Johan Gadolin
PROCESS CHEMISTRY CENTRE

Åbo Akademi University

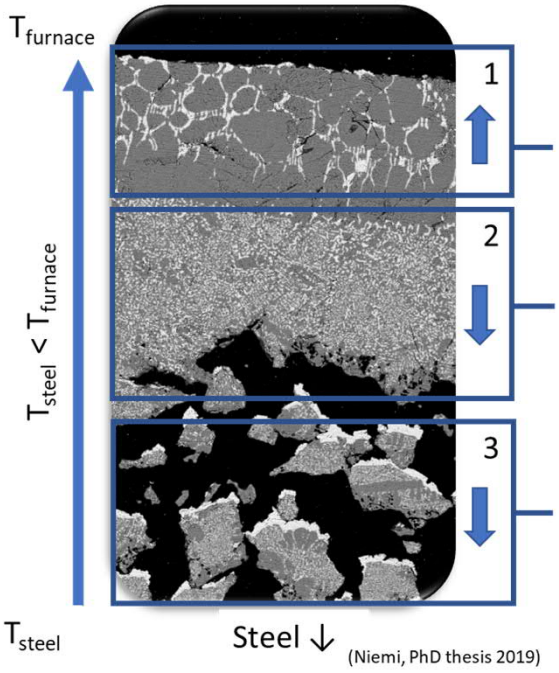
Pulp mill deposit formation and aging – role of intra-deposit alkali chloride transport – Phase 2

Roland Balint, Tor Laurén, Emil Vainio, Markus Engblom

SKY LTR 30.11.2021

Mechanisms that change deposit morphology and chemistry with time and due to temperature gradient

Laboratory deposit exposed to temperature gradient



(Niemi, PhD thesis 2019)

Mechanism changing deposit chemistry and morphology

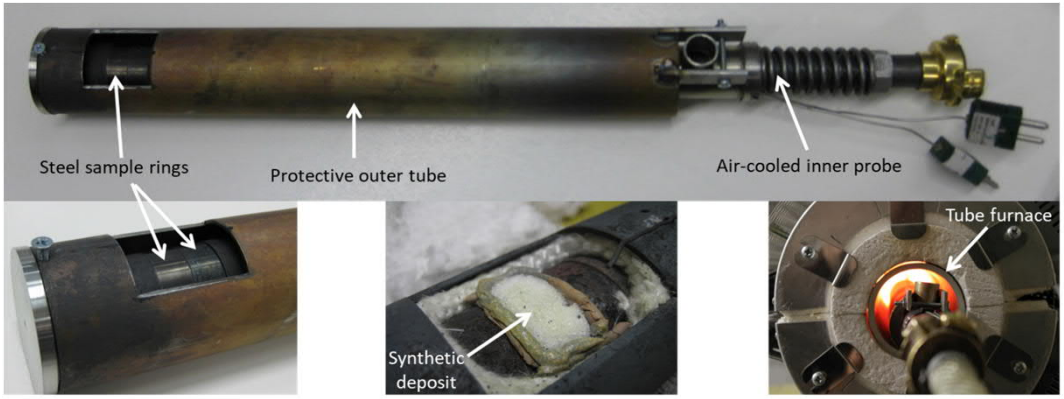
1. Transport of alkali chloride toward outer deposit surface
2. Movement of alkali chloride enriched melt toward steel
3. Gas phase transport and enrichment of alkali chloride toward steel

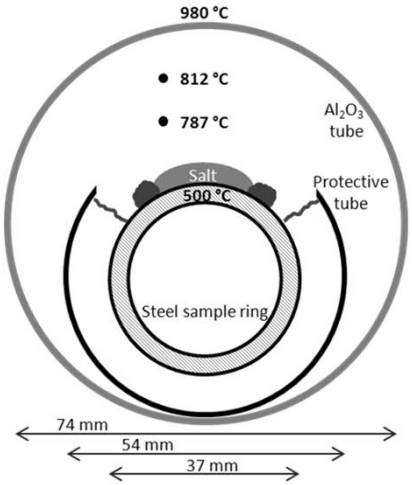
These mechanisms are observed in Brazilian superheater deposits

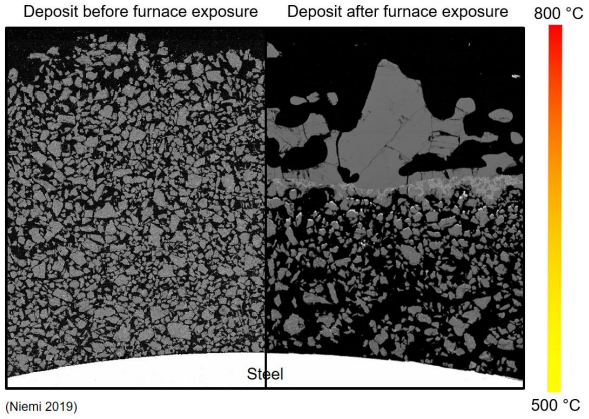
The gas phase alkali chloride transport is observed in SKY project probe samples as well as SH deposit samples from the same Finnish boiler.

(Gas phase alkali chloride transport also seen in Brazilian deposits)

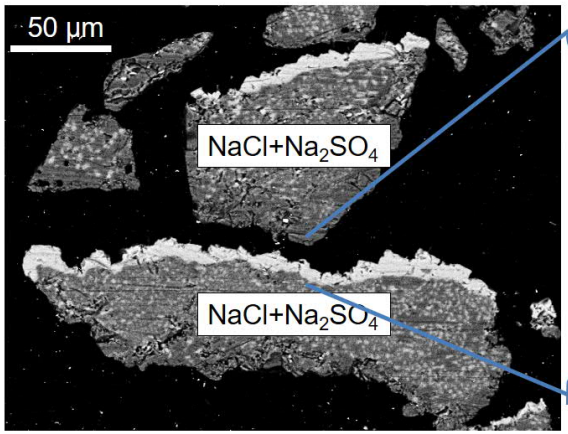
Gas phase transport and enrichment of alkali chlorides toward steel

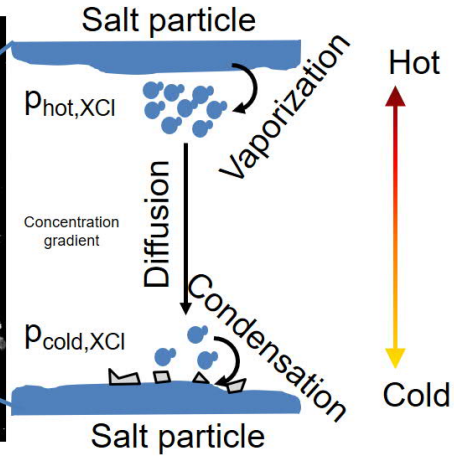






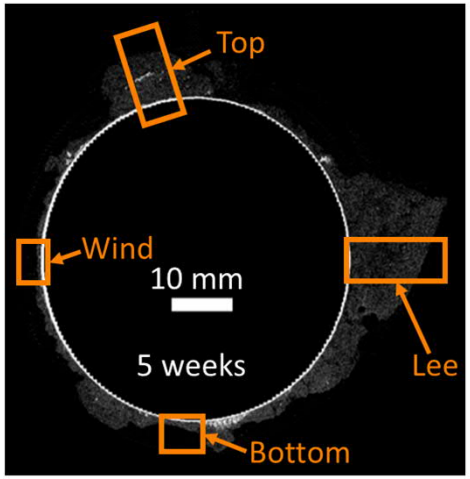
- Temperature gradient induced concentration diffusion
- Moves alkali chlorides toward steel resulting in alkali chloride enrichment toward and onto onto steel

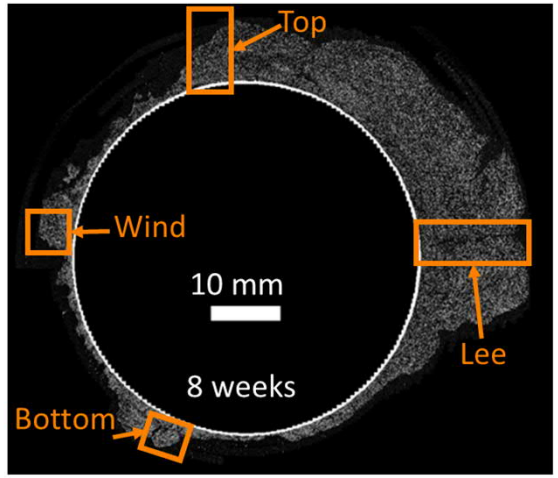


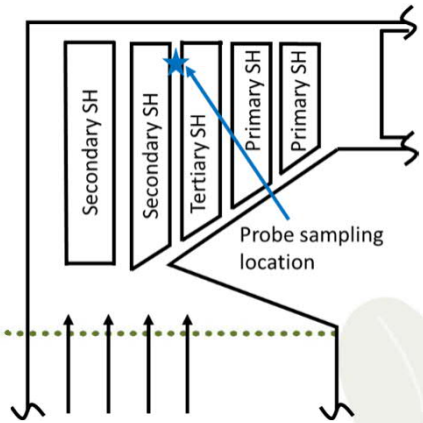


Probe measurements

- Phase 1
  - 1 week measurement
- Phase 2
  - 5 and 8 week measurements

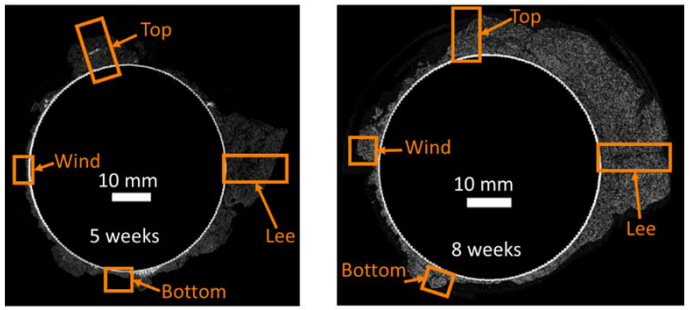


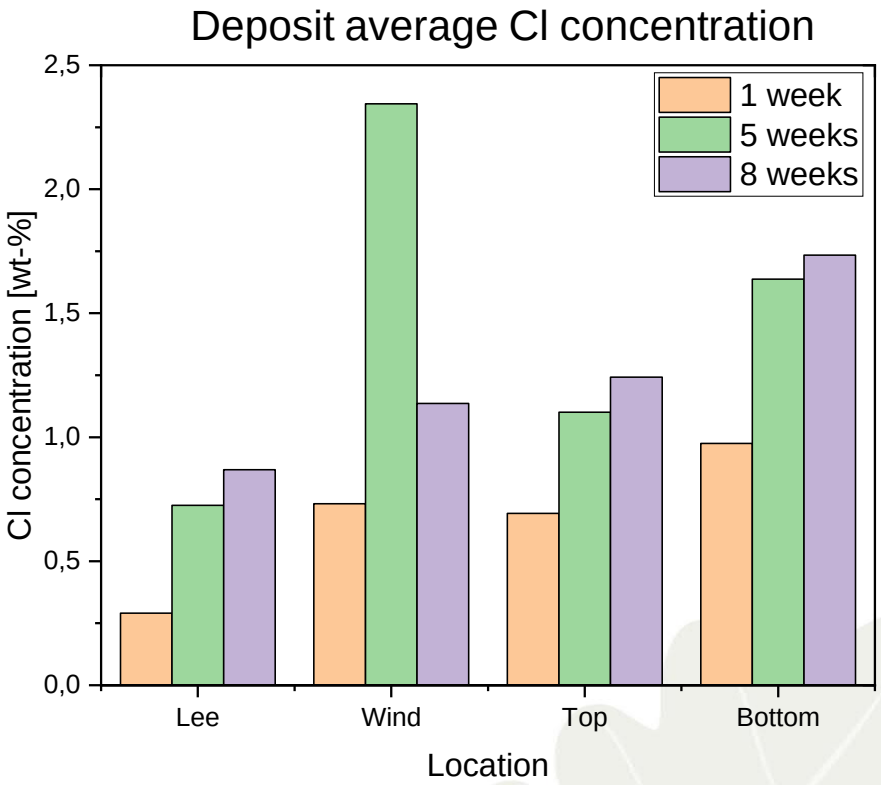




Probe measurements - Results

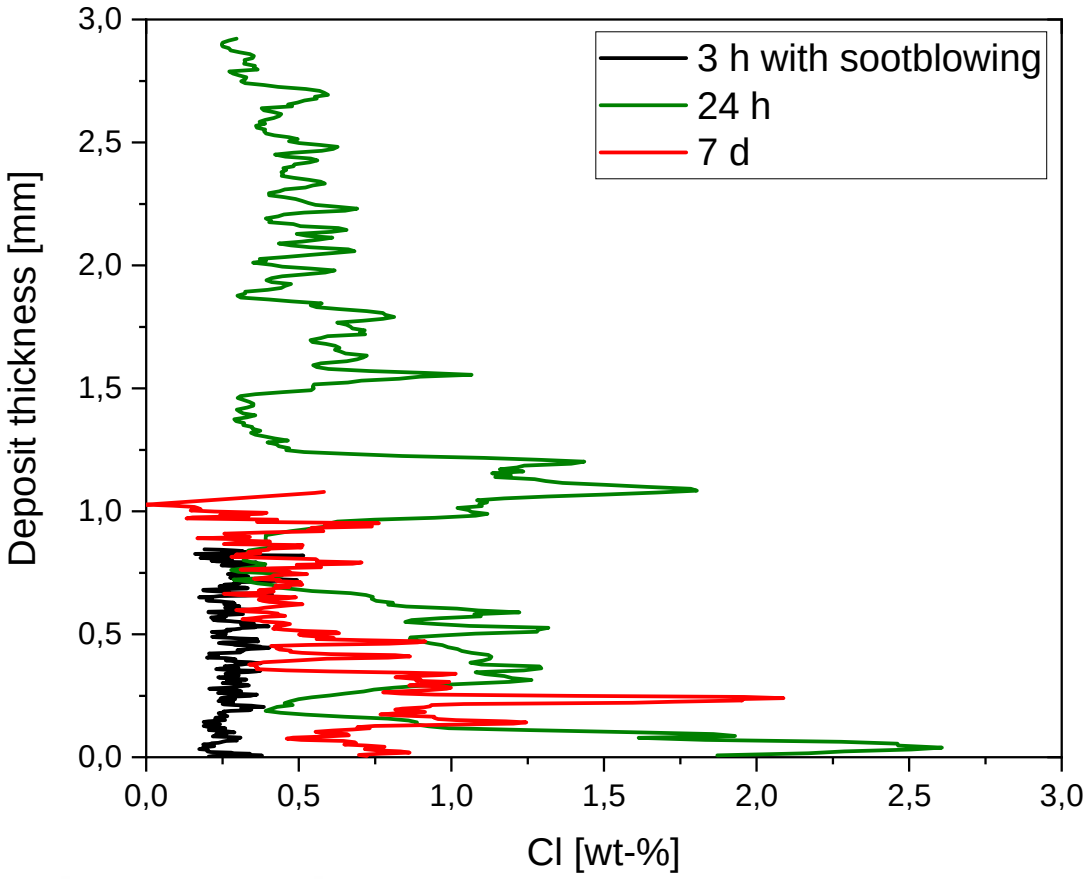
- Deposit chloride concentration increases with time



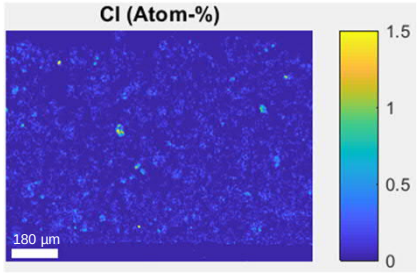


1 week measurement is from Phase 1

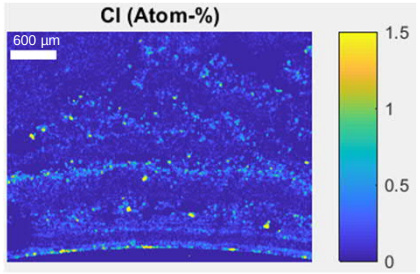
Phase 1 probe measurements



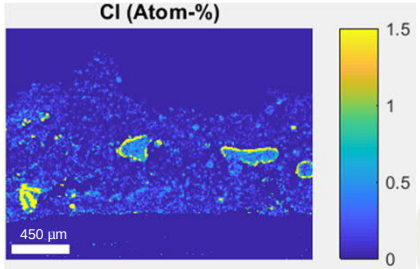
Measurement time



3 h with sootblowing



24 h

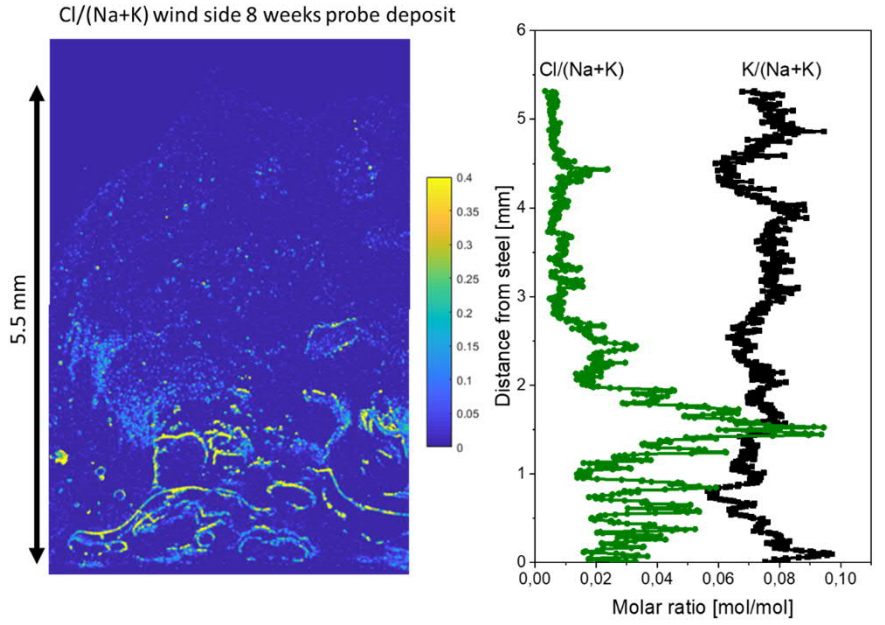


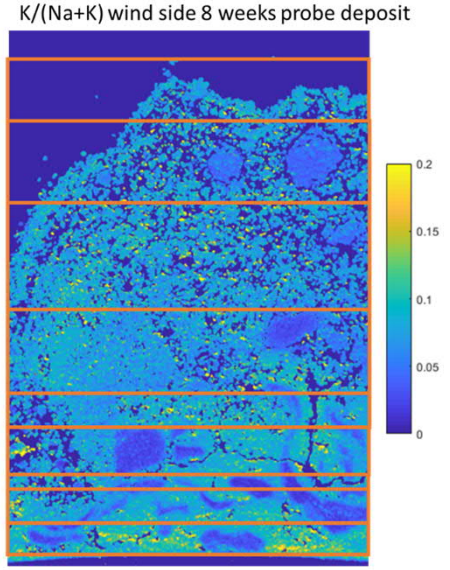
7 d

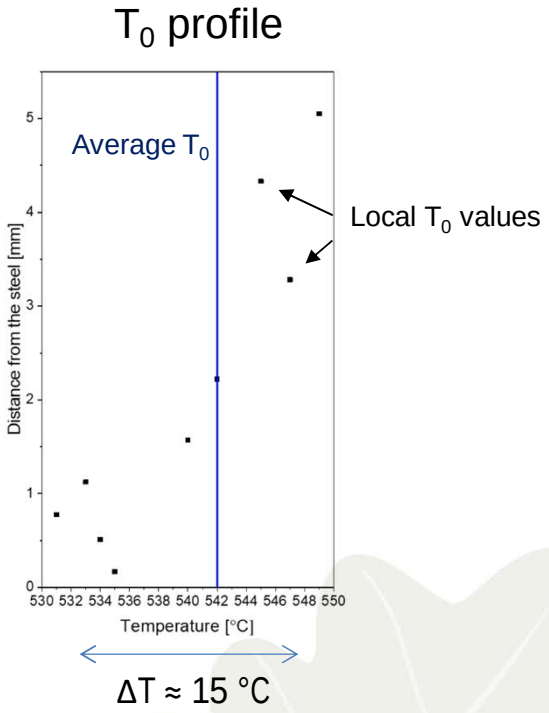
Samples from vind side
The profiles are calculated from maps on right by averaging over the horizontal plane

Phase 2 probe results – Deposit T_0 profiles

- Deposit local T_0 is lower toward steel







Phase 2 probe results – Deposit T_0 profiles

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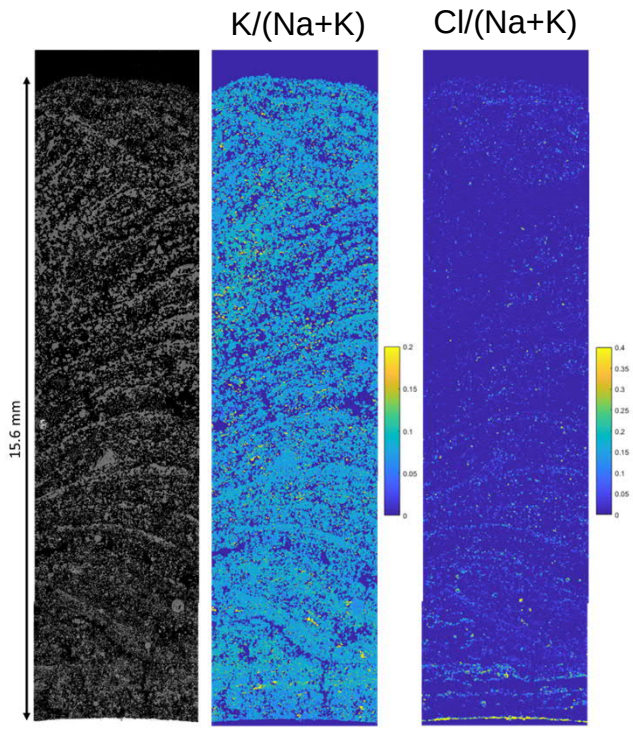
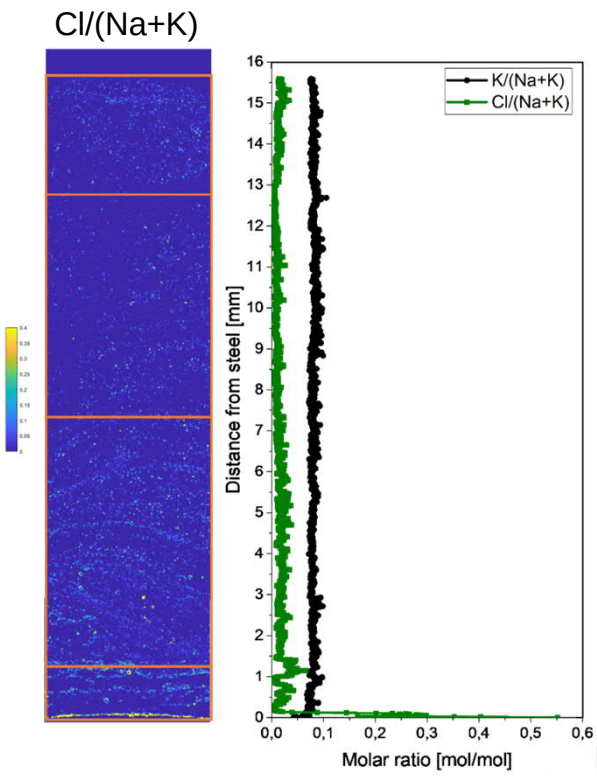
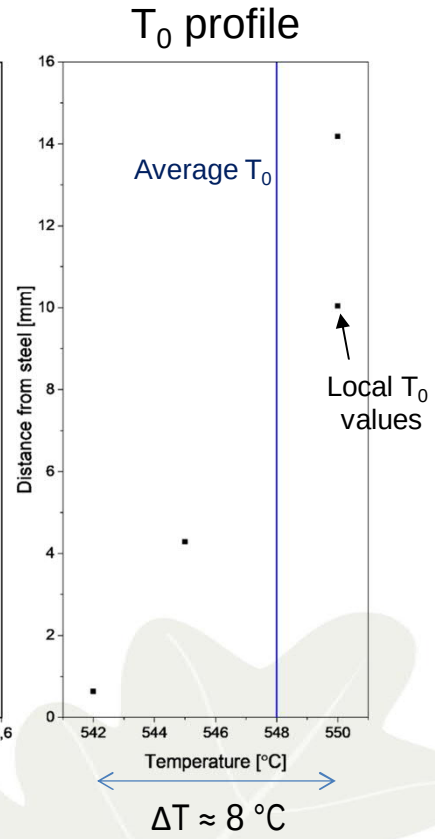
Sample from lee side



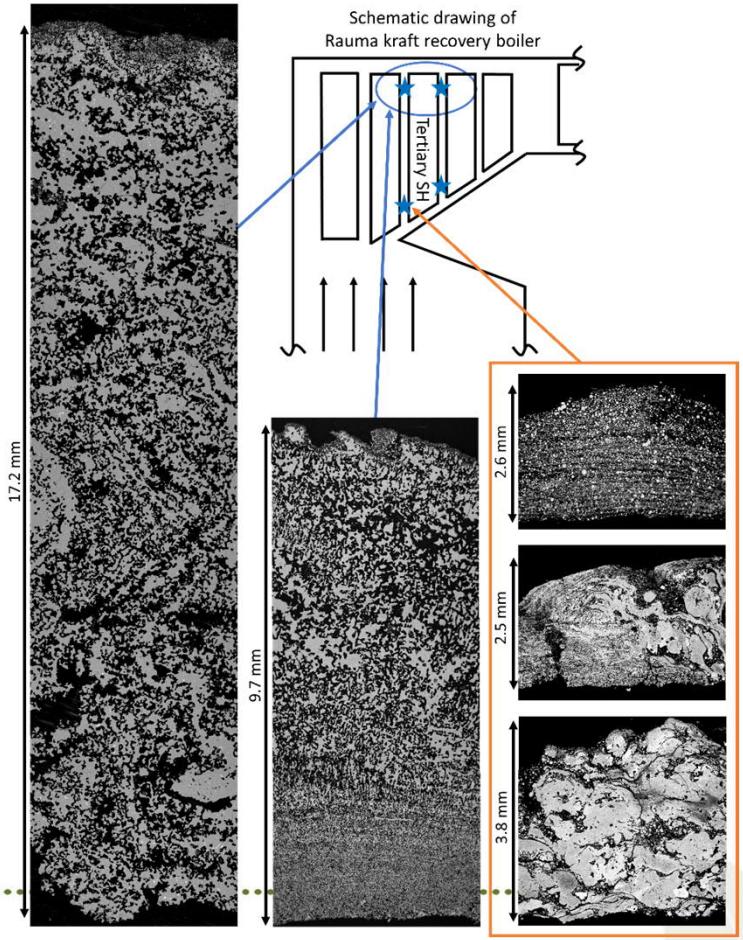




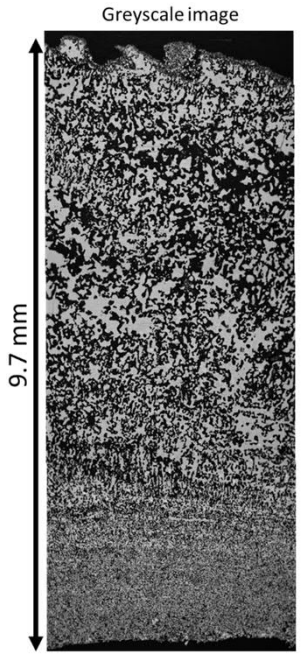
Superheater deposit samples

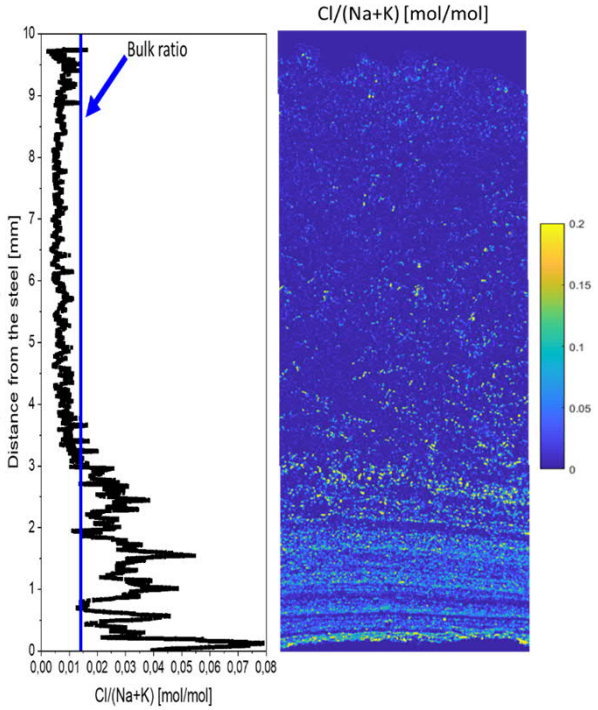
- In addition to probe samples, deposit samples have been obtained from superheaters
- Superheater samples ”only” 1 month old
- Similar observations as with probe samples (”Type 1 deposit”)
  - Cl enrichment toward/onto steel
  - Local T_0 lower toward steel

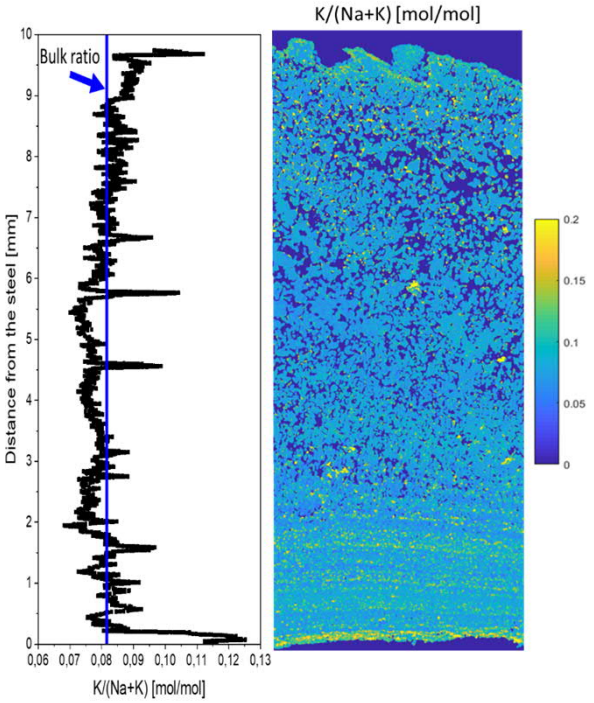
- In addition, in some probe and SH deposits, a Cl depleted region close to steel observed (”Type 2 deposit”)
  - Possibly due to sulfation

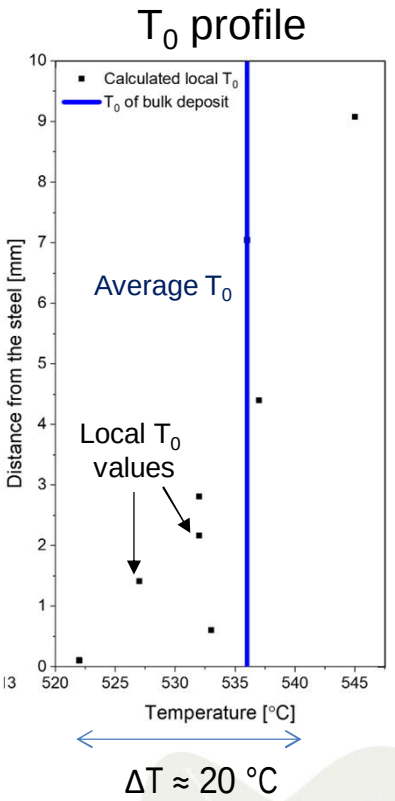


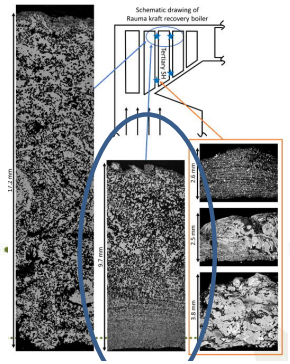
Superheater deposit samples (”Type 1”)





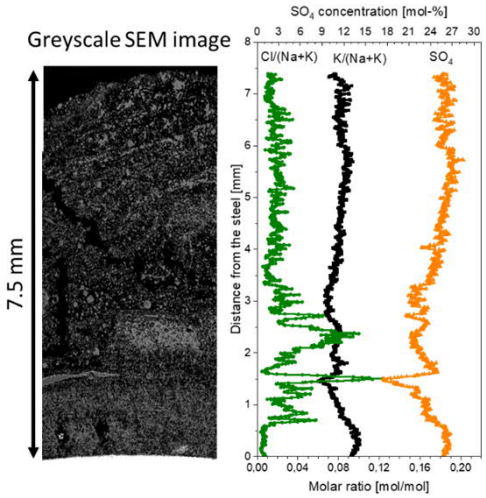




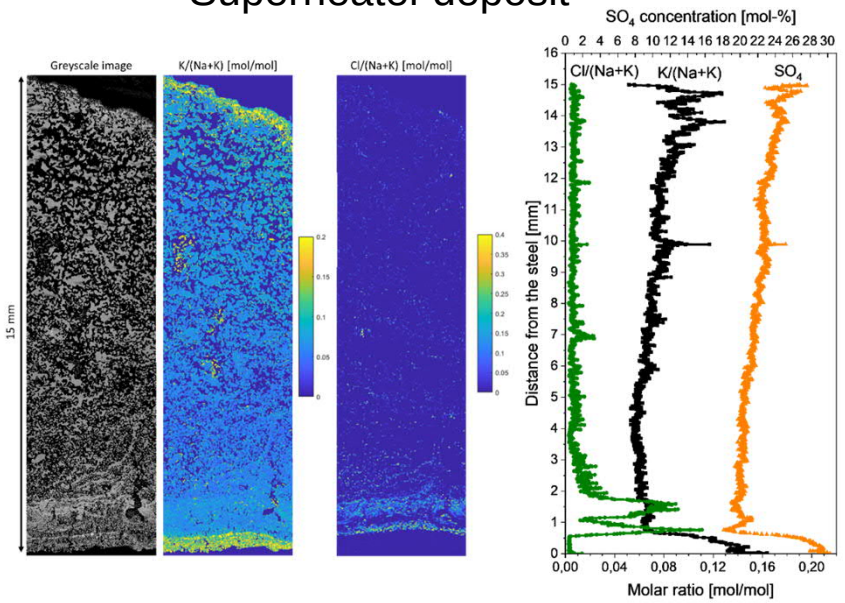


Deposit samples (”Type 2”)

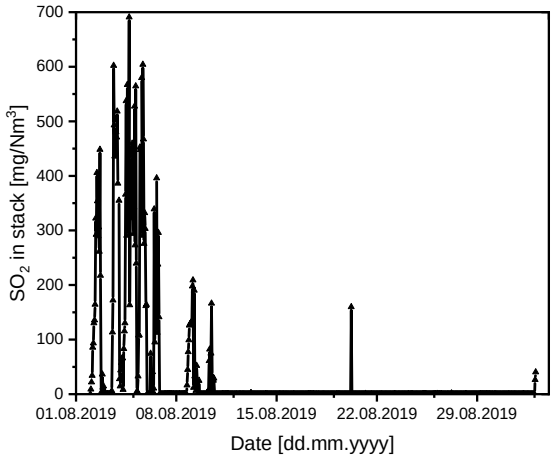
8 week probe deposit



Superheater deposit



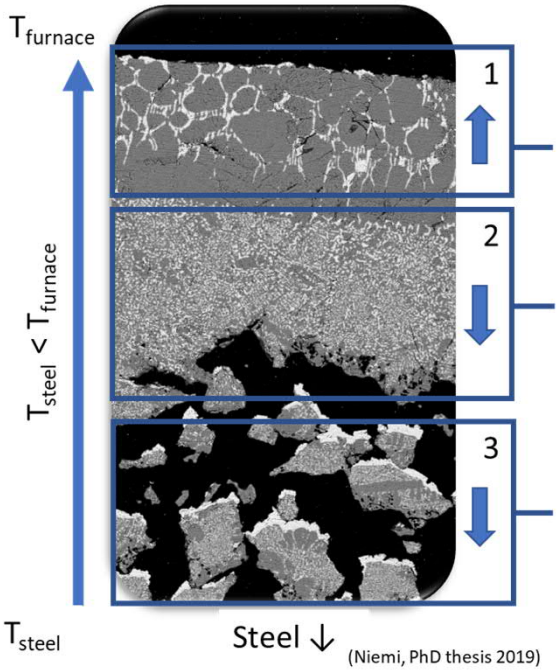
Stack SO_2 during time when superheater deposit in boiler



- In some probe and SH deposits, a Cl depleted region close to steel observed (”Type 2 deposit”)
  - Possibly due to sulfation
- Further work needed to understand better

Mechanisms that change deposit morphology and chemistry with time and due to temperature gradient

Laboratory deposit exposed to temperature gradient



(Niemi, PhD thesis 2019)

Mechanism changing deposit chemistry and morphology

1. Transport of alkali chloride toward outer deposit surface
2. Movement of alkali chloride enriched melt toward steel
3. Gas phase transport and enrichment of alkali chloride toward steel

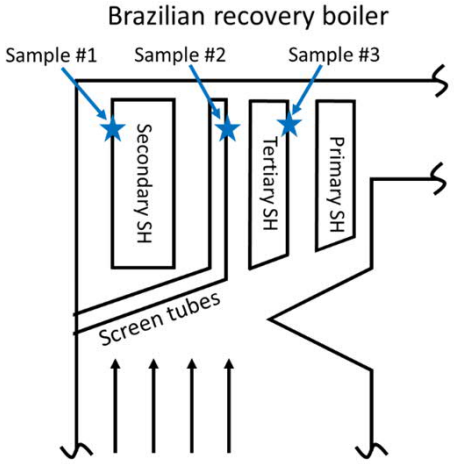
These mechanisms are observed in Brazilian superheater deposits

The gas phase alkali chloride transport is observed in SKY project probe samples as well as SH deposit samples from the same Finnish boiler.

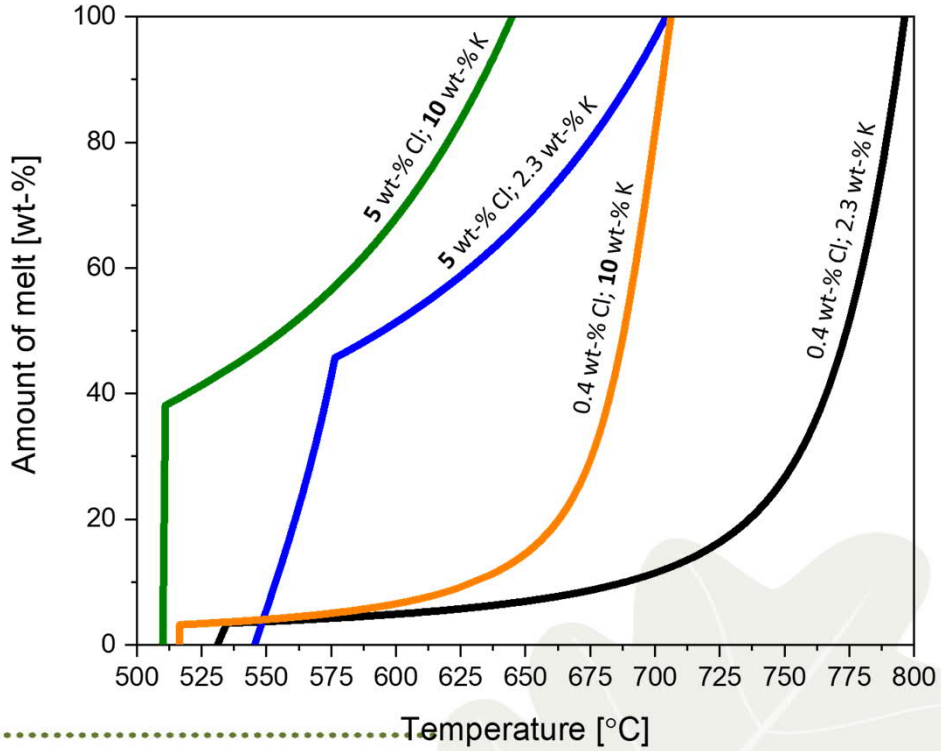
(Gas phase alkali chloride transport also seen in Brazilian deposits)

Brazilian superheater deposits

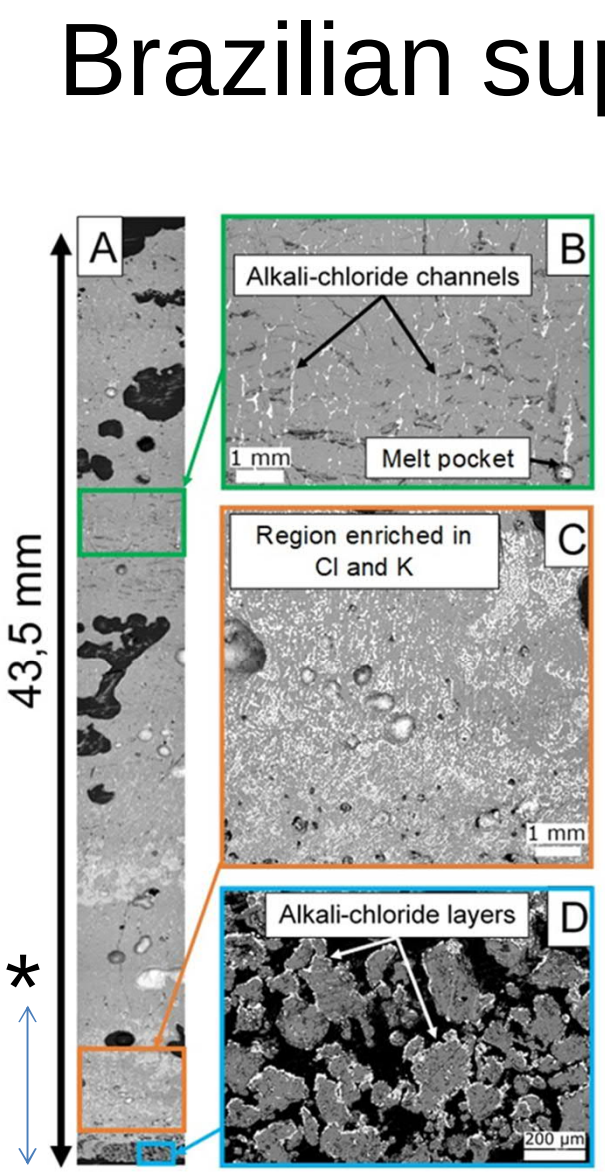
- Brazilian liquor/deposits higher in Cl
- More melt formed at temperatures relevant for SH region
- The melt that forms has a lower T_0 than the original bulk deposit
- The low-T_0 melt moves toward the steel

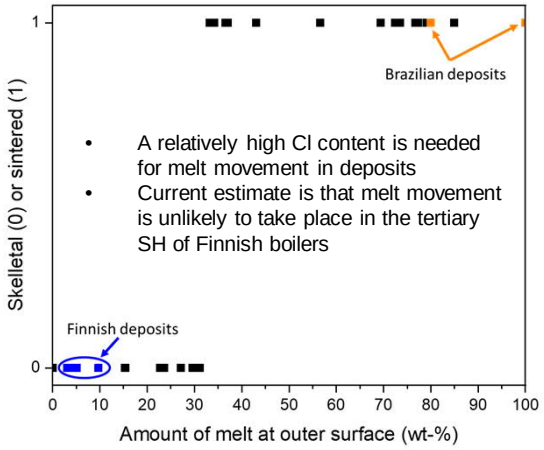


Compound [wt-%]	Brazilian deposits	Finnish deposits
Na	34.4	31.6
K	3.4	4.9
Cl	4.4	0.7
SO_4	37.5	48.9
CO_3	20.3	13.9

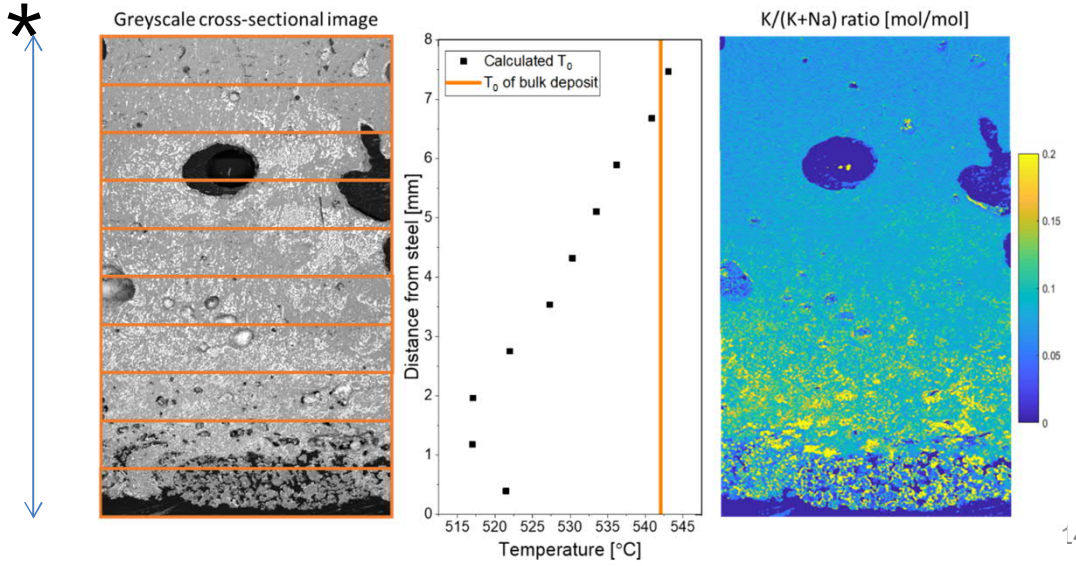


Brazilian superheater deposits





Melt with low T_0 moves toward steel



Rauma probe and SH deposits - Conclusions

- 5 and 8 week probe measurements successfully carried out
- Deposit chlorine content increases with time
- Chlorine enrichment toward steel
- Local T_0 within deposit (up to ~15 °C) lower toward steel as compared to T_0 at outer parts of the deposit
  - Increased risk of corrosion