

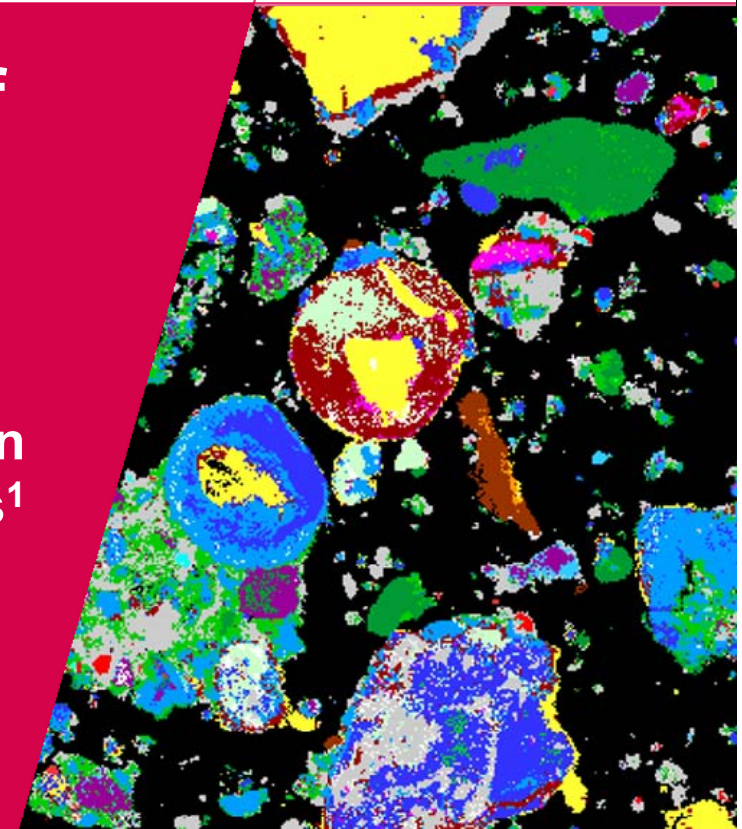
Investigating the Mineralogy of MSWI Bottom Ash using XRD and PARC

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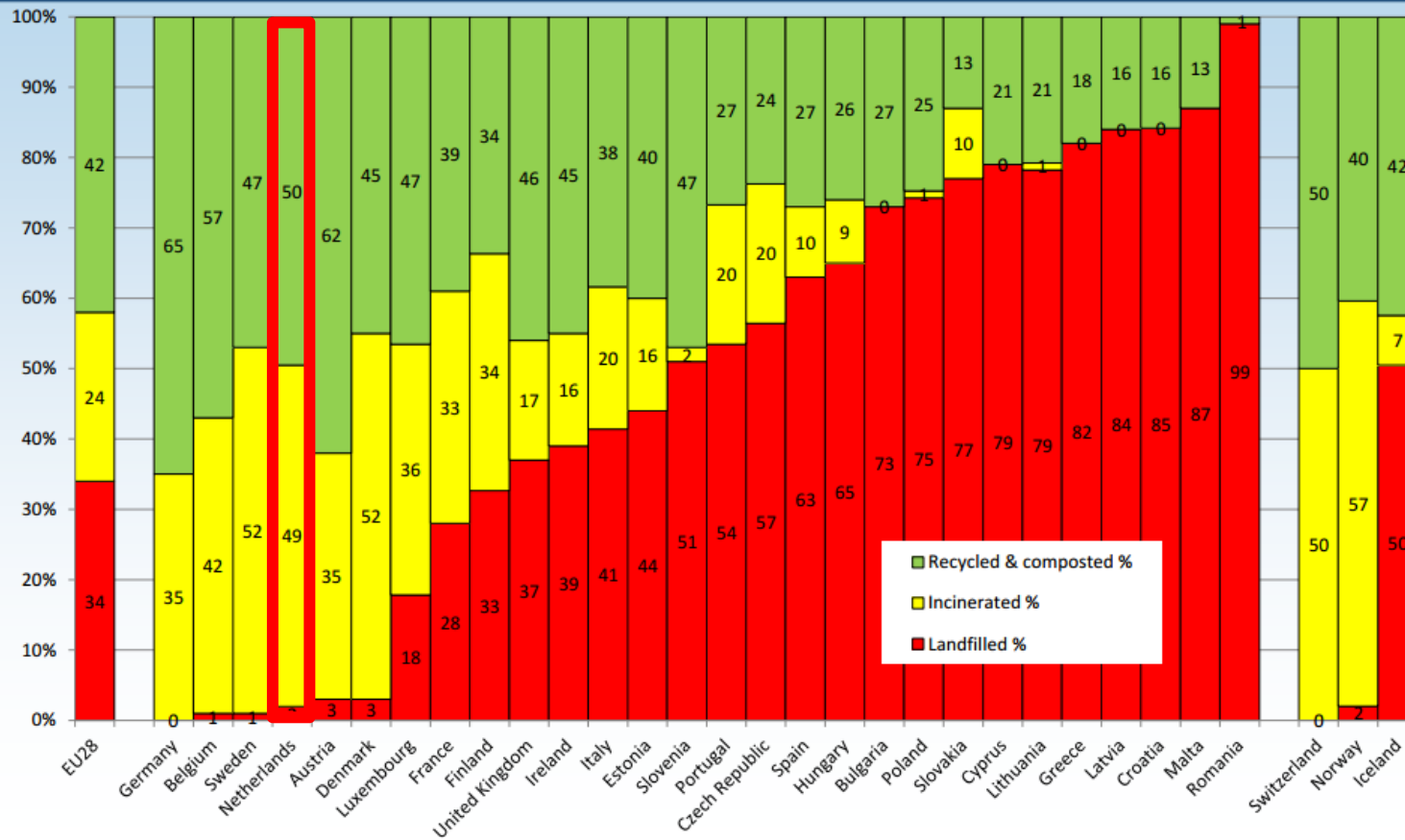
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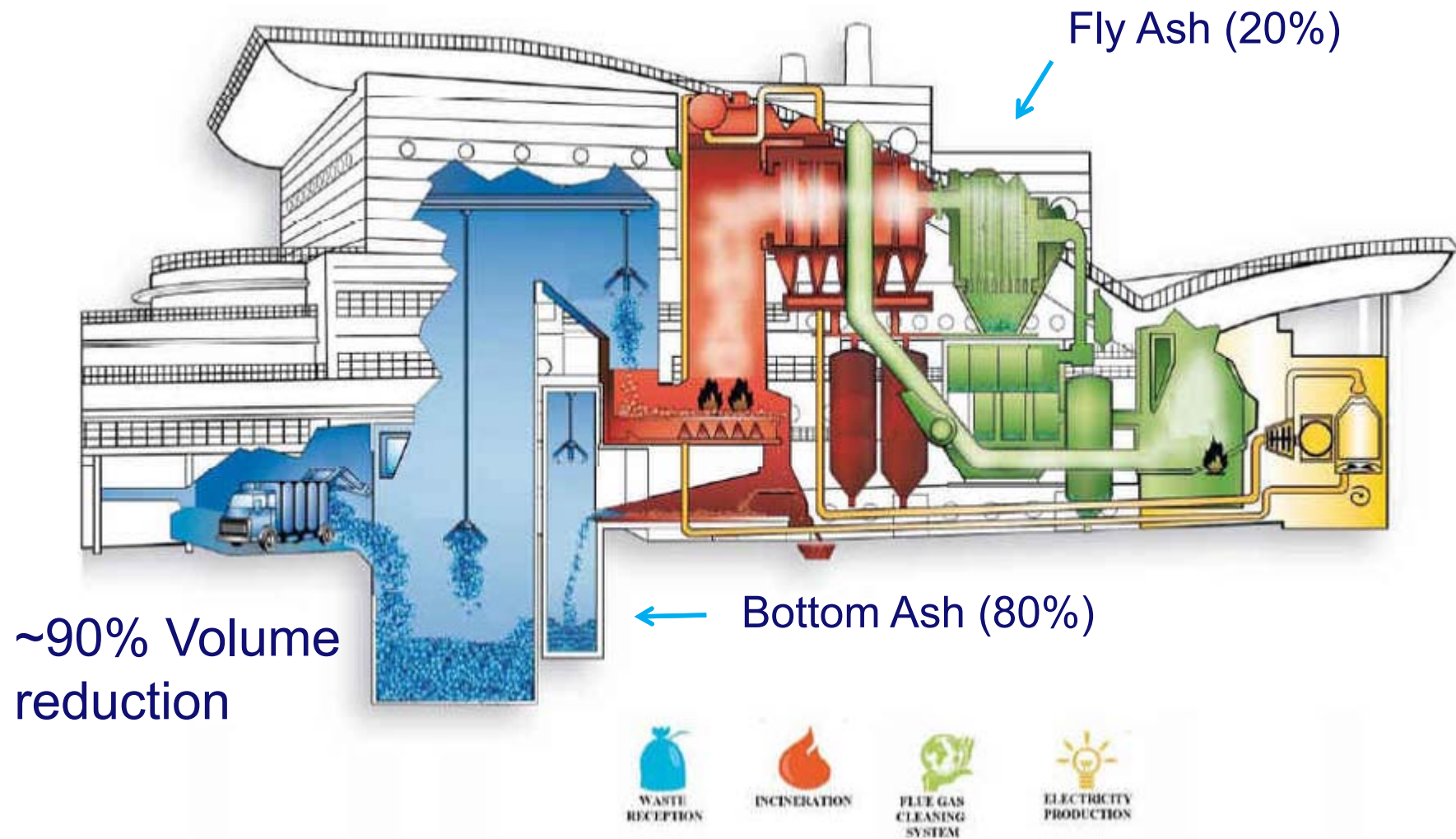
Municipal waste

Municipal waste treatment in 2012 EU 28 + Switzerland, Norway and Iceland

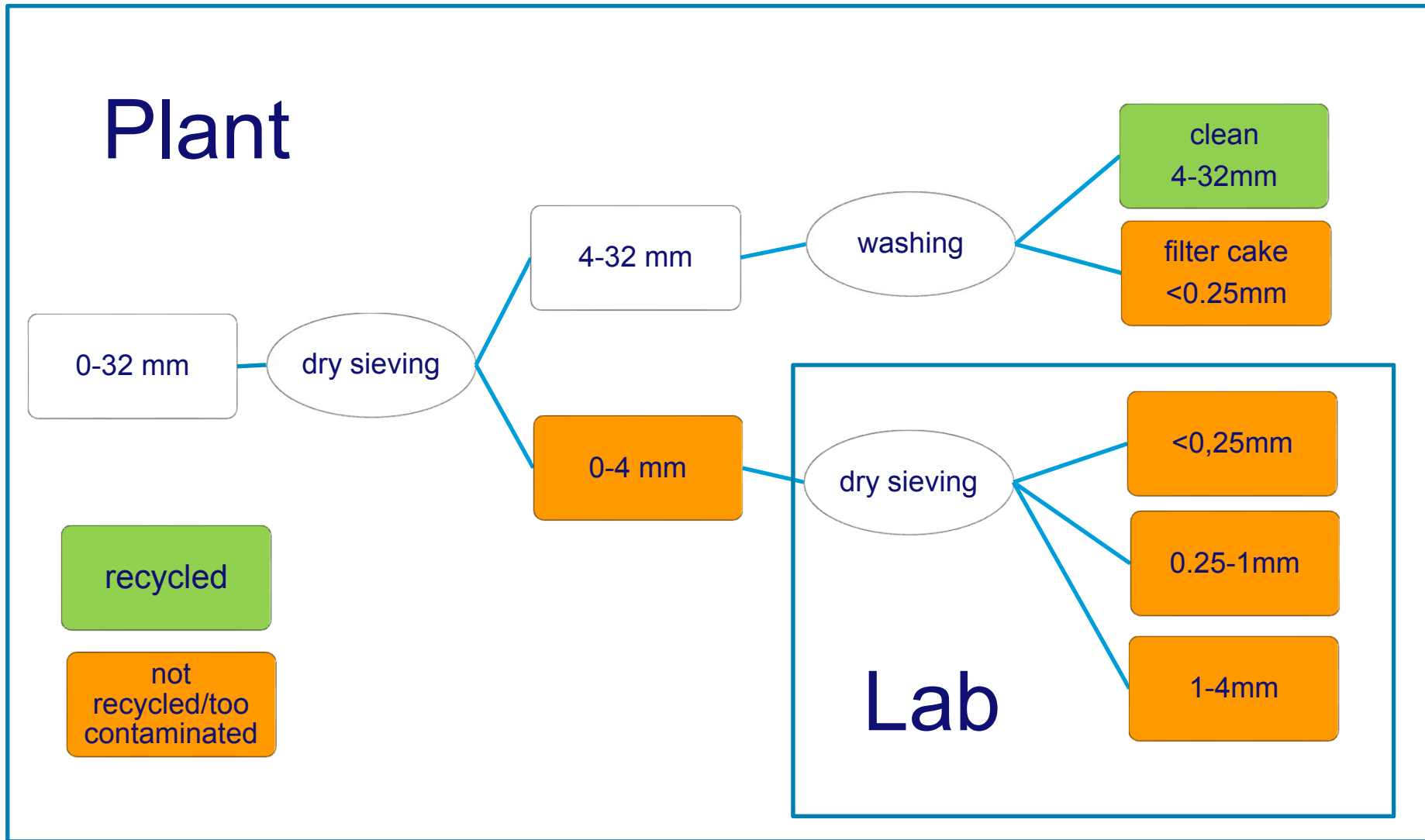
Graph by CEWEP, Source: EUROSTAT 2012



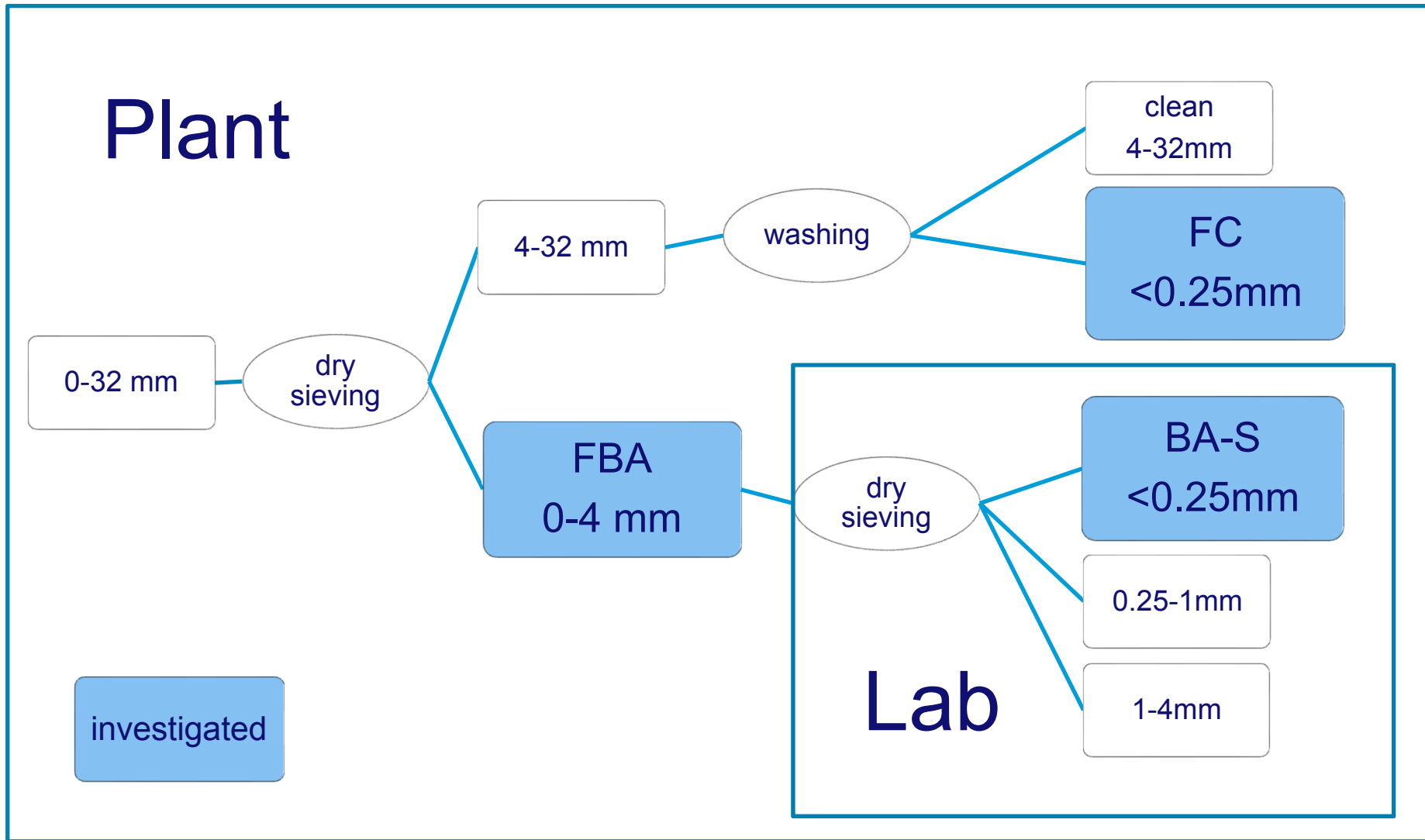
MSW Incineration/ Waste to Energy plant



BA Processing



BA Processing



BA fines (<4mm)

Problems:

- by 2020 all BA has to be recycled in NL/ no landfilling
- highly contaminated: Cl^- , SO_4^{2-} , Cu, Sb...
- very high porosity

Positives:

- very low/no metallic aluminum content
- potential pozzolanic reactivity

Goal of using XRD/PARC

- **What phases (crystalline and amorphous) are present in BA?**
- **How much of each phase is present?**
- **What is the composition of each phase?**

- **Are contaminants located in specific phases?**
- **Can modeling of leaching/treatments be improved based on this information?**
- **Can the pozzolanic reactivity be predicted based on this?**

Leaching behaviour

Element	SQD Limits	FBA (<4mm)	BA-S (<0.25mm)	FC (<0.25mm)
Sb	0.32	0.22	0.82	2.4
As	0.9	< 0.0	0.06	< 0.3
Ba	22	0.7	0.82	0.4
Cd	0.04	< 0.001	-	< 0.02
Cr	0.63	0.12	1.79	0.2
Co	0.54	< 0.03	0.036	< 0.02
Cu	0.9	14	9.64	1.3
Pb	2.3	< 0.1	0.12	0.1
Mo	1	1.1	2.02	0.7
Ni	0.44	0.24	0.077	0.07
Se	0.15	< 0.007	-	< 0.2
Sn	0.4	< 0.02	-	< 0.1
V	1.8	< 0.1	-	< 0.1
Zn	4.5	0.48	-	0.4
Cl ⁻	616	6200	11013	2966
SO ₄ ²⁻	1730	1700	2558	21179

- mg/kg_{ds}

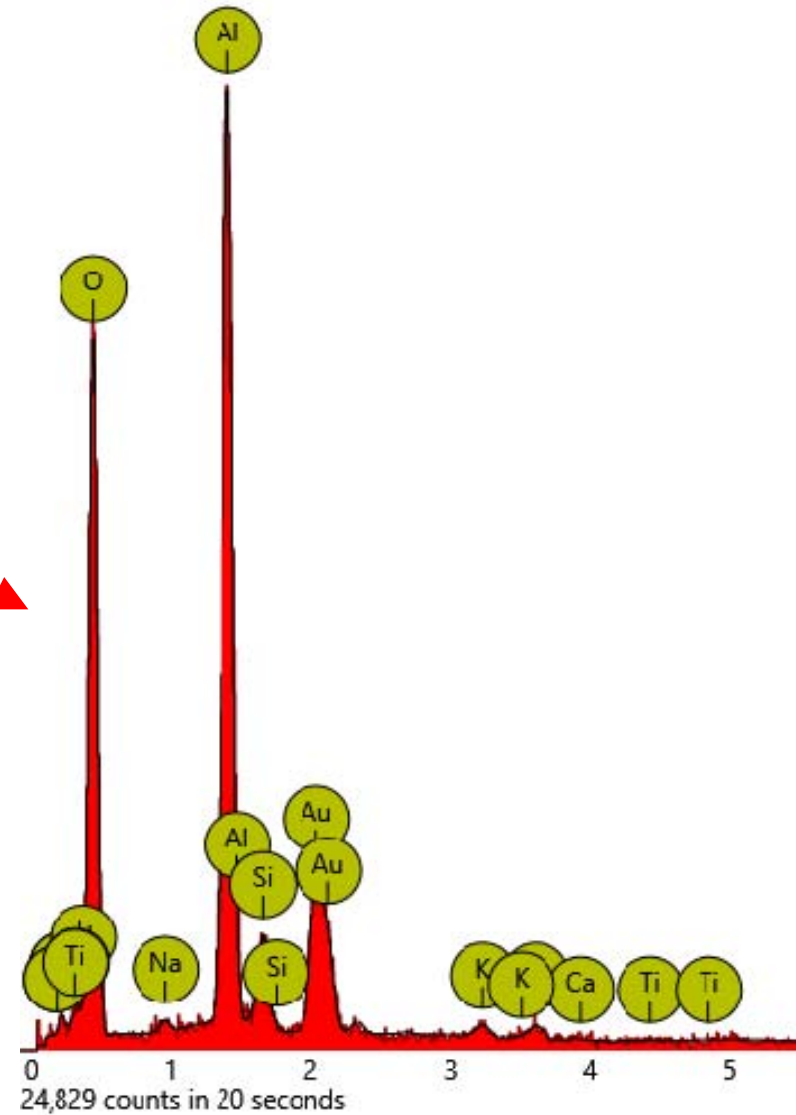
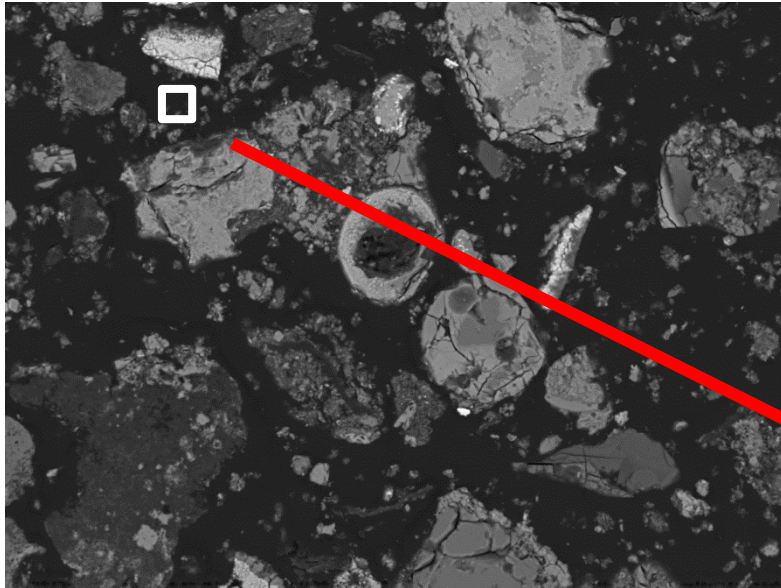
- One batch shaking test:

72h, L/S=12

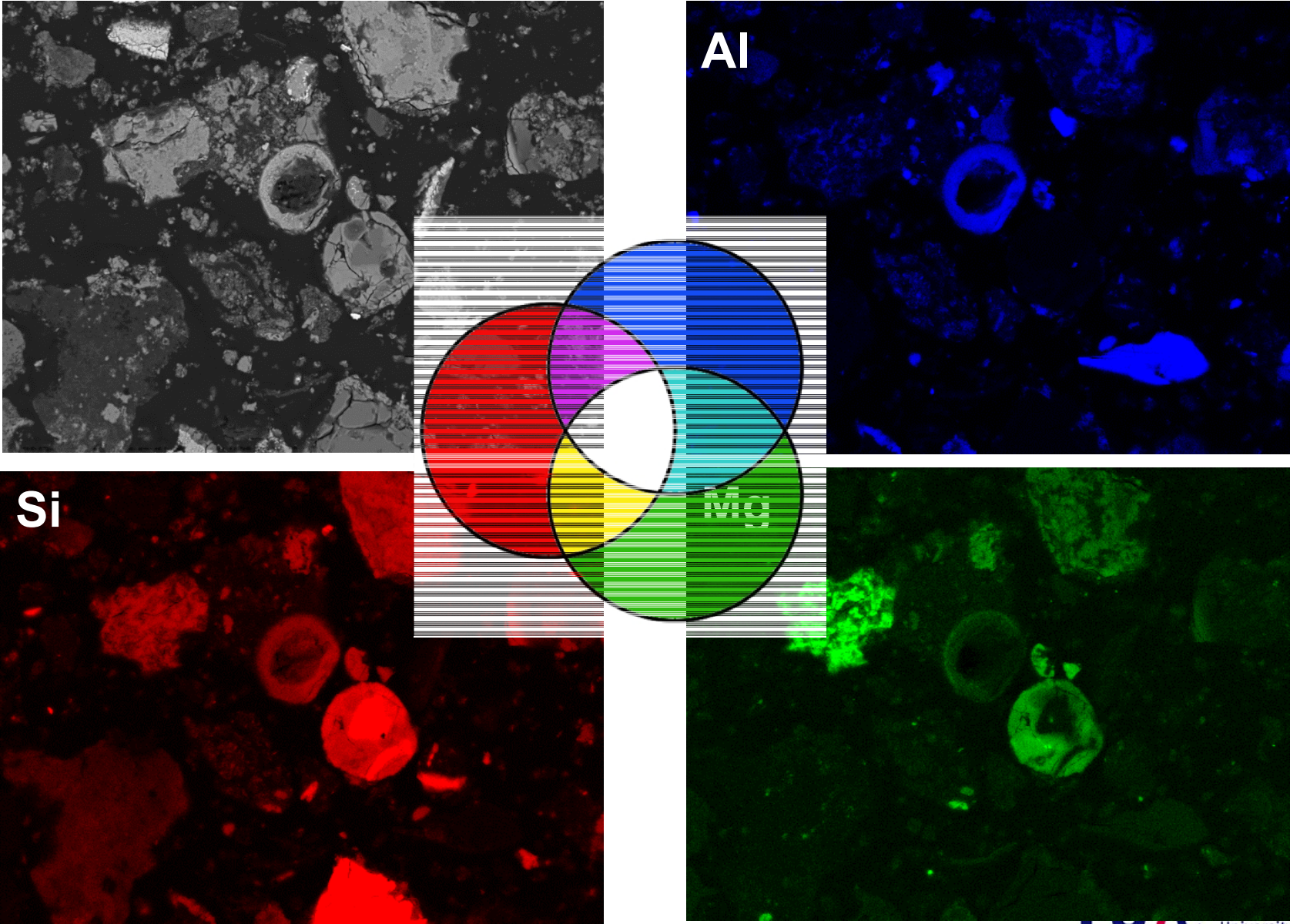
Mineral Phases

Mineral	Formula	FBA 0-4mm % wt.	BA-S <0.25 % wt.	FC <0.25 % wt.
Melilite	$(\text{Ca,Na})_2(\text{Al,Mg,Fe})(\text{Al,Si})_2\text{O}_7$	4.7	3	0.7
Feldspar	$\text{CaAl}_2\text{Si}_2\text{O}_8$	5.7	3.9	1.4
Calcite	CaCO_3	13.5	25.6	17.4
Ettringite	$\text{Ca}_6\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12}\cdot 26\text{H}_2\text{O}$	0.2	4.1	10.4
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	0.2	5.4	2.6
Halite	NaCl	0.8	0.7	0.4
Apatite	$\text{Ca}_5(\text{OH})(\text{PO}_4)_3$	6.5	5.2	-
Quartz	SiO_2	12.5	7	2.1
Hematite	Fe_2O_3	3.8	2.2	1.2
Magnetite/Spinel	Fe_3O_4	8.9	3.8	0.5
Other	-	7.1	4.2	0.4
Amorphous	-	36.1	34.9	63

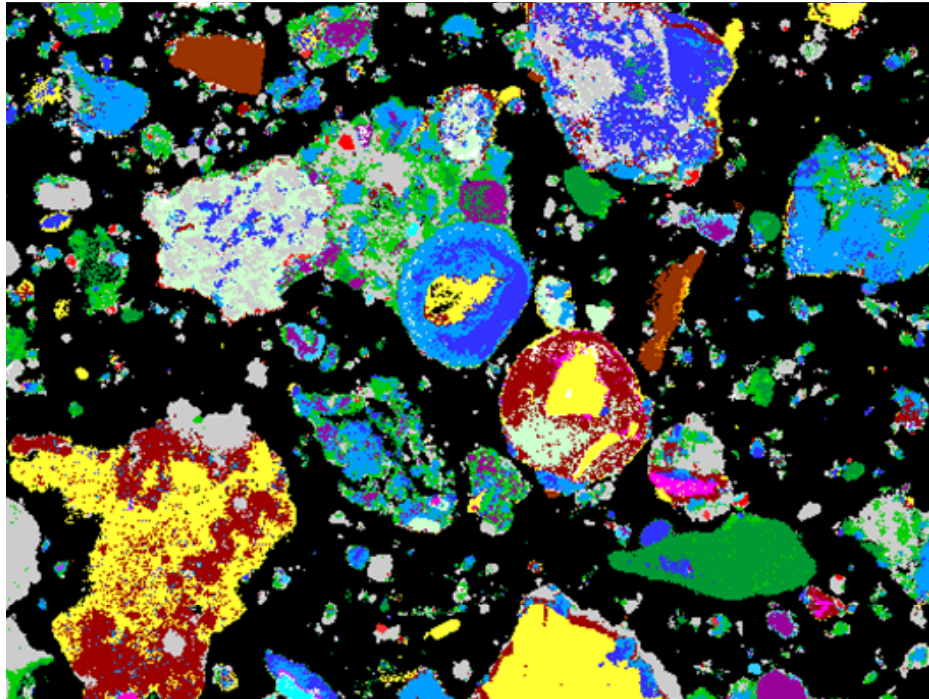
SEM – Single point EDX



SEM – Elemental mapping

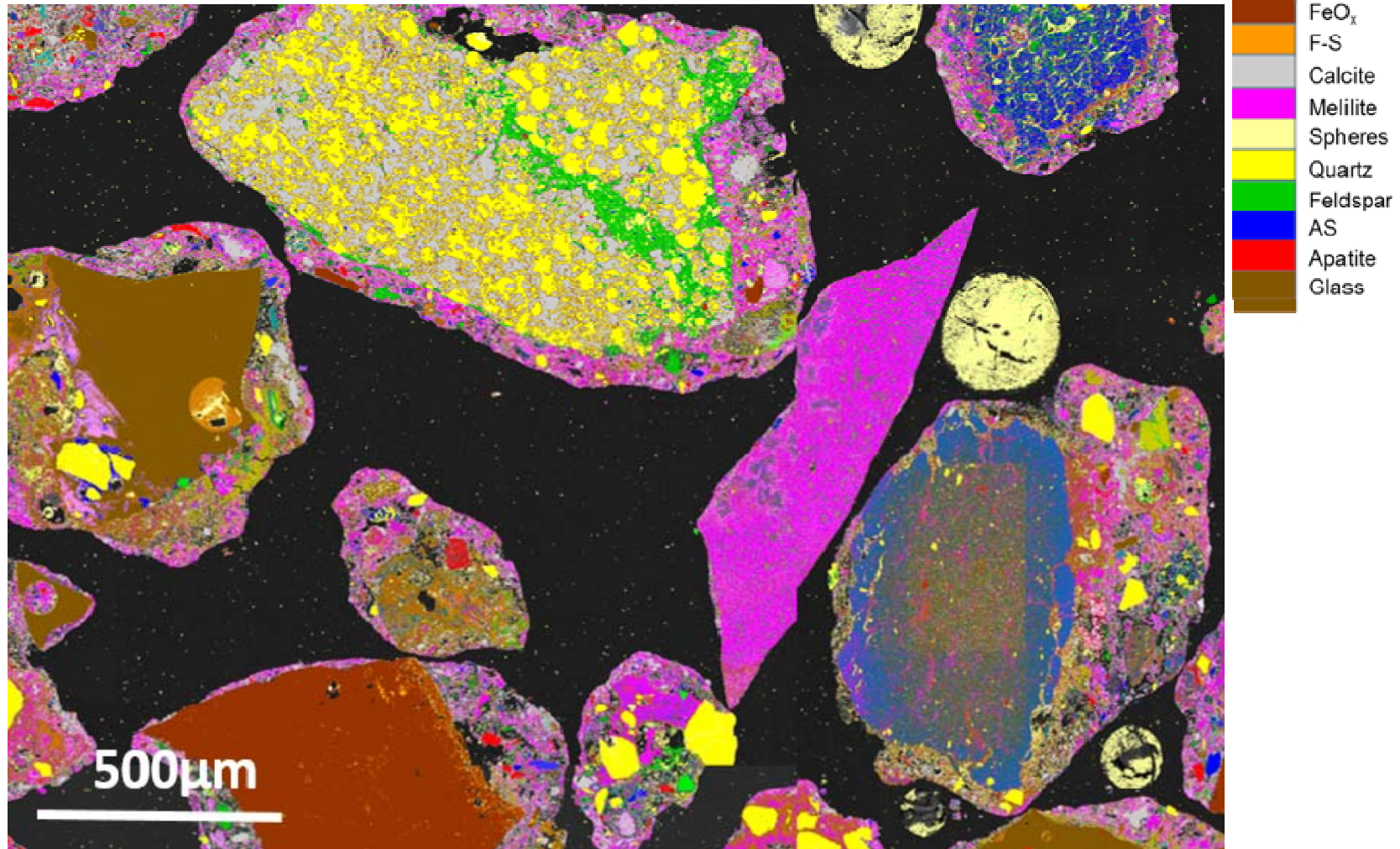


PARC - Phase Recognition and Characterization

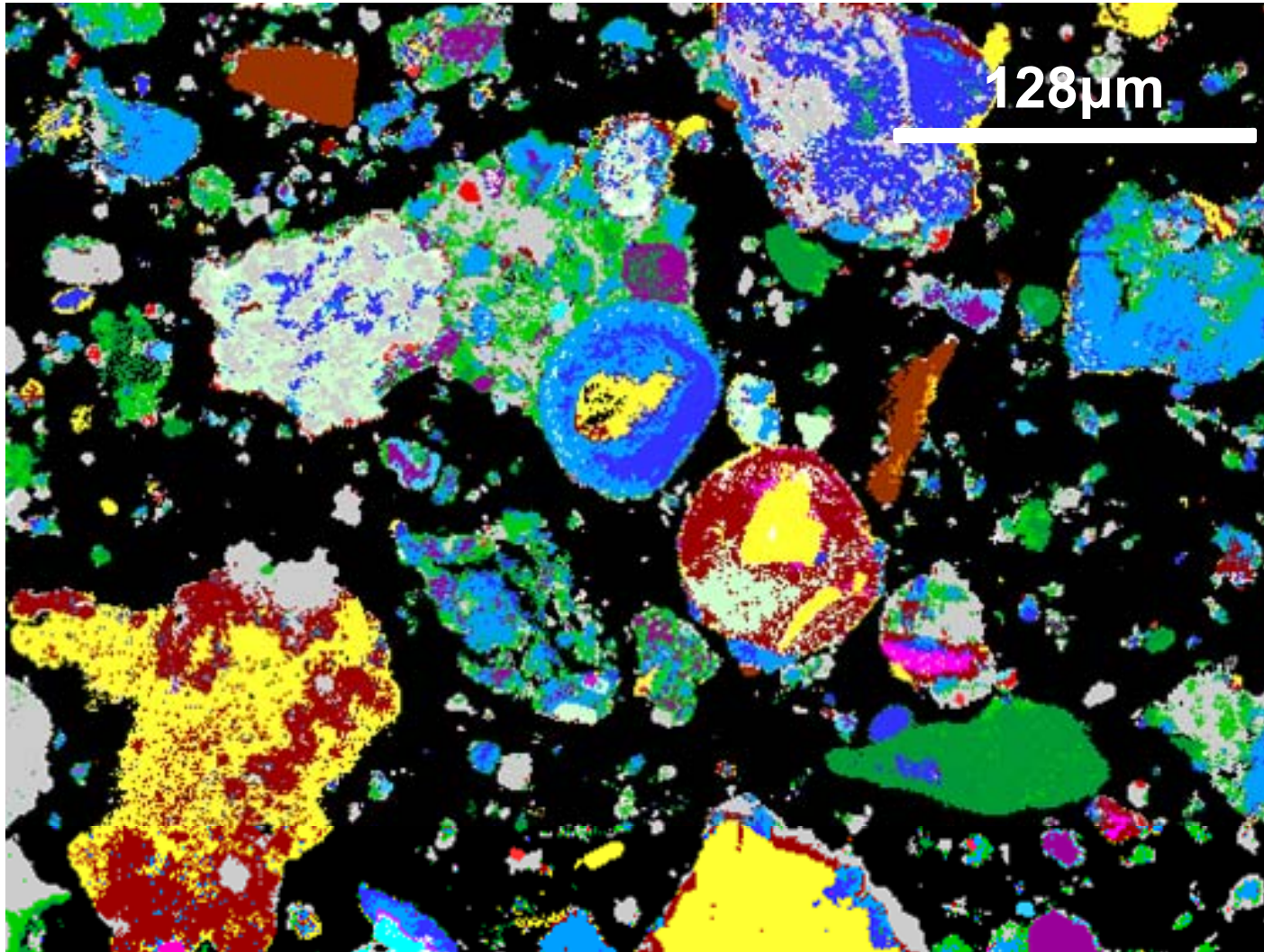


- Software compares spectral image from each pixel and groups them into phases according to composition
- no information about crystallinity

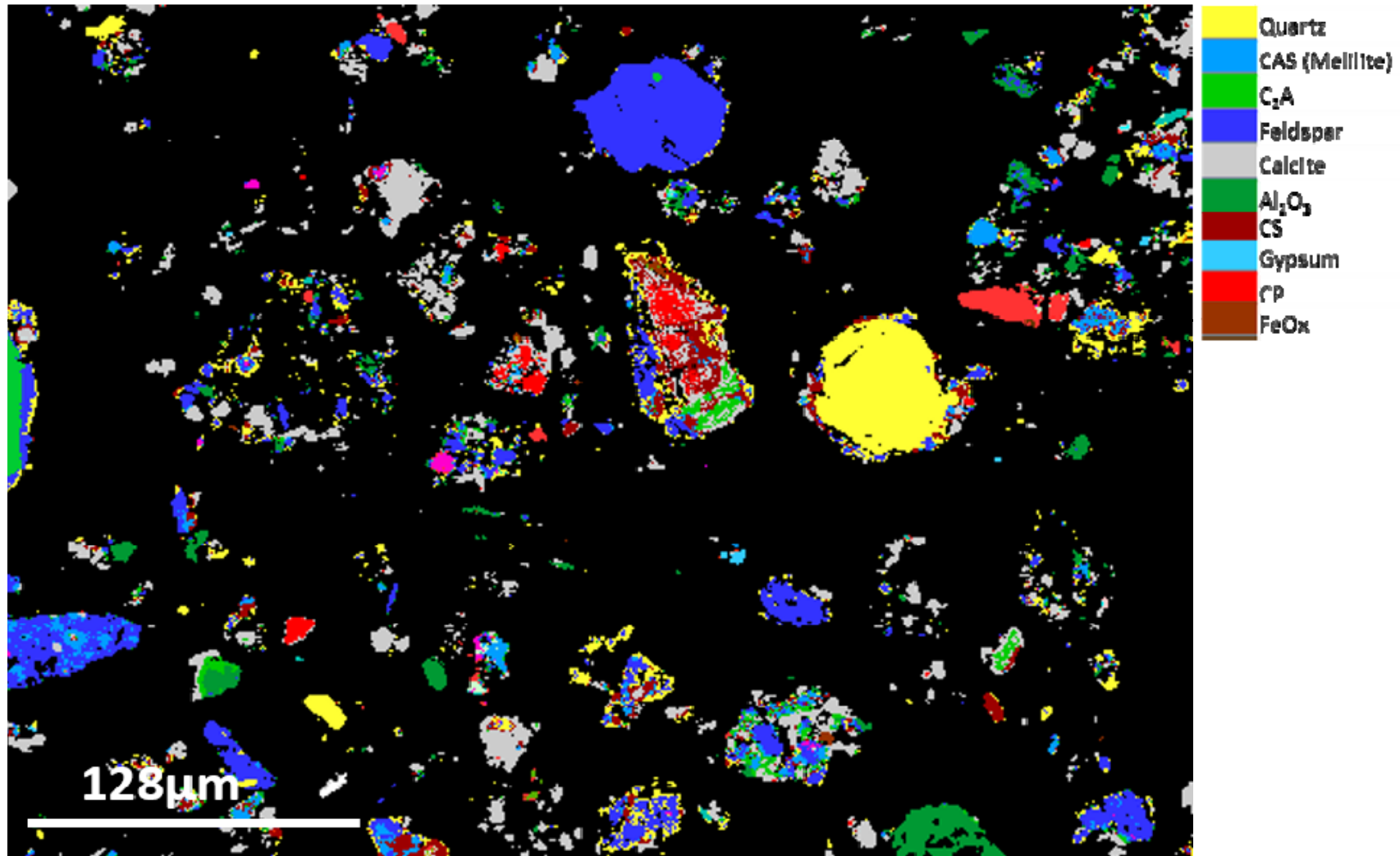
FBA (0-4mm)



BA-S (>0.25mm)

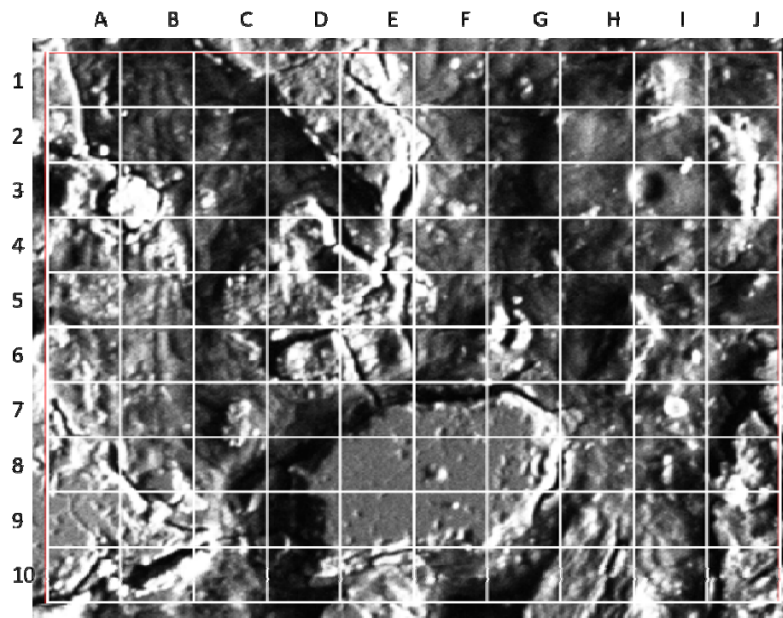


FC (<0.25mm)



Outlook - Contaminants

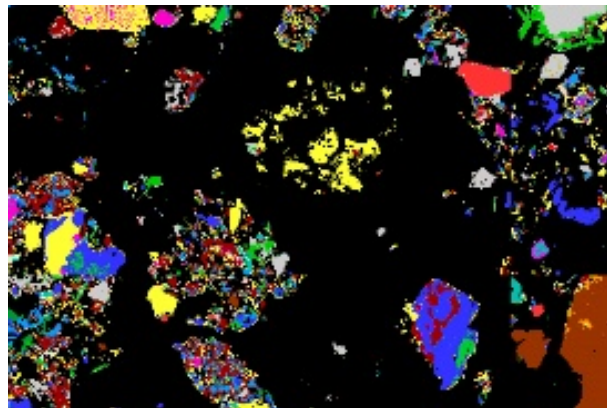
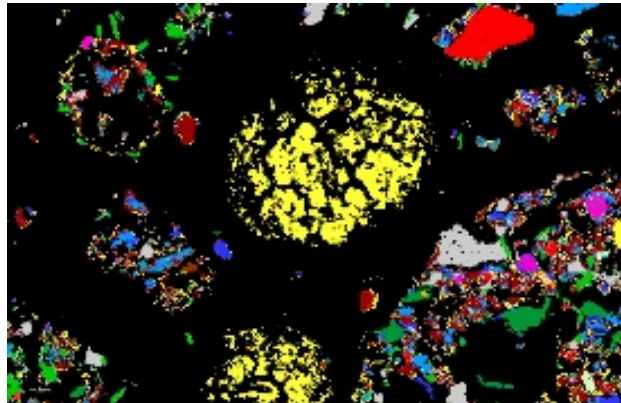
- **Result: amorphous and crystalline phases present**
composition and amount of each phase
- **determination of trace element/contaminant content with PARC difficult → Microprobe**



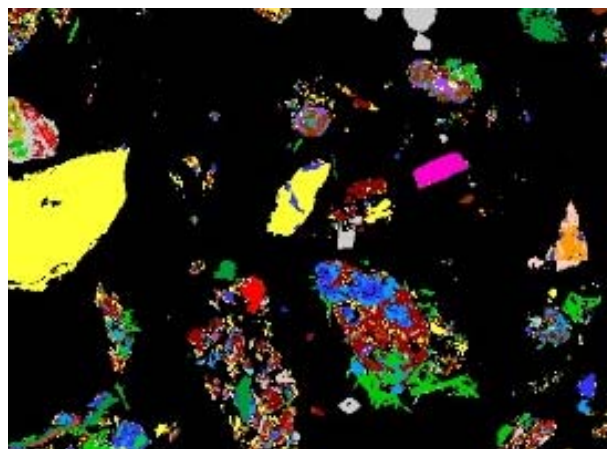
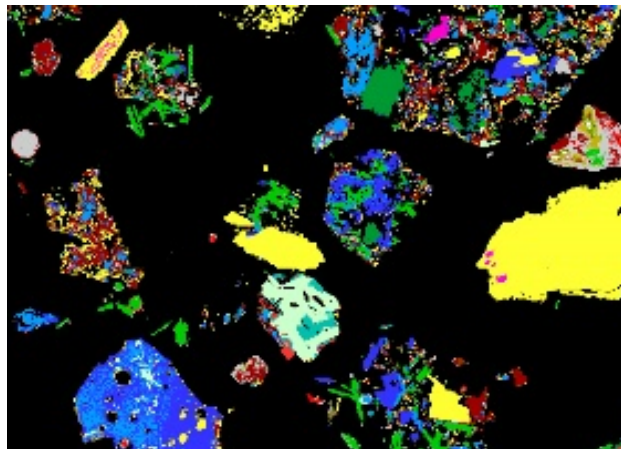
	Cr*	Ni	Cu	Zn
A1	<DL	<DL	0.03526	0.02335
B1	<DL	<DL	0.01555	0.01537
C1	<DL	<DL	0.01803	0.06354
D1	0.01383	<DL	0.07783	0.1427
E1	0.01458	<DL	0.14249	0.23788
F1	<DL	<DL	0.0179	
G1	<DL	<DL	0.07301	0.11487
H1	<DL	<DL	0.27364	0.23414
I1	<DL	<DL	0.08569	0.04842
J1	<DL	<DL	0.07354	0.03134
A2	<DL	<DL	0.02719	0.02391
B2	<DL	<DL	0.01764	
C2	<DL	<DL	0.05493	0.09468
D2	<DL	<DL	0.04516	0.08512
E2	<DL	<DL	0.04979	0.23706
F2	<DL	<DL	0.04857	
G2	<DL	<DL	0.15388	0.21067
H2	<DL	<DL	0.24606	0.27359
I2	<DL	<DL	0.26332	0.27625
J2	<DL	<DL	0.07176	0.0461

DL (wt.%, 15 kV, 300 nA, 240 s)
Cr: 0.007
Ni: 0.009
Cu: 0.013
Zn: 0.016

Outlook - Reactivity



FC after
digestion in
NaOH



larger area
analyzed

← 512μm →

8x8 fields

Thank you for your attention

