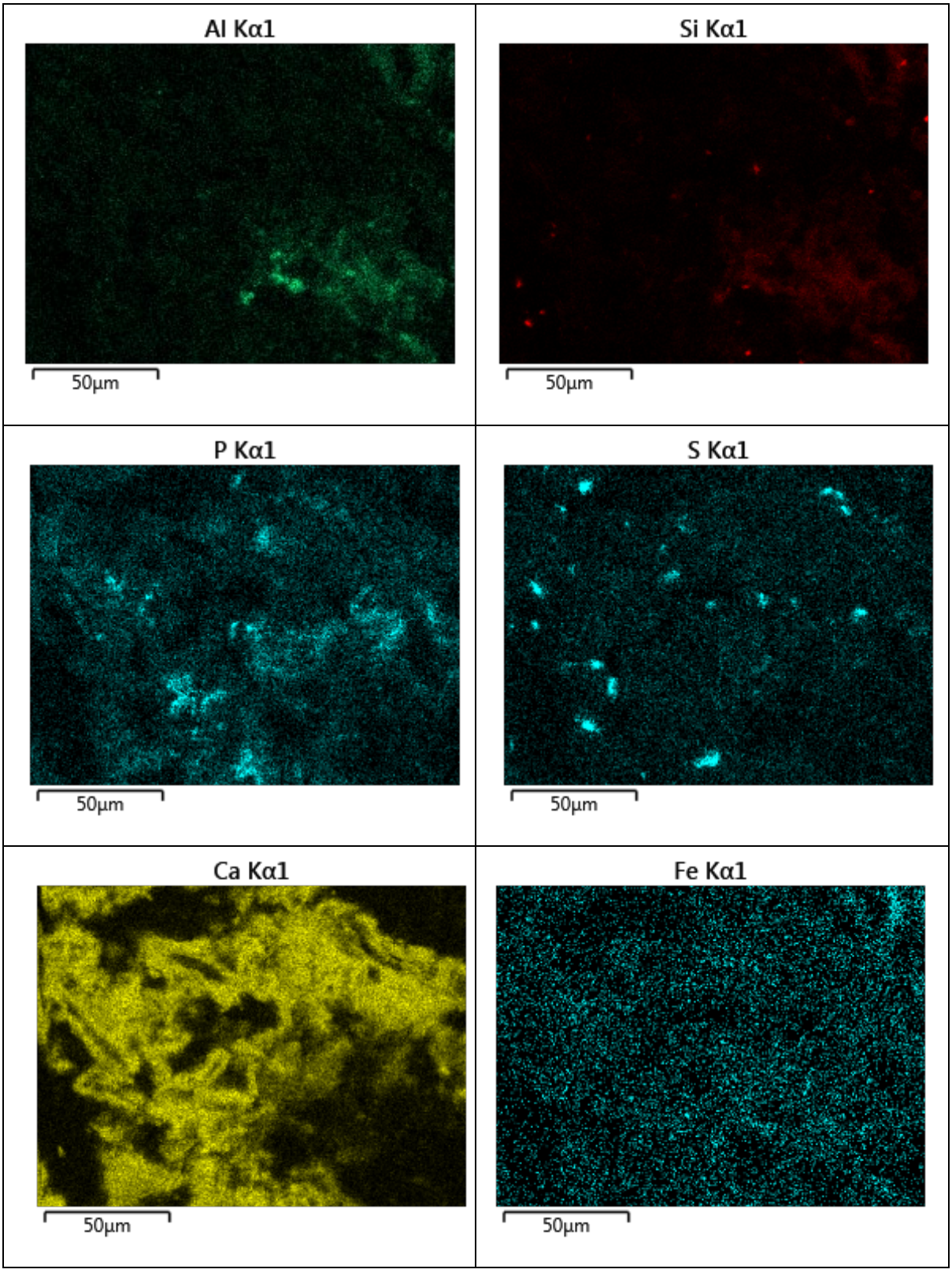
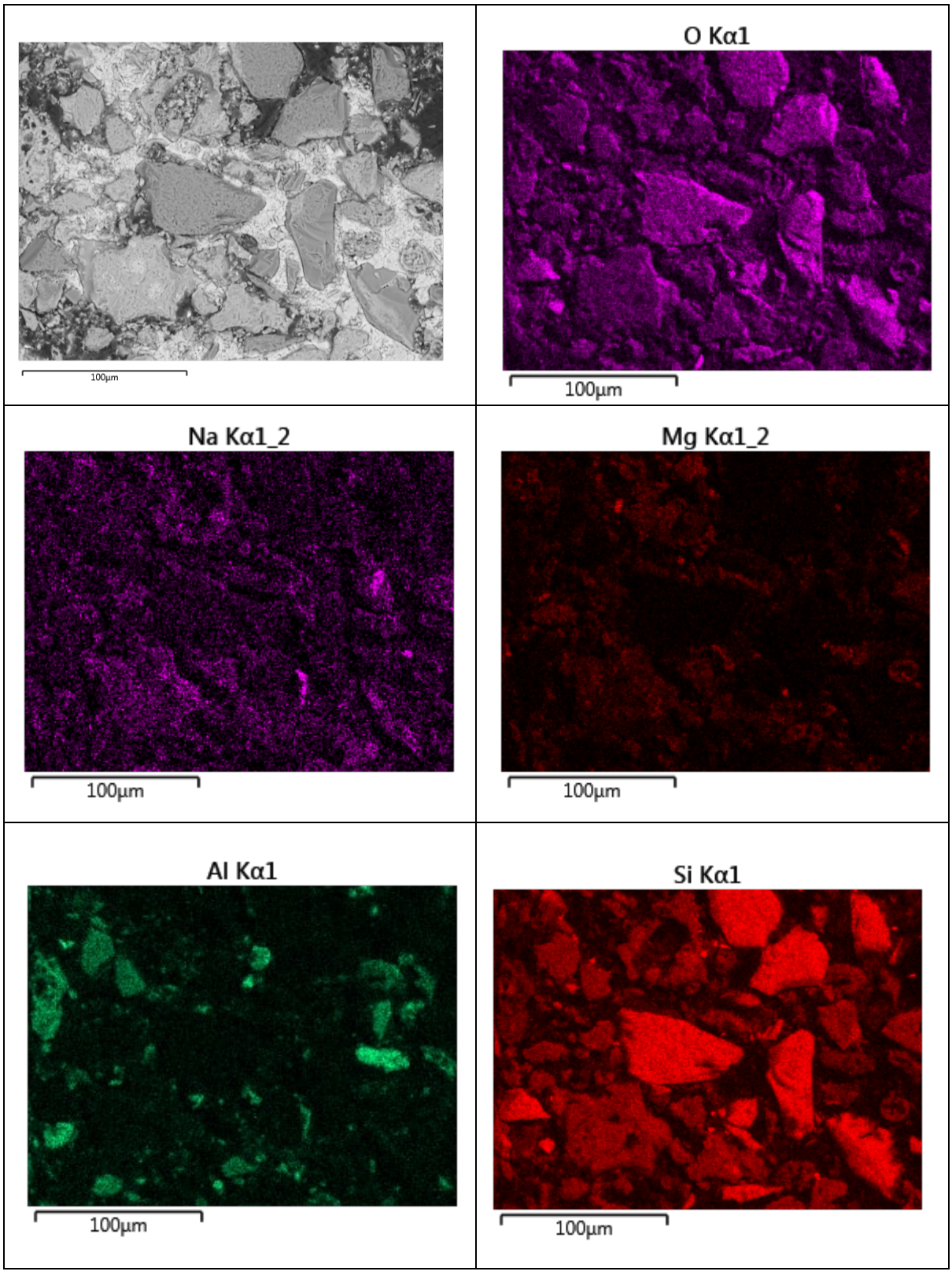

Al Kα1
50μm
Si Kα1
50μm
P Kα1
50μm
S Kα1
50μm
Ca Kα1
50μm
Fe Kα1
50μm

Fig. S3 (b)


100µm
O Kα1
100µm
Na Kα1_2
100µm
Mg Kα1_2
100µm
Al Kα1
100µm
Si Kα1
100µm

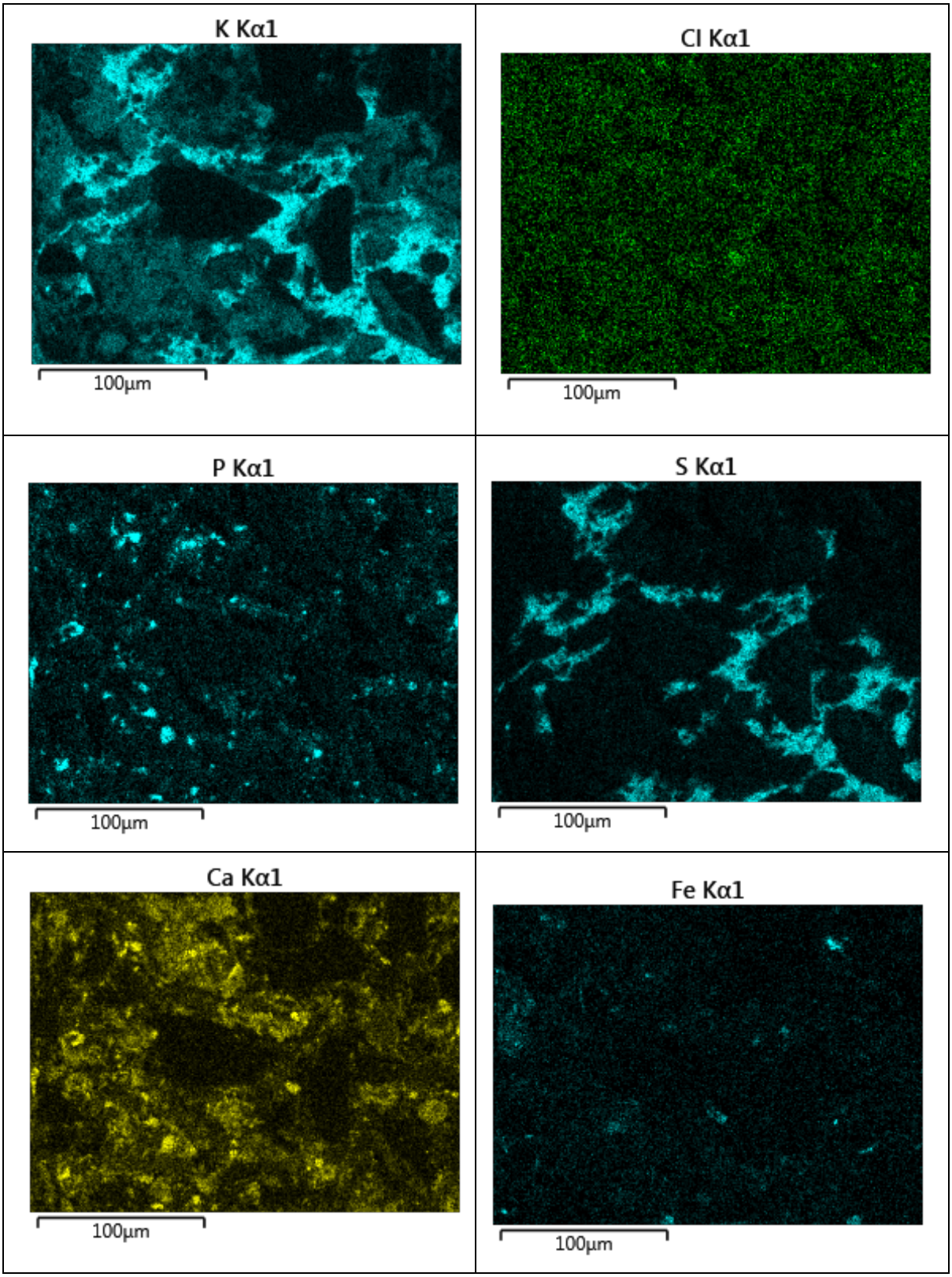
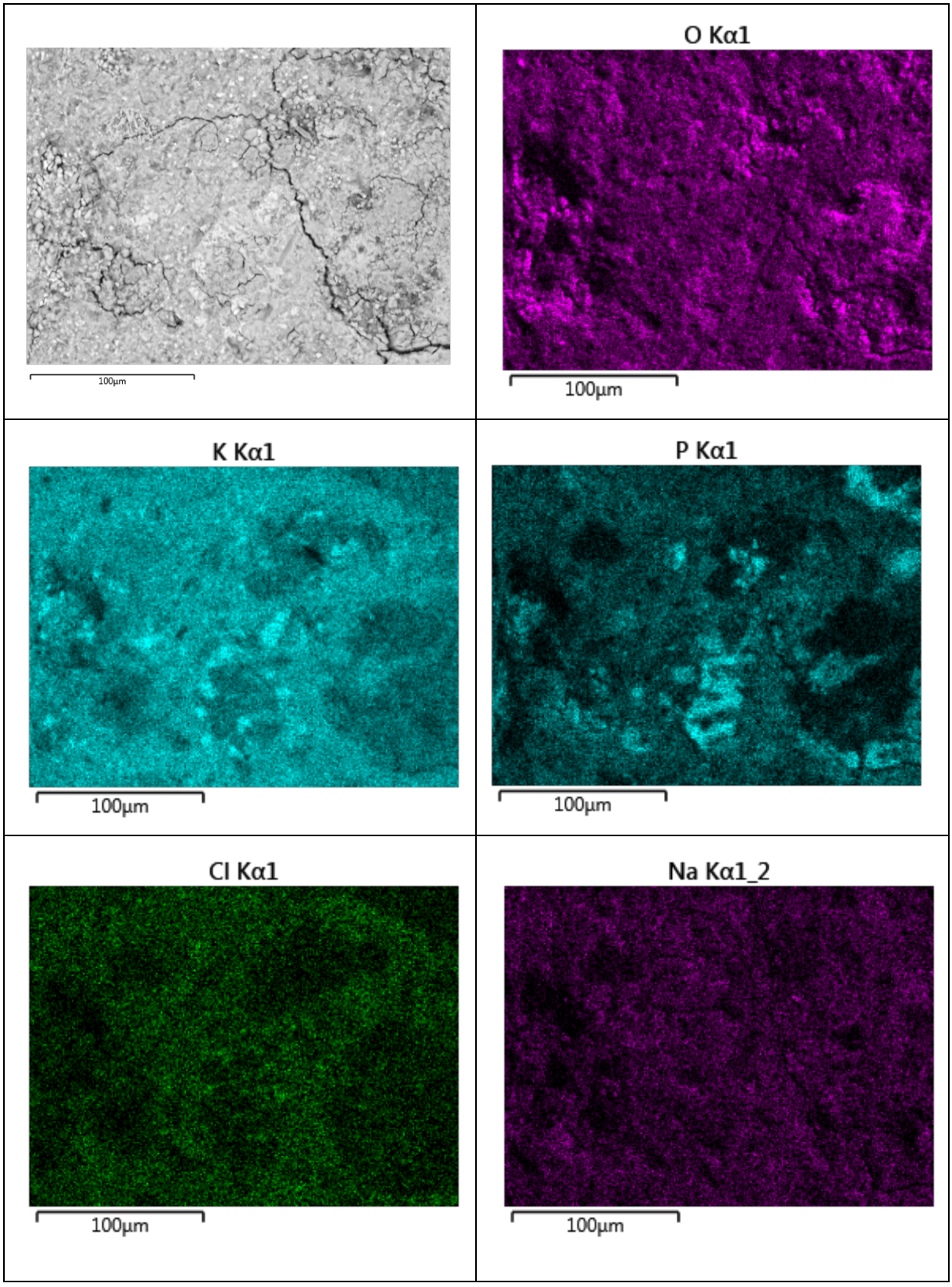

K Kα1
100μm
Cl Kα1
100μm
P Kα1
100μm
S Kα1
100μm
Ca Kα1
100μm
Fe Kα1
100μm

Fig. S3 (c)



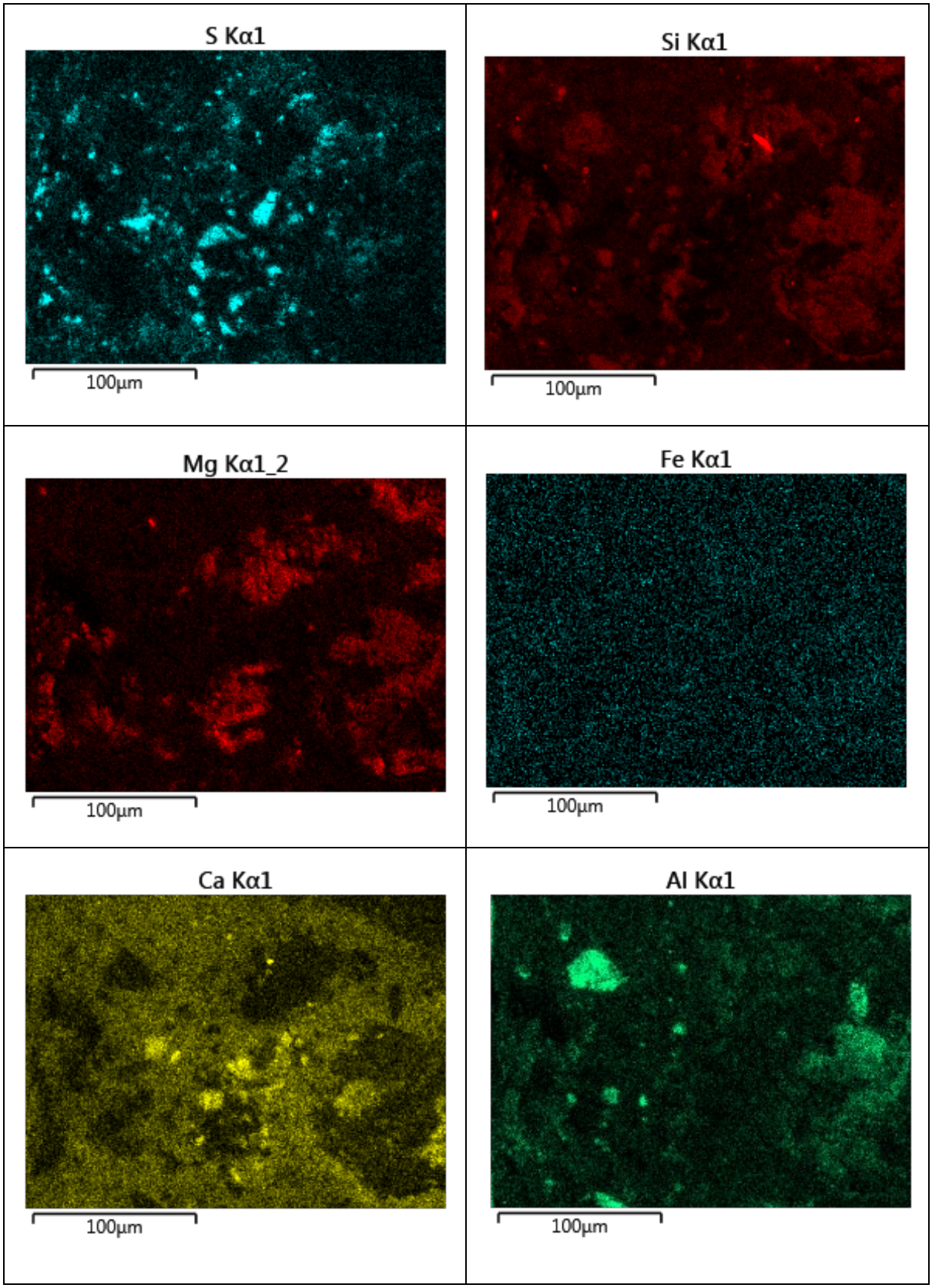


Fig. S3: Elemental analysis (EDS) of micrographs of carbonated biomass ash cylinders as shown in figure 2 (a) - Mixed wood ash, showing relic-planty structures; (b) - Nut shell-derived ash, rich in silica; (c) - Wood ash, with dispersed, discrete precipitates of carbonate