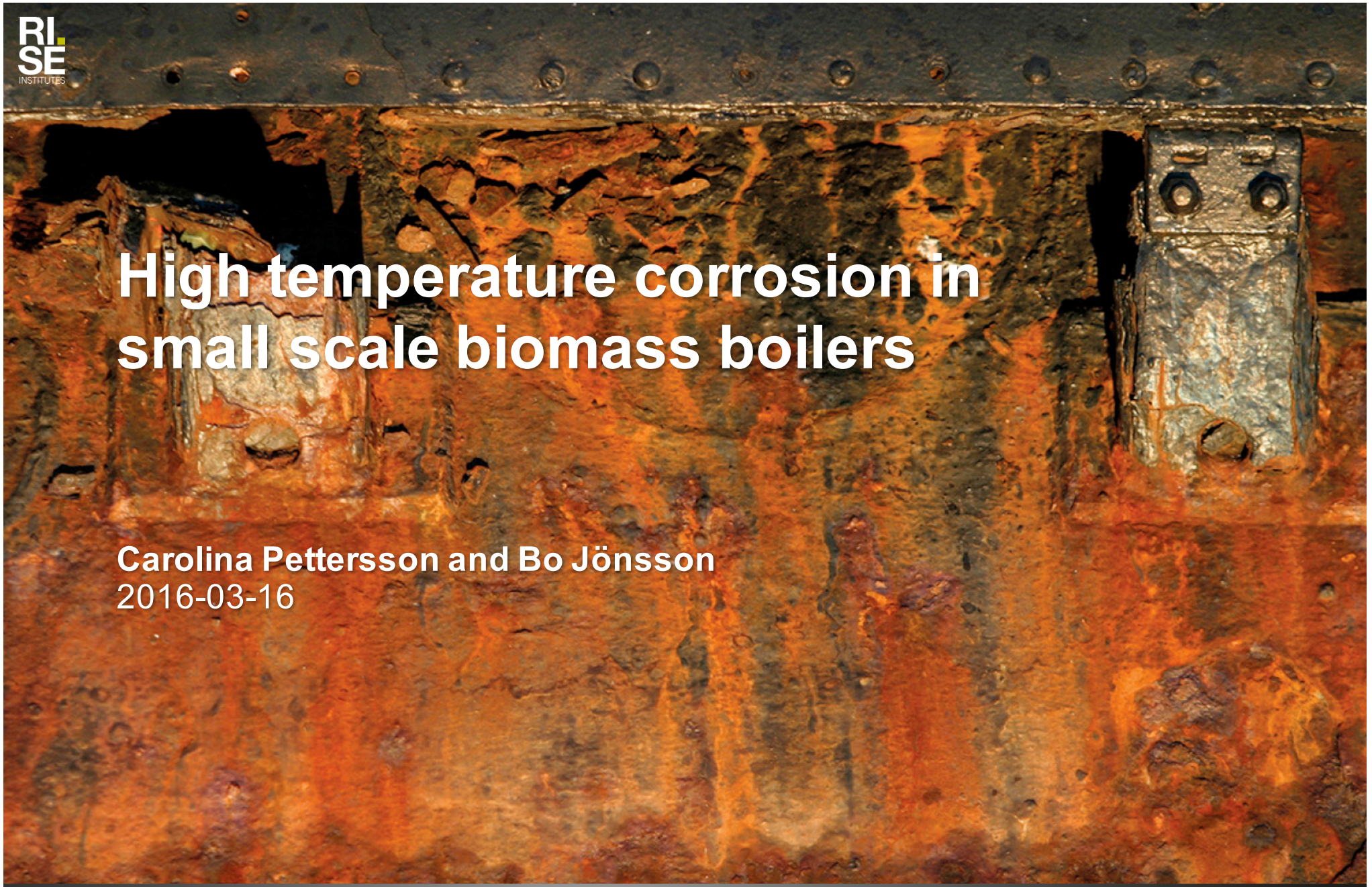


High temperature corrosion in small scale biomass boilers

Carolina Pettersson and Bo Jönsson

2016-03-16

swerea IVF

swerea swedish research

Project members

Project partners

- Janfire
- NIBE
- Sandvik Heating Technology
- Swerea IVF
- Chalmers

Background

- In the combustion of bio-based fuels the critically exposed burner parts in small boilers are typically **uncooled** and are usually made of **FeCr or FeCrNi alloys.**
- These materials can suffer attack from the **ashes** because of the formation of **alkali chromate**.
- The reaction depletes the protective oxide in chromia, leading to accelerated corrosion.
- This ultimately results in failure of the boiler unit and/or is limiting the service life of critical burner components.

Goals

- To develop practically oriented knowledge about HTC in small and medium sized plants fired mainly by pellet based bio-fuels
- Apply this knowledge and assist the SME producers with current urgent problems
- Increasing lifetime of selected critical components by a factor of 2-3 and decreasing failure complaints to below 5%

Project plan

Year	*Activity*
2014	Planning and selecting materials to be investigated
2015	Cyclic lab exposures at Sandvik
	Analysis of lab tested materials at Swerea IVF
	SEM: surface and cross sections
2016	Field exposures (Janfire)
	Analysis of field tested materials at Swerea IVF
	New cyclic lab exposures at Sandvik
	Analysis of lab tested materials at Swerea IVF

Production of model alloys – Ranking test, thermal cycling

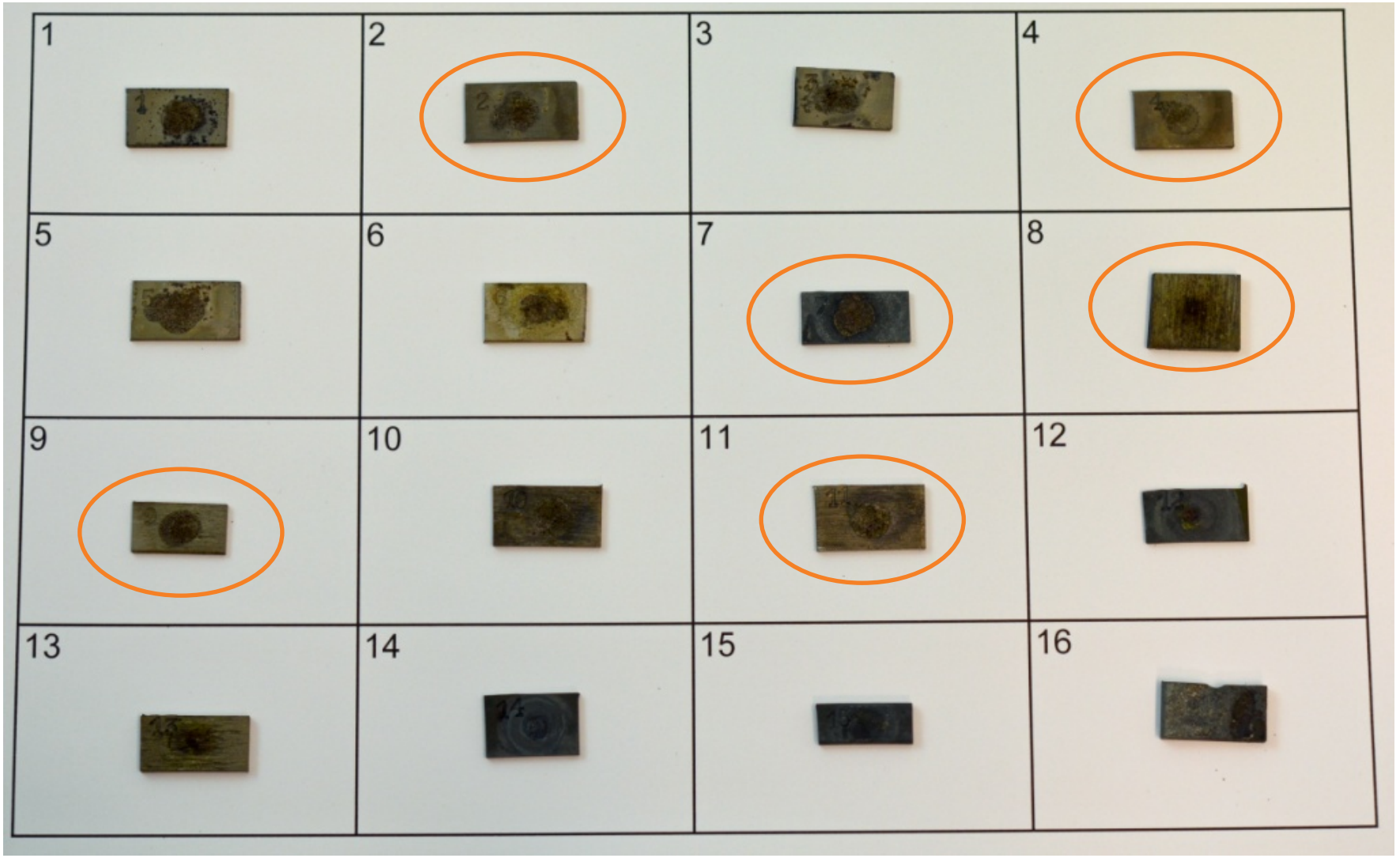
- Performed at Sandvik Heating Technology in Hallstahammar
- Ongoing work

Testing – Ranking test, thermal cycling

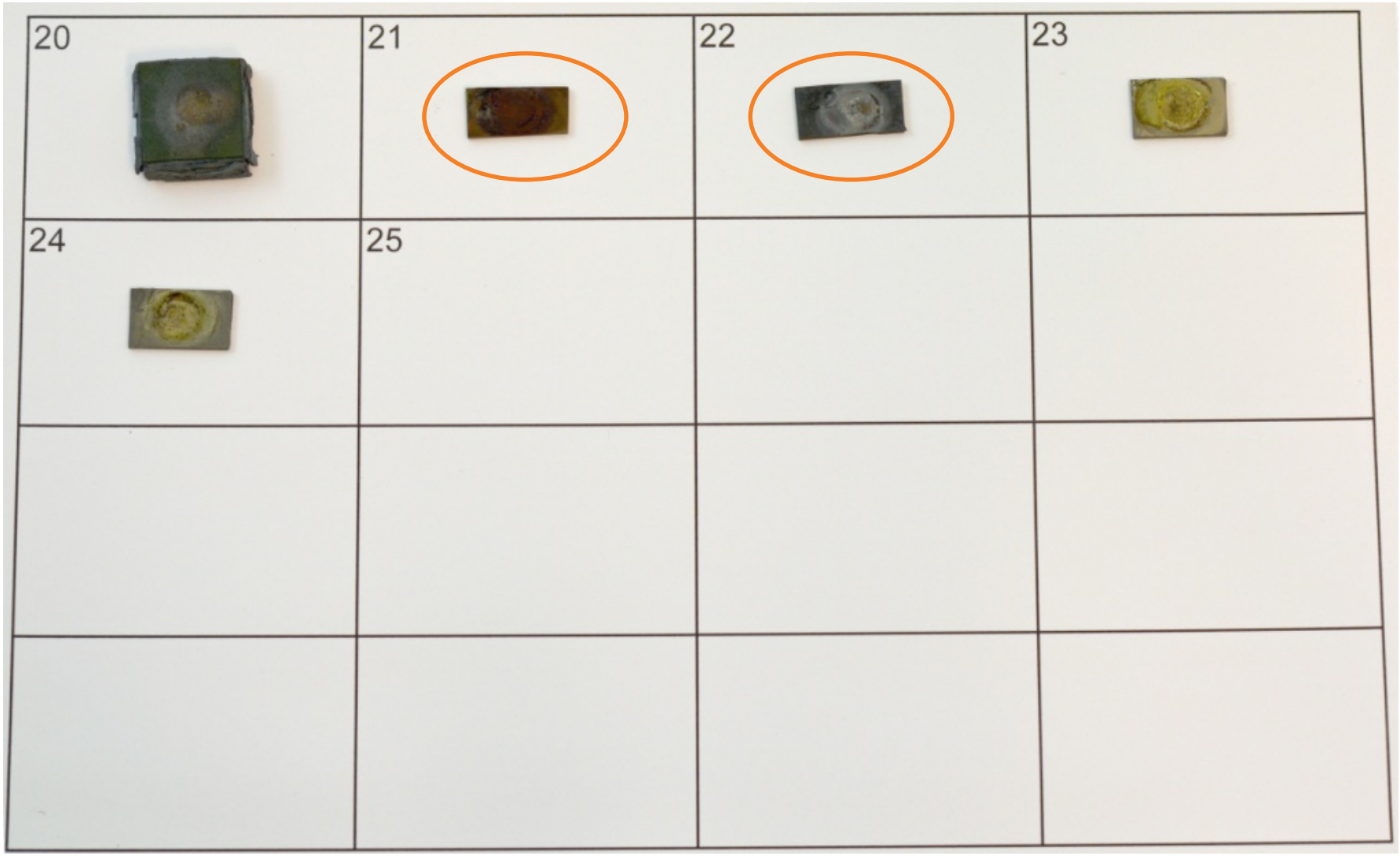
- Performed at Sandvik Heating Technology in Hallstahammar
- 50 cycles with a hold at 850°C
- All materials, 2 coupons of each kind. The ashes are replaced on one and kept on the other, selected samples are also coated

Results

Thermal cycling at Sandvik Heating Technology



Thermal cycling at Sandvik Heating Technology



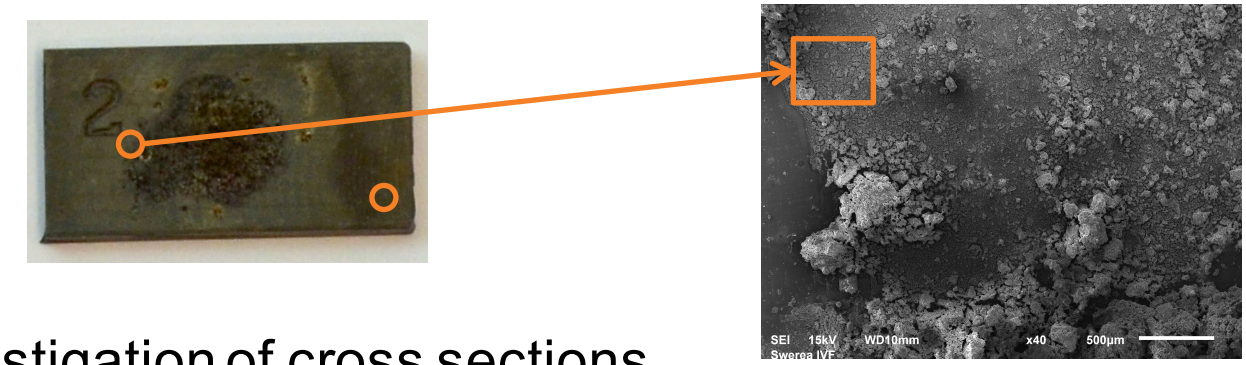
Analysed samples

No.	Material	No. of cycles	Fe	Ni	Cr	Al	Other
2	Kanthal model	50					
4	Kanthal model	50					
7	253MA	50	Bal	11	21		RE
8	Kanthal D	60	Bal		21	4.8	RE
9	Kanthal APMT	50	Bal		21	5	Mo 3, RE
11	Kanthal APMT + CS repeated dipping*	50	Bal		21	5	Mo 3, RE
21	Nikrothal PM58	60	18	Bal	20	5	RE
22	Inconel 625	60		58	21	0.4	Mo 9, Nb 3-4

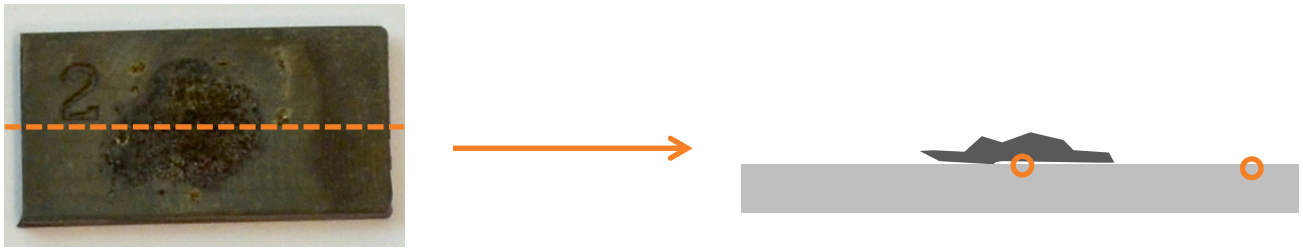
* CS = colloidal silica

SEM analysis of the samples

- Surface investigation in 2 areas:
  - At the edge of the ashes and at the edge of the sample



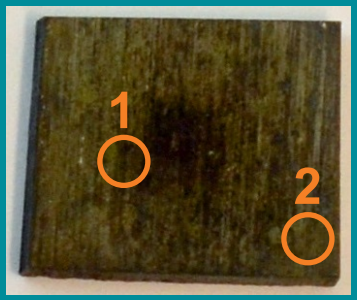
- Investigation of cross sections
  - Beneath the ashes (in the middle)
  - At the end of the sample
  - Other interesting areas



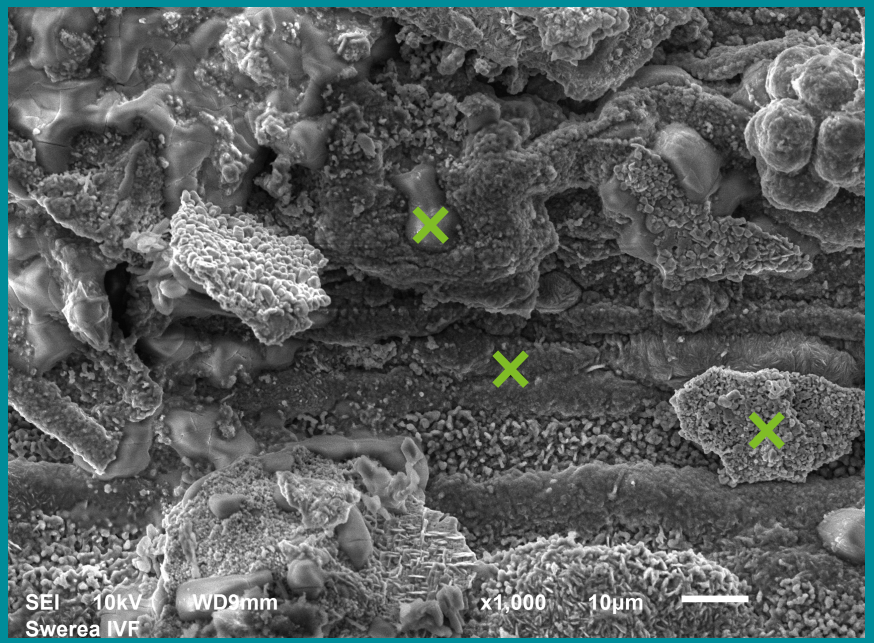
Example of results

Two samples

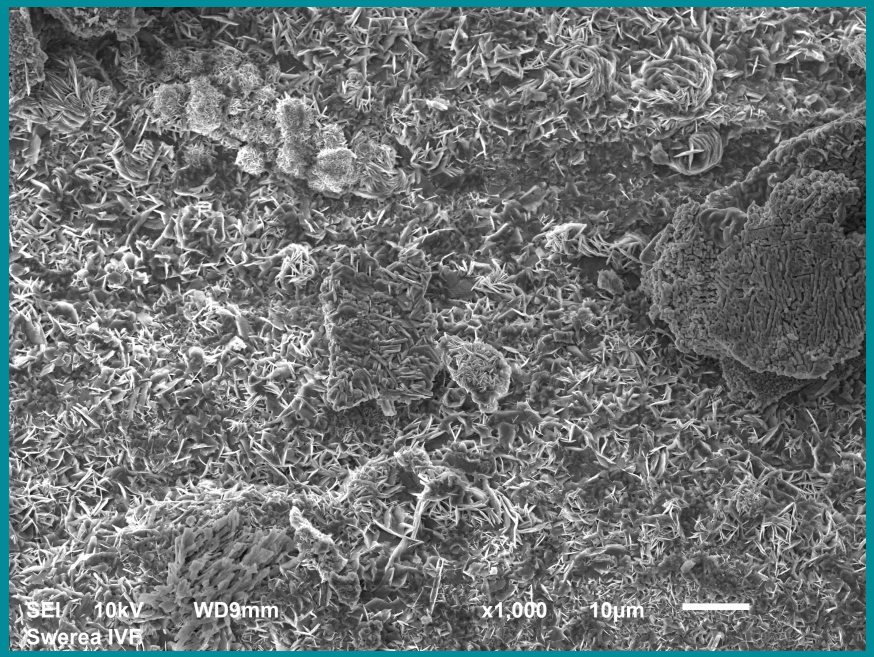
Sample 8: Kanthal D (reference) Surface

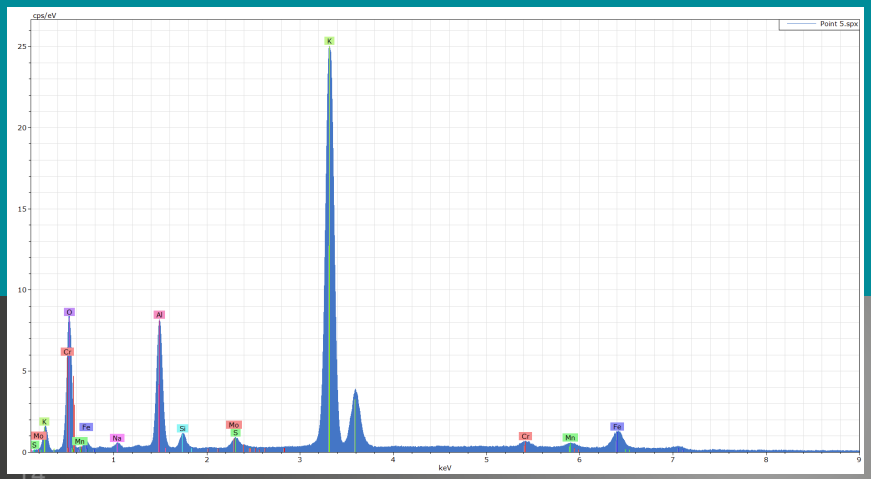


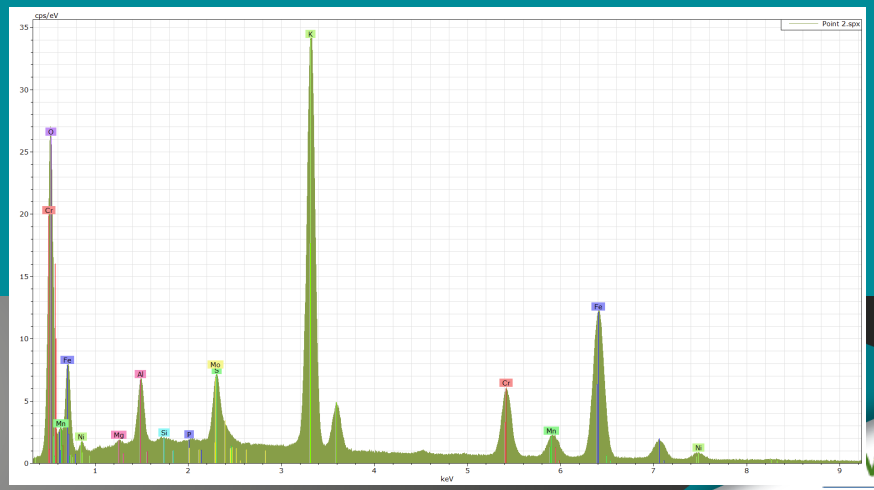
Area 1 (outer area of the ashes)



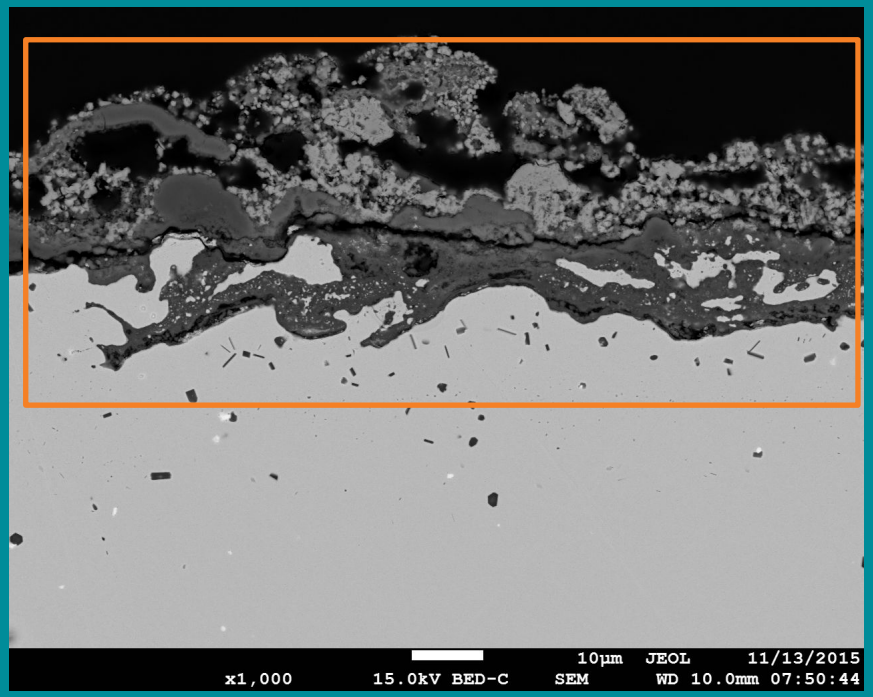
Area 2 (close to edge)

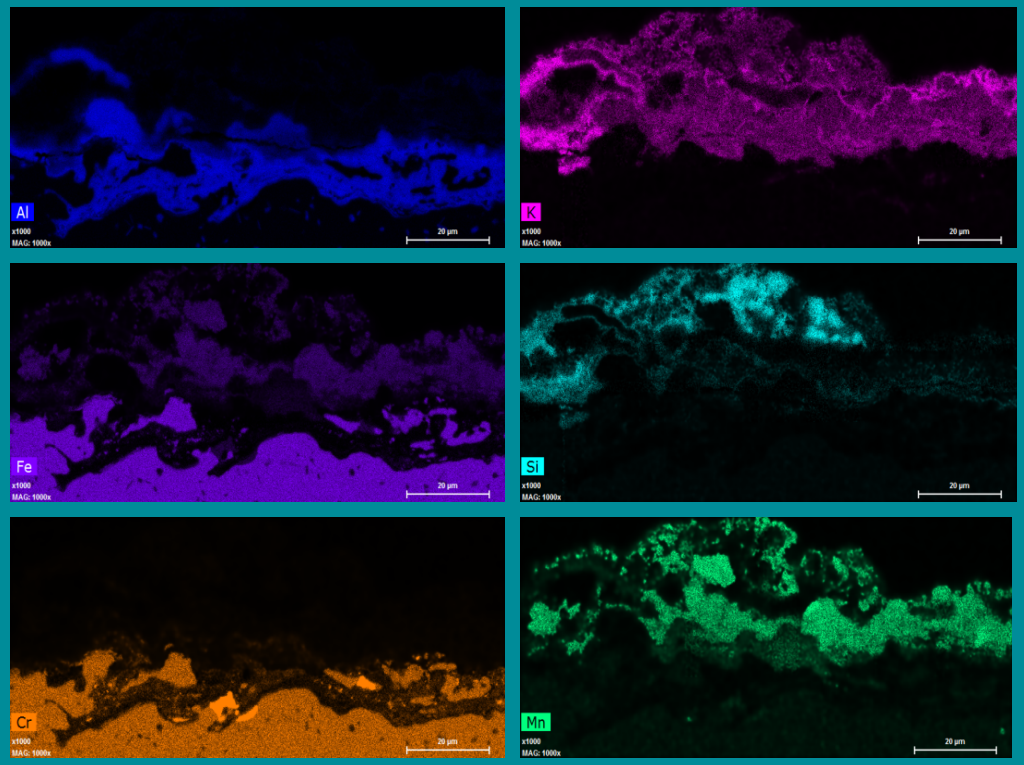


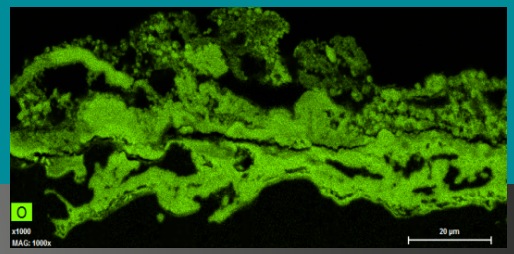




Sample 8: Kanthal D (reference)
Cross section, middle, EDS-analysis



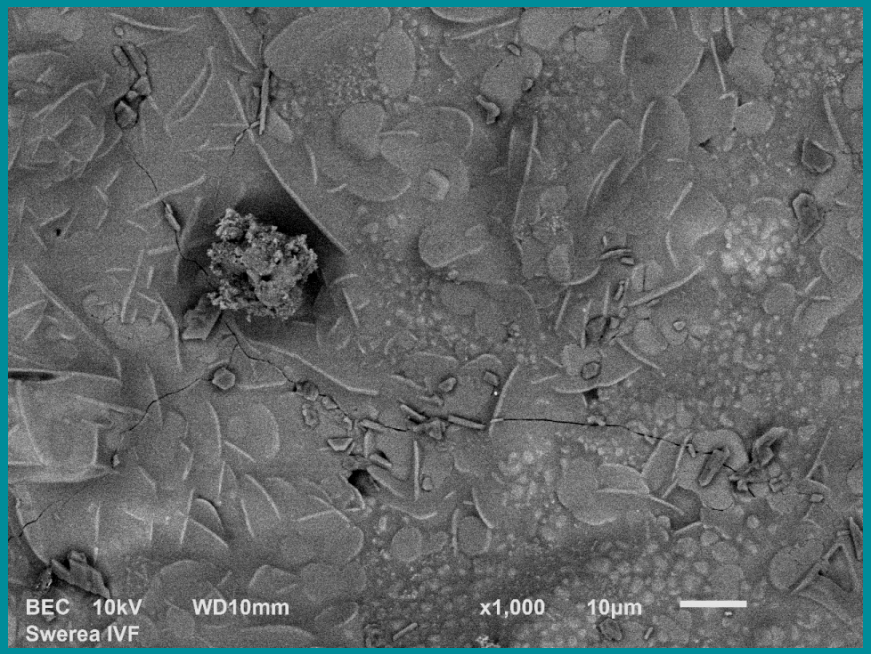




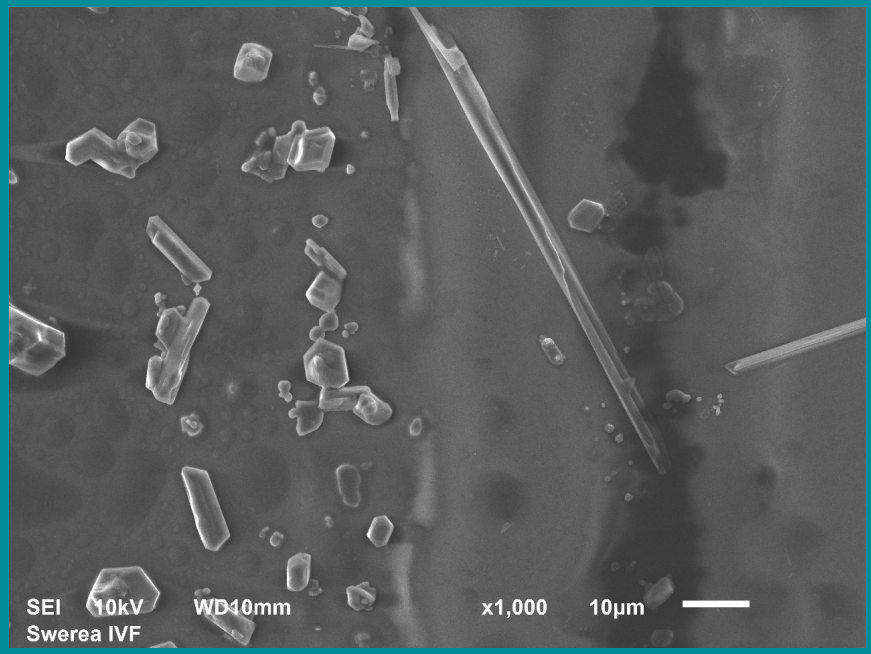
Inner Al oxide and an outer oxide rich in iron and potassium. Potassium chromate is detected on the surface.
Oxide thickness ~10-20 µm.

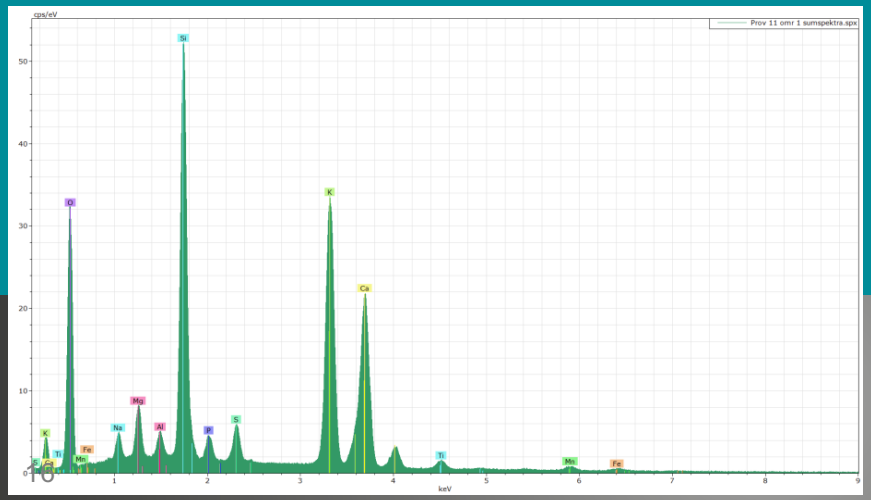
Sample 11: Kanthal APMT + CS Surface

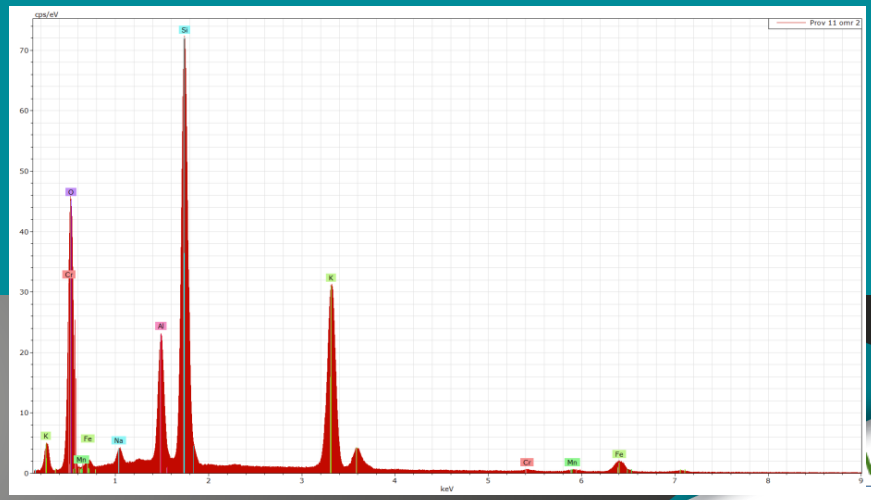
Area 1 (outer area ashes)



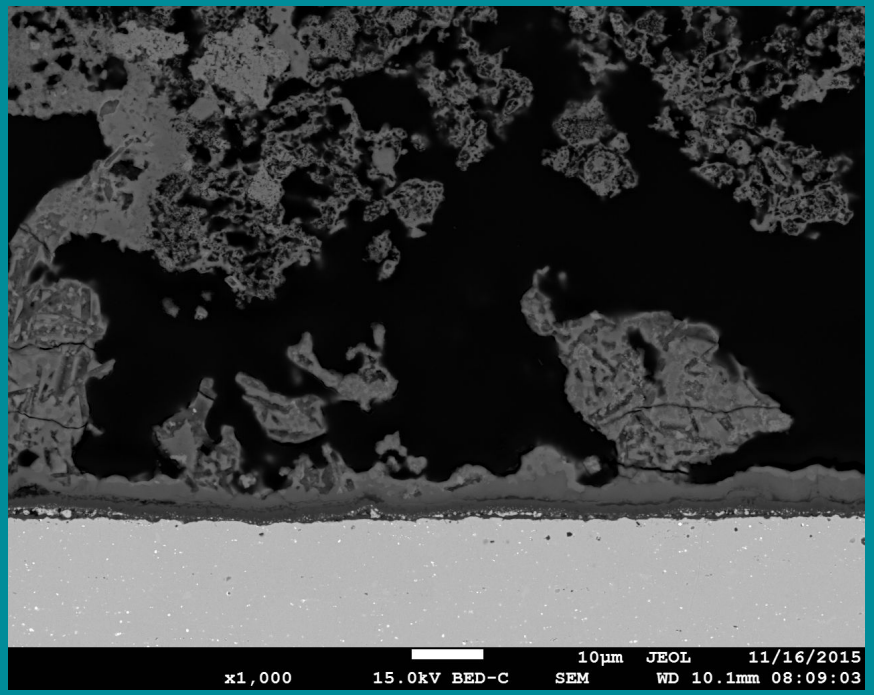
Area 2 (close to edge)

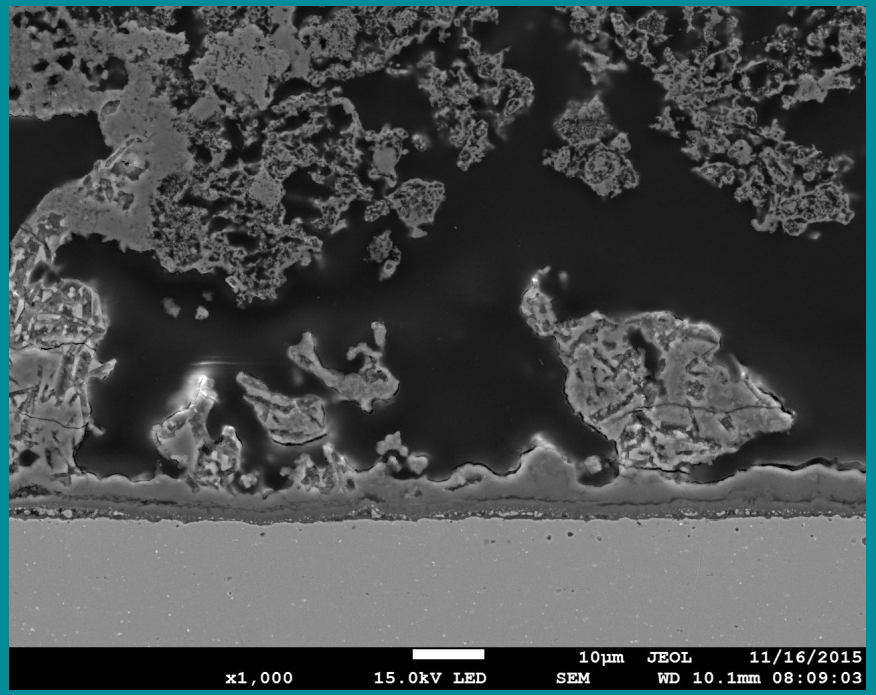






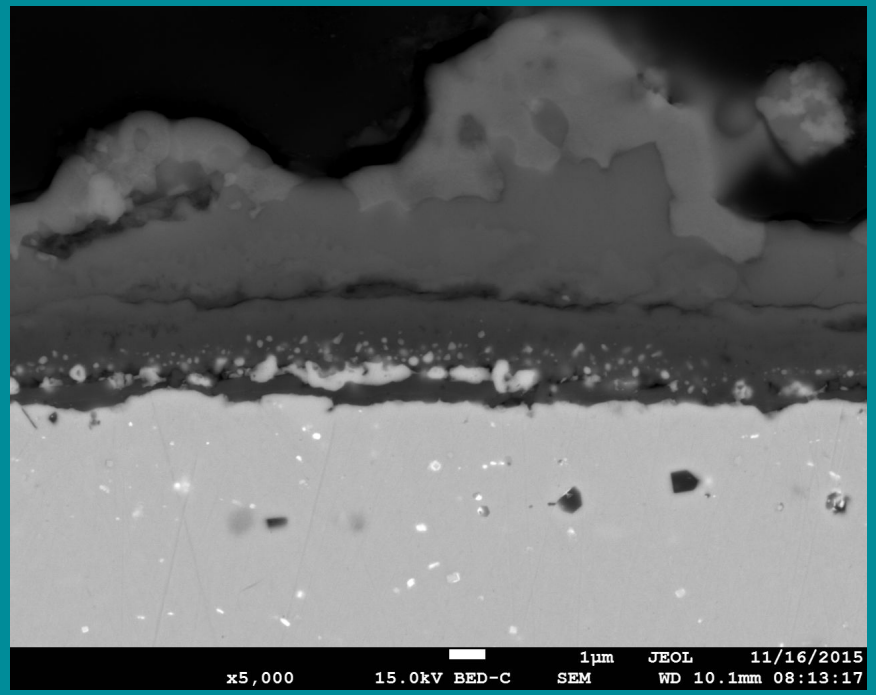
Sample 11: Kanthal APMT + CS
Cross section, middle

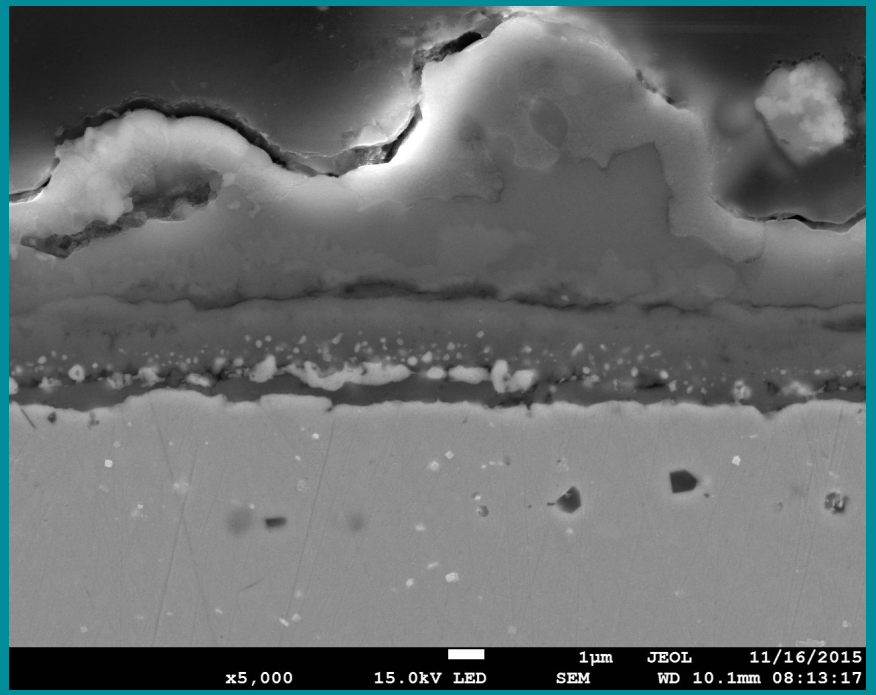




Duplex oxide, thickness ~ 5-10 µm, magnification x1000 times

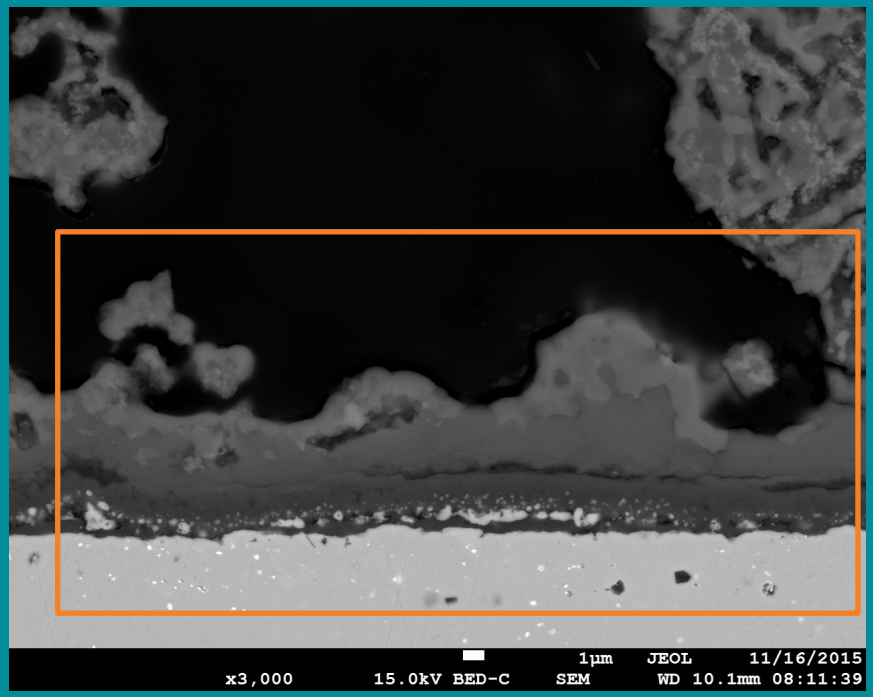
Sample 11: Kanthal APMT + CS
Cross section, middle

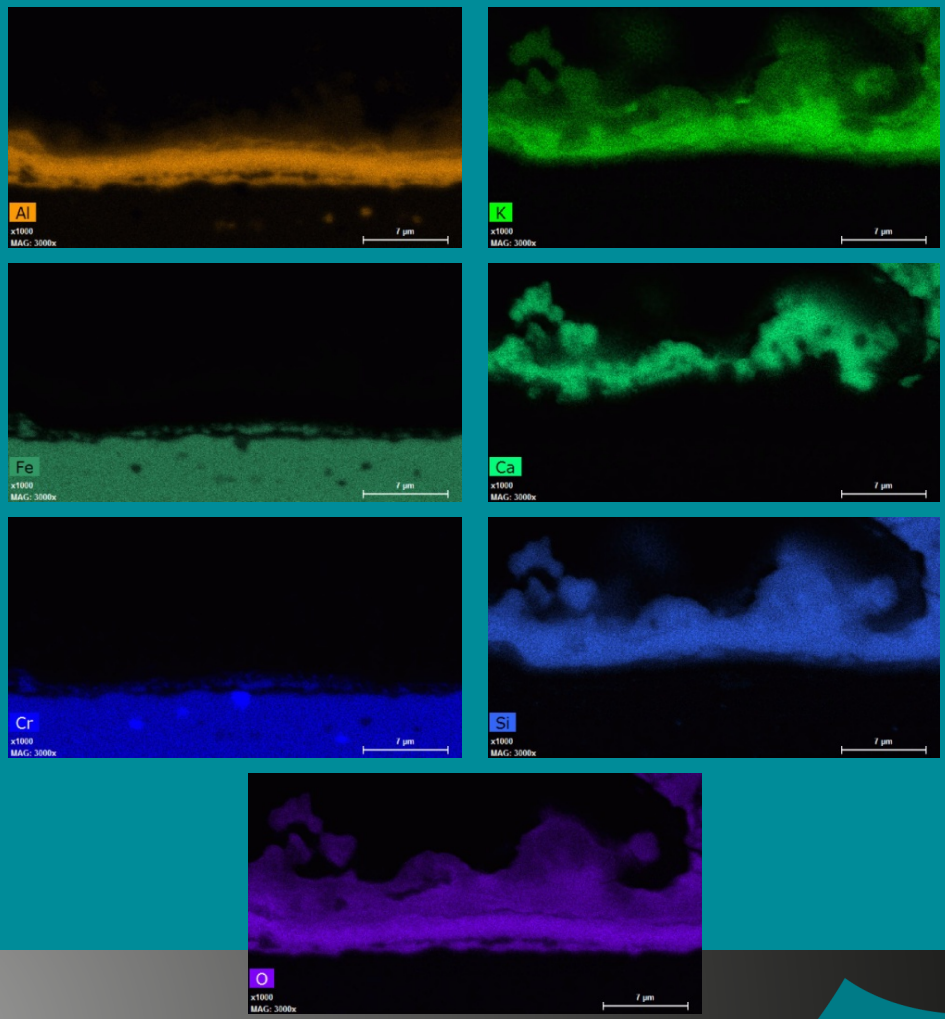




Duplex oxide, thickness ~ 5-10 µm, magnification x5000 times

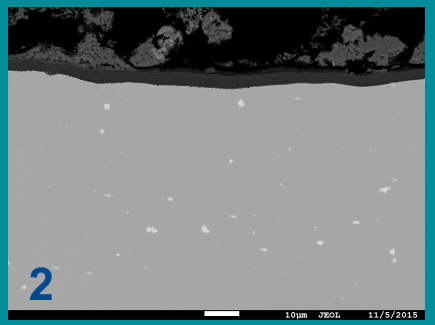
Sample 11: Kanthal APMT + CS
Cross section, middle, EDS-analysis

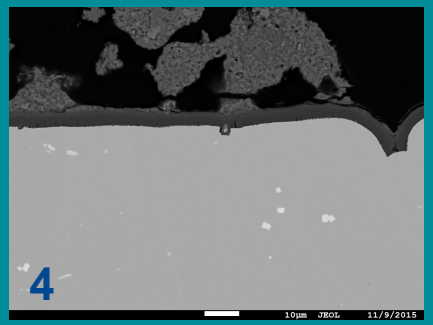


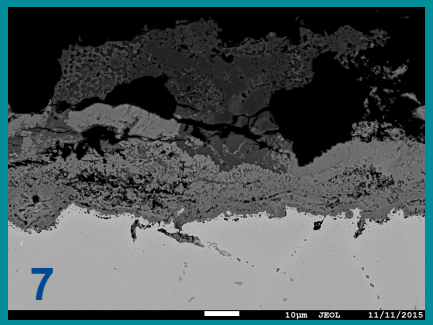


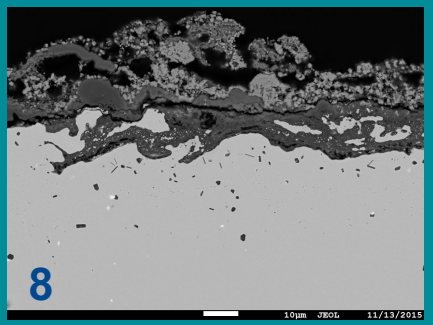
Duplex oxide scale with inner Al-rich oxide and outer Si-rich oxide. Potassium is detected in the outer part of the oxide scale. Oxide thickness ~5-10 µm.

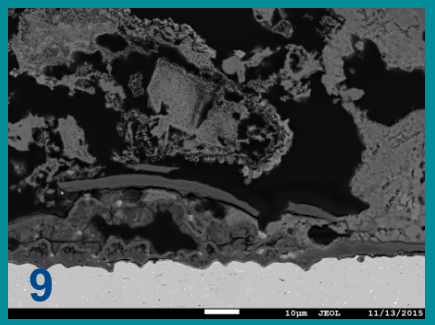
Cross sections at 1000x magnification

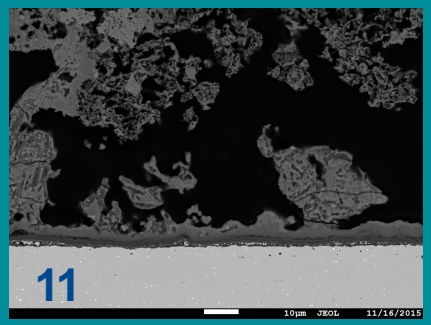


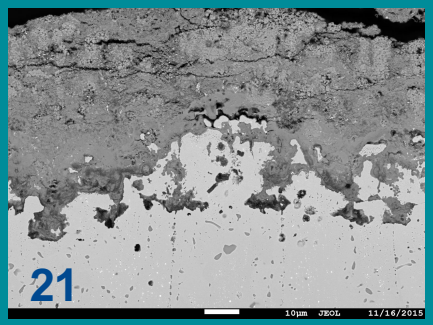


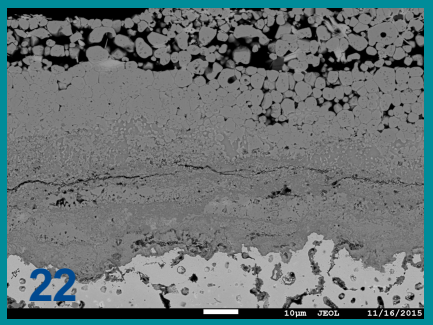












The appearance of the oxides is very different on the different samples.

The thicknesses varies from about 3 µm to almost 100 µm in the thickest oxide.

Summary of results

No.	Material	Ox. thickness beneath ashes	Comments
2	Kanthal Model alloy	4 µm	Al oxide
4	Kanthal Model alloy	3-5 µm	Al oxide
7	253MA	20-30 µm	Thick Fe rich oxide + inner oxidation
8	Kanthal D	10-20 µm	Fe rich oxide + inner oxidation
9	Kanthal APMT	4-5 µm	Al oxide
11	Kanthal APMT + CS repeated dipping	5-10 µm	Duplex oxide scale: inner Al oxide + outer Si oxide
21	Nikrothal PM58	50-70 µm	Very thick oxide + inner oxidation
22	Inconel 625	70-90 µm	Very thick oxide + inner oxidation

Field exposures in boilers

- Exposure in boilers ongoing at Janfire

Planned activities for 2016

- Repeat lab exposures at Sandvik but at a lower temperature (600°C instead of 850°C), with following SEM analysis
- Analysis of field exposures (same kind of materials as in the lab exposures) and compare the results

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