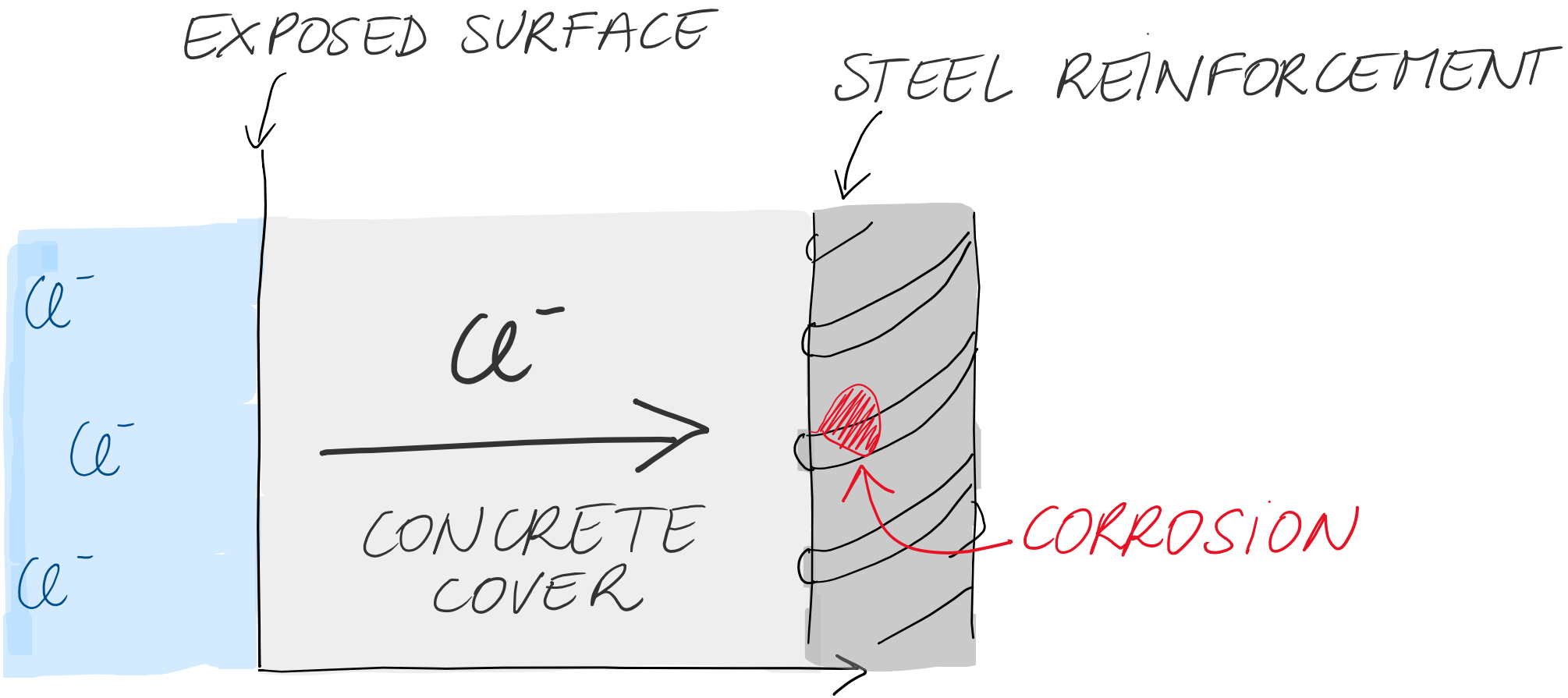
Long-term behavior of concrete in marine environment

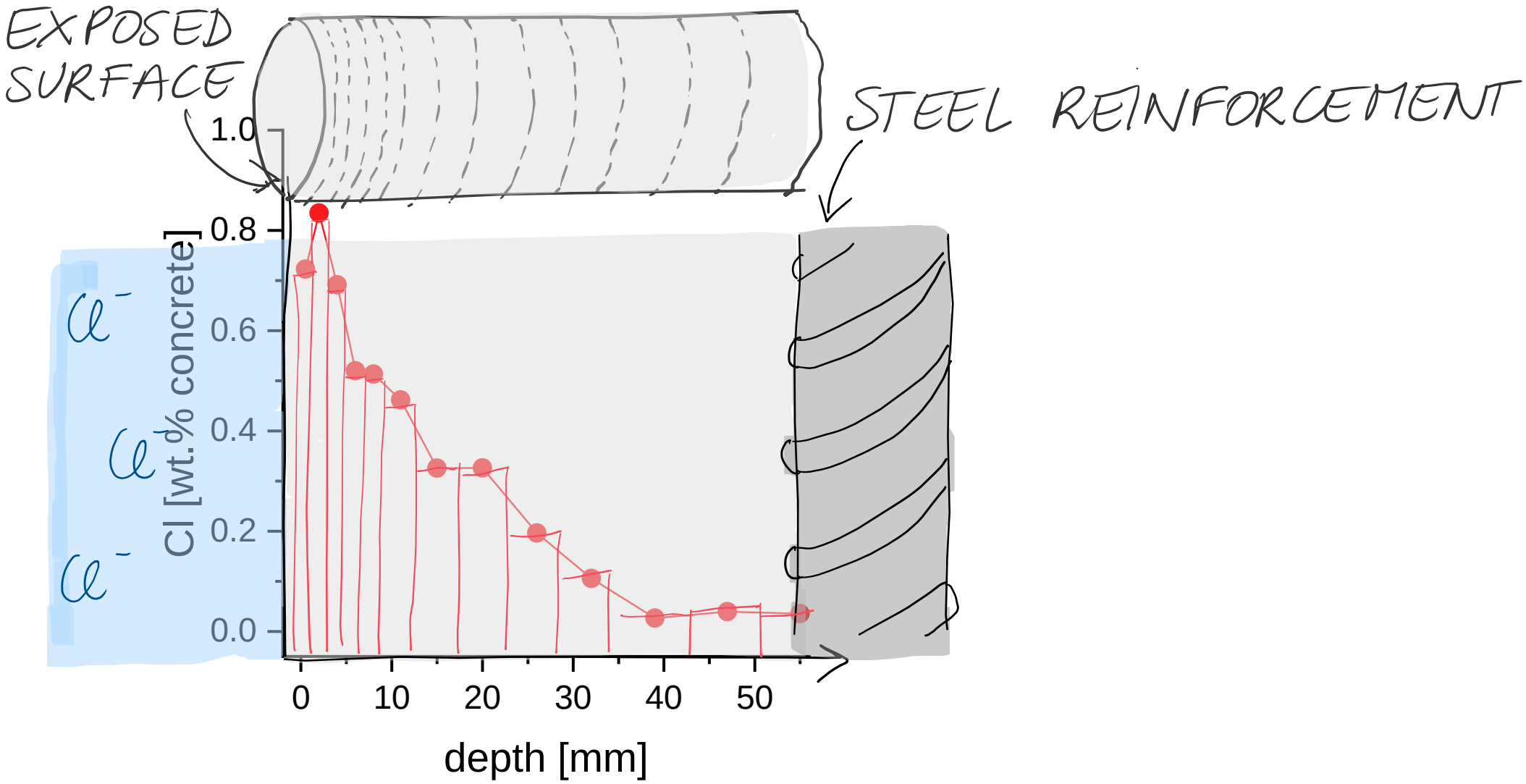
Klaartje De Weerdt, NTNU

Wolfgang Kunther, DTU

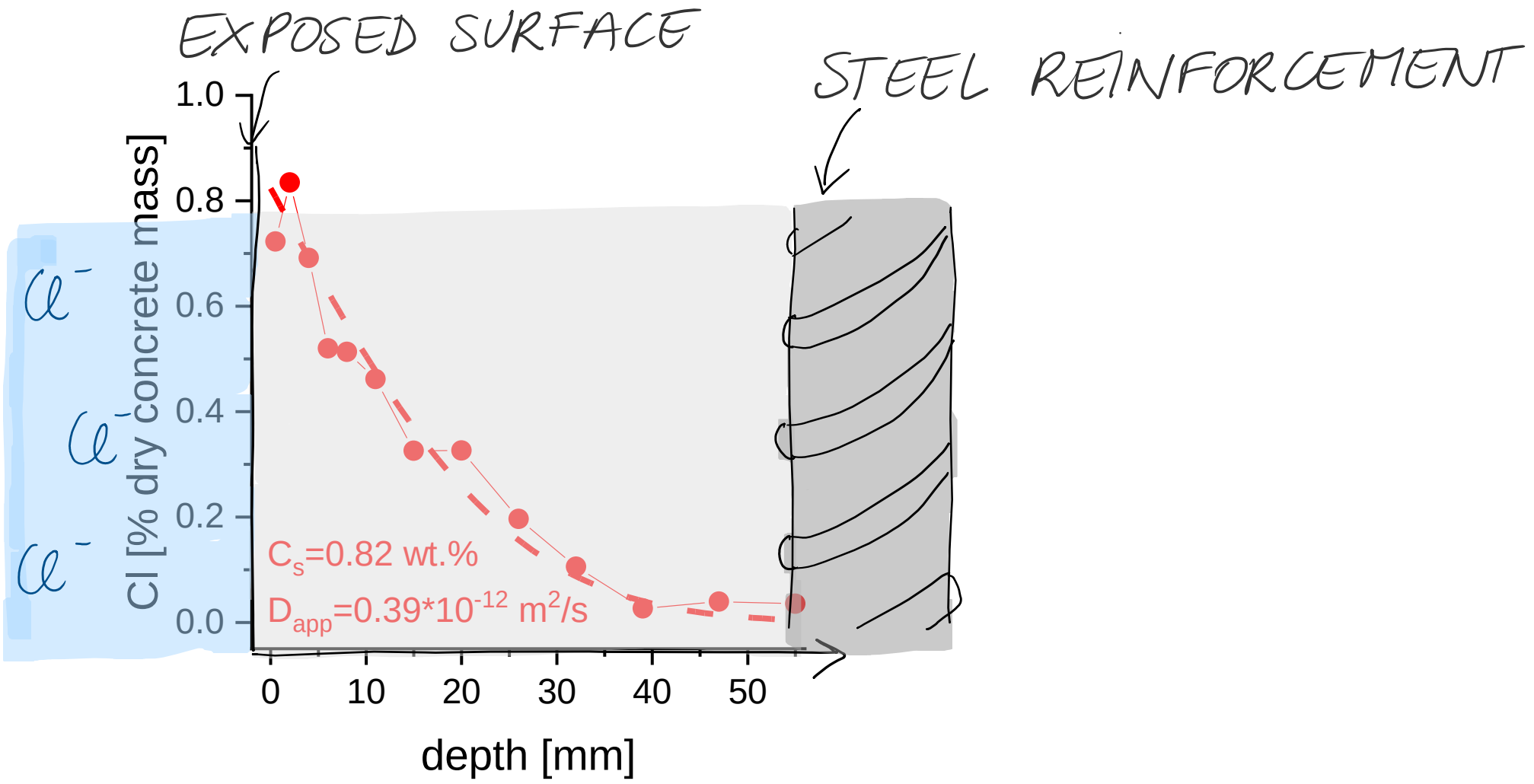
Chloride-induced reinforcement corrosion



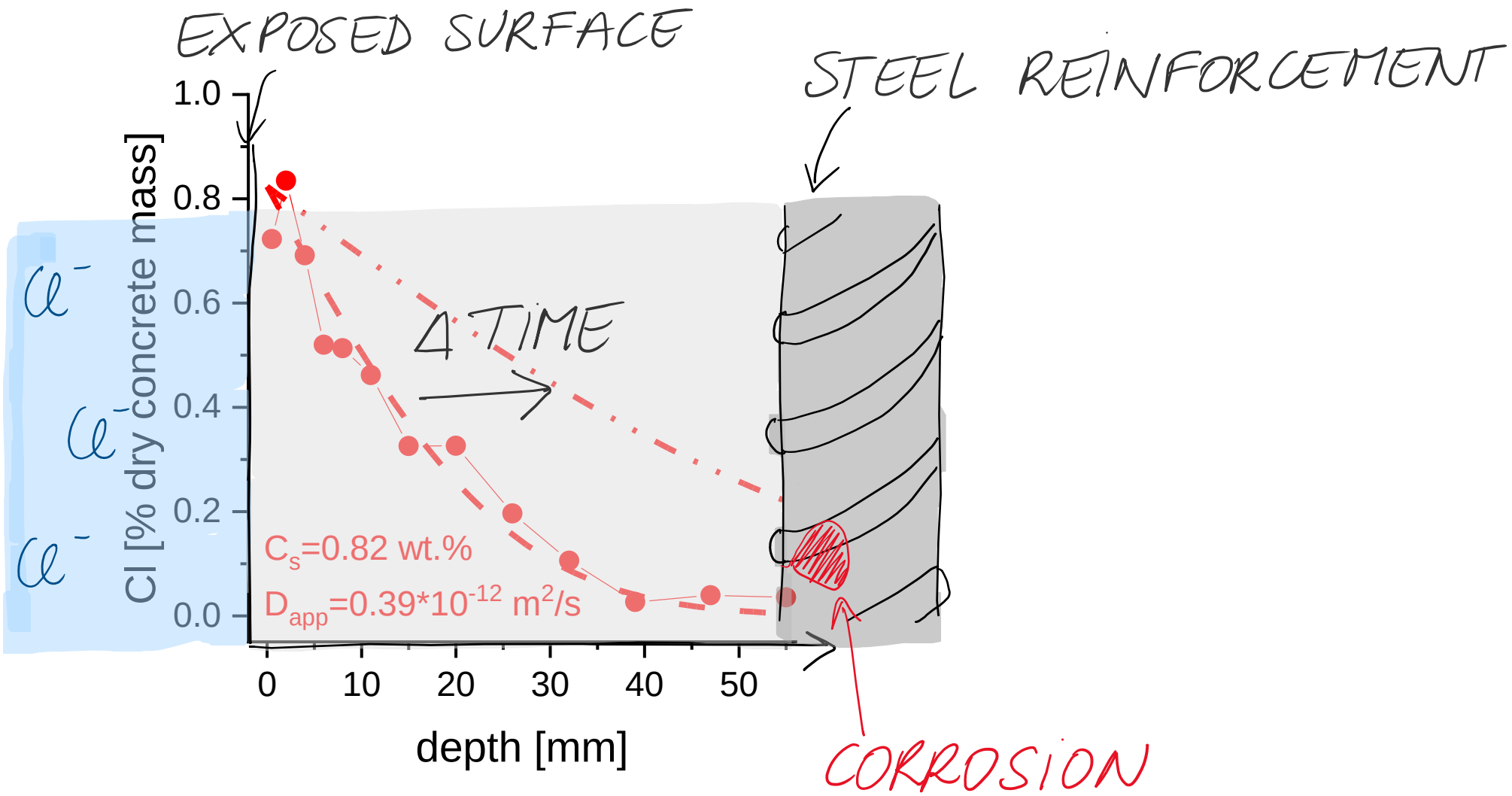
Chloride-induced reinforcement corrosion



Chloride-induced reinforcement corrosion



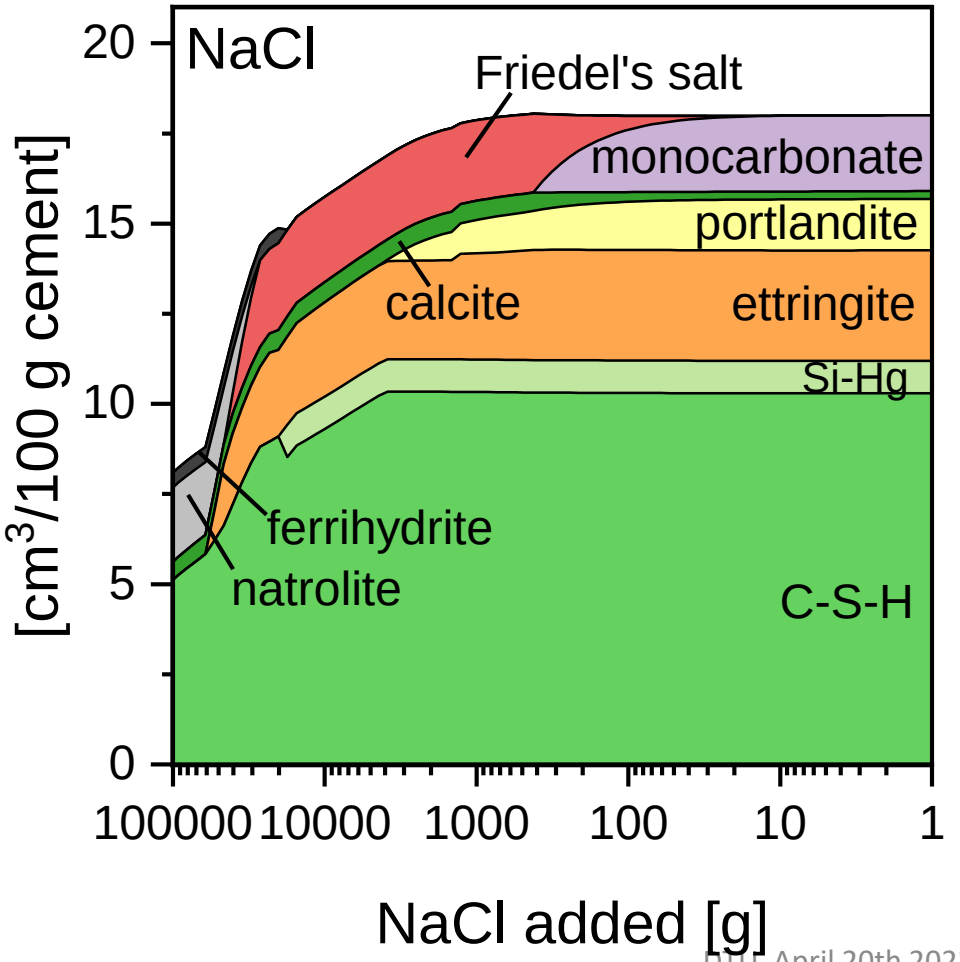
Chloride-induced reinforcement corrosion

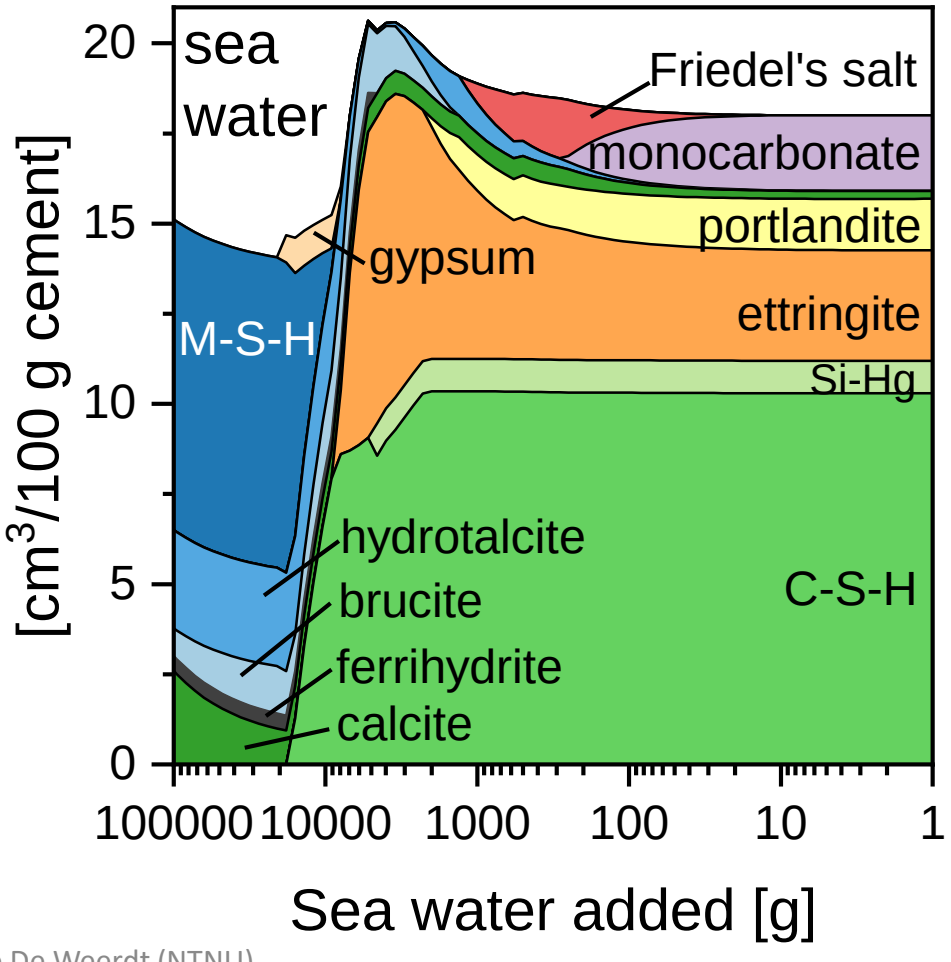


Comparing seawater composition with pore solution in concrete

Concentration [mmol/L]	**K**	**Na**	**Ca**	**Mg**	**Al**	**Si**	**SO_4**	**Cl**	**HCO_3**	**pH**
NaCl solution (3%)	-	545	-	-	-	-	-	545	-	7.1
Seawater (Trondheim Fjord)	8.9	411	8.8	47	-	-	26.9	548	n.d.	n.d.
Seawater (Atlantic ocean)	9.7	457	10	56	-	-	27.8	536	2.3	7.7
Seawater (Baltic)	1.8	93	1.2	11	-	-	17.8	110	n.d.	n.d.
Pore solution cement paste	532	279	1.2	-	0.31	0.29	27.6	-	-	13.7

NaCl vs. seawater





Laboratory exposure

Cement and Concrete Research 115 (2019) 80–89

Contents lists available at ScienceDirect

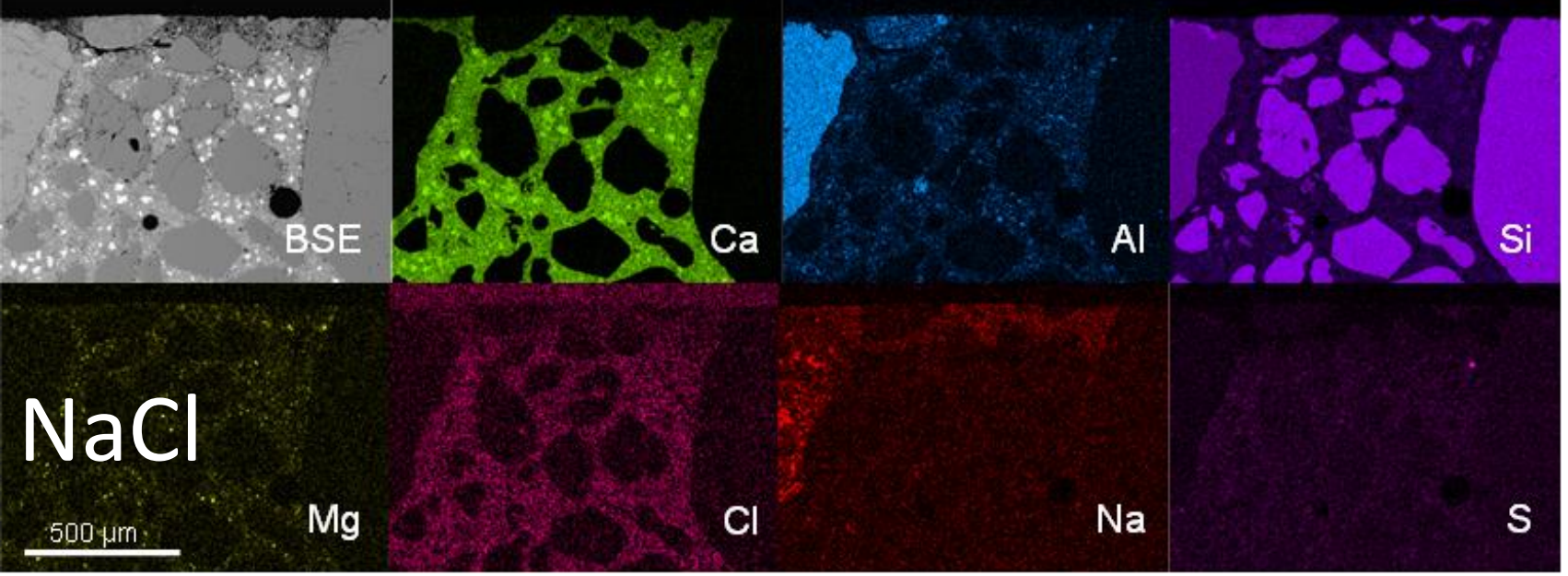
Cement and Concrete Research

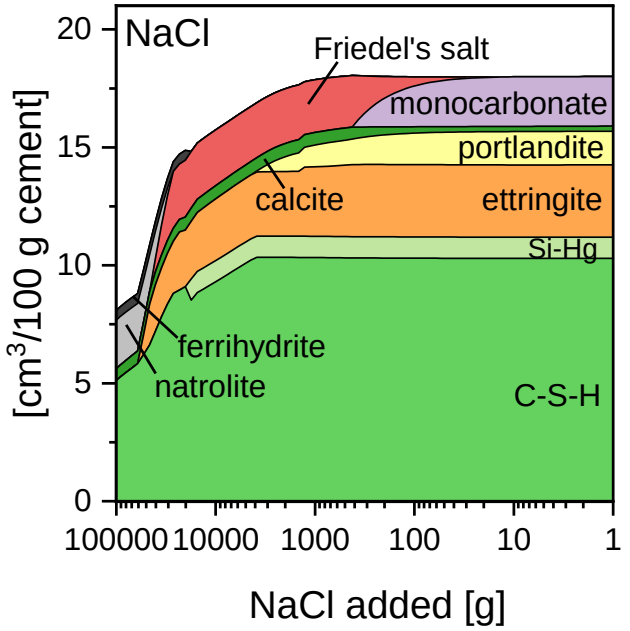
journal homepage: www.elsevier.com/locate/cemconres

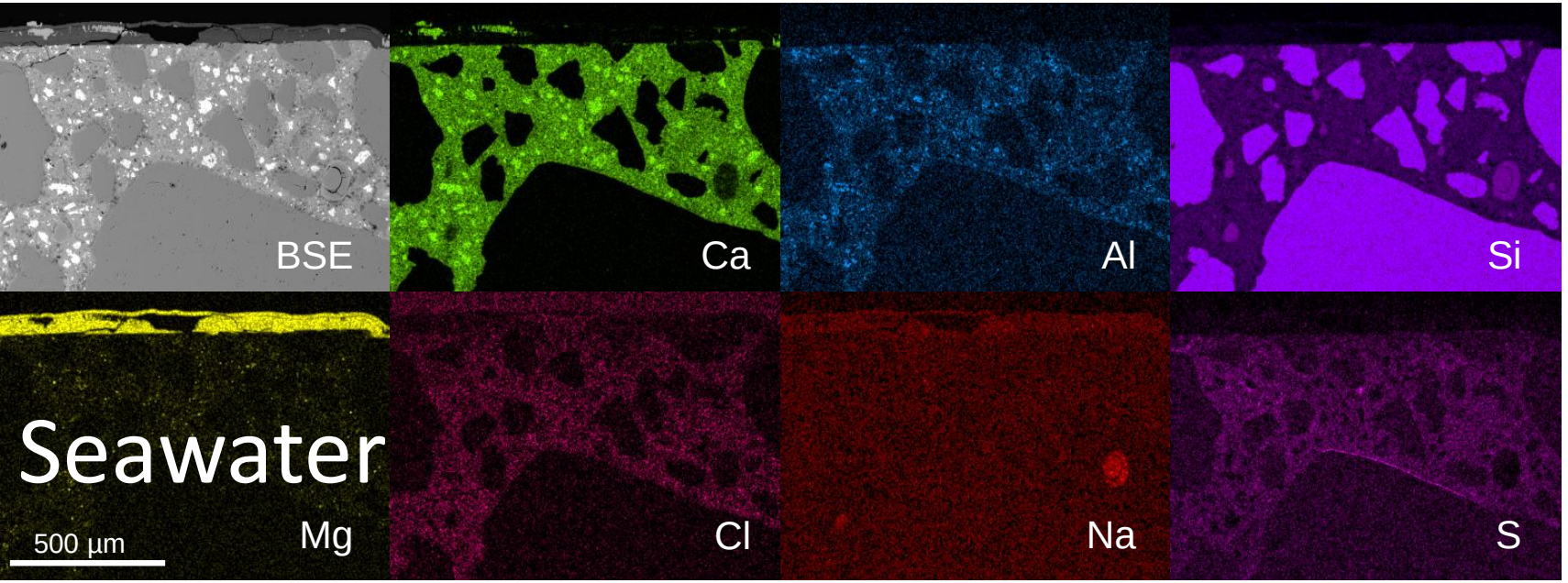
Comparing chloride ingress from seawater and NaCl solution in Portland cement mortar

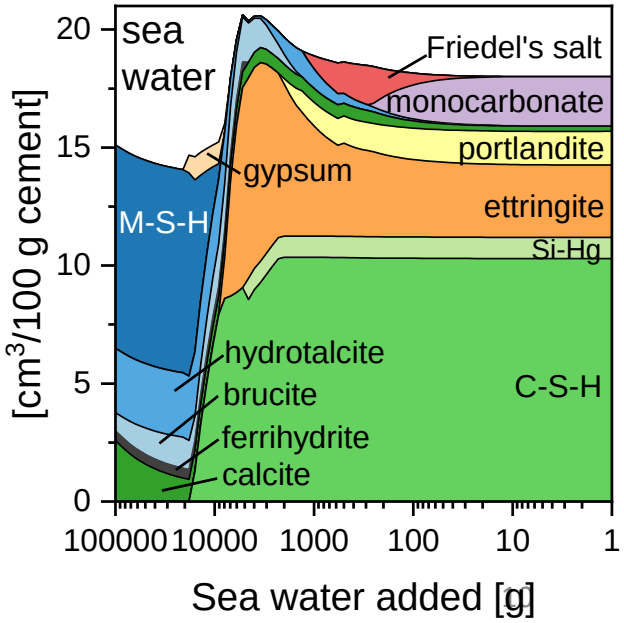
K. De Weerdt[a,*], B. Lothenbach[a,b], M.R. Geiker[a]

[a] Department of Structural Engineering, NTNU, Norway
[b] EMPA, Dübendorf, Switzerland

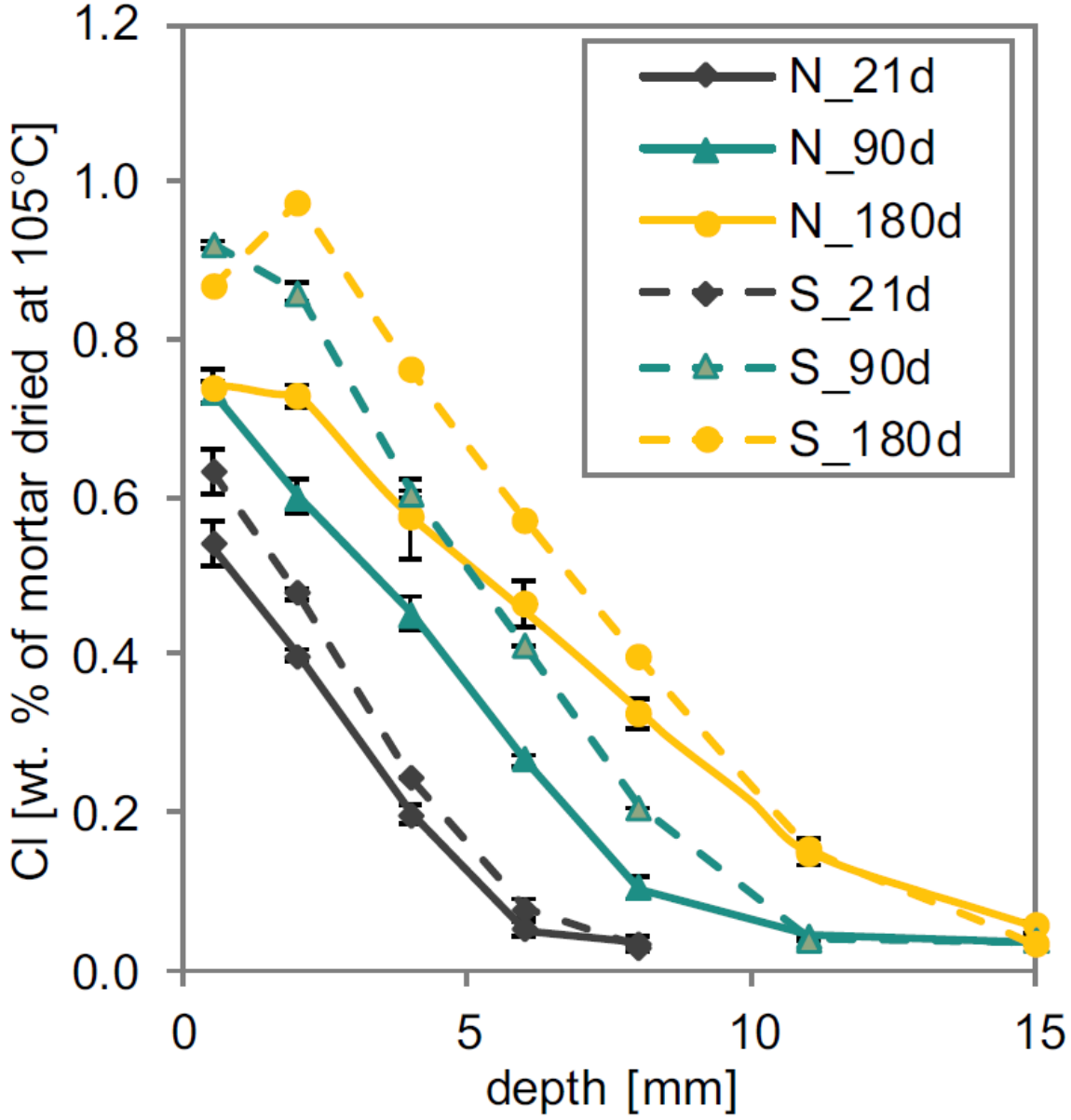

BSE
Ca
Al
Si
NaCl
Mg
Cl
Na
S
500 µm


NaCl
Friedel's salt
monocarbonate
portlandite
calcite
ettringite
Si-Hg
ferrihydrite
natrolite
C-S-H
[cm3/100 g cement]
NaCl added [g]
20
15
10
5
0
100000
10000
1000
100
10
1


BSE
Ca
Al
Si
Seawater
Mg
Cl
Na
S
500 µm


sea
water
Friedel's salt
monocarbonate
portlandite
gypsum
ettringite
M-S-H
Si-Hg
hydrotalcite
brucite
ferrihydrite
calcite
C-S-H
[cm3/100 g cement]
Sea water added [g]
20
15
10
5
0
100000
10000
1000
100
10
1

Impact of the other ions on Cl ingress



(De Weerdt et al. CCR 2019)

Marine exposure

Cement & Concrete Composites 47 (2014) 53–63

Contents lists available at ScienceDirect

Cement & Concrete Composites

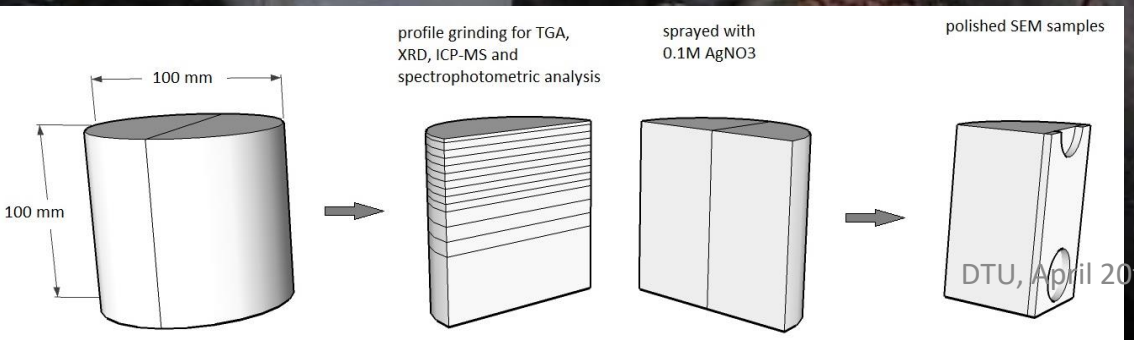
journal homepage: www.elsevier.com/locate/cemconcomp

Changes in the phase assemblage of concrete exposed to sea water

Klaartje De Weerdt [a,b,*], Harald Justnes [b], Mette R. Geiker [a]

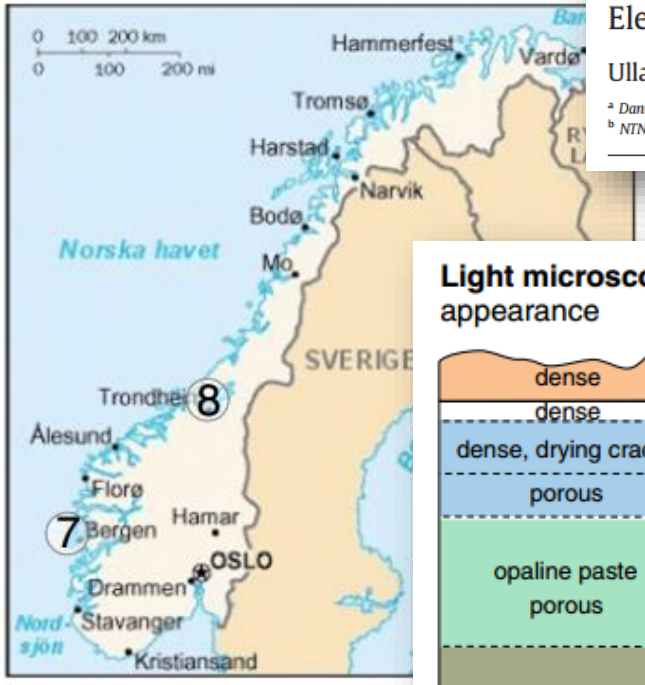
10 year old concrete wall in tidal zone

Spring 2013


100 mm
100 mm
profile grinding for TGA, XRD, ICP-MS and spectrophotometric analysis
sprayed with 0.1M AgNO3
polished SEM samples

Spring 2013

Marine exposure:
Focus concrete



Cement and Concrete Research 85 (2016) 12–27

Contents lists available at ScienceDirect

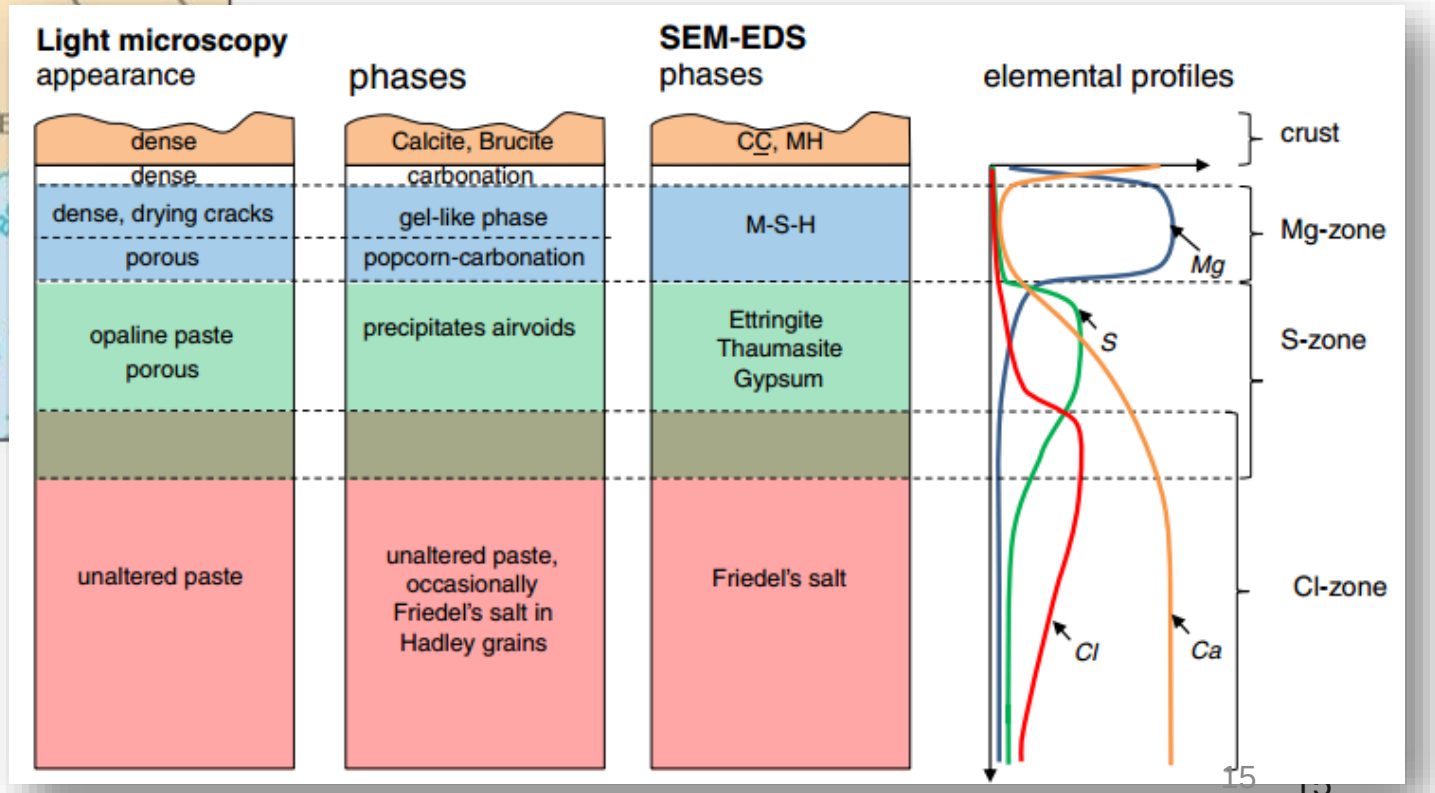
Cement and Concrete Research

journal homepage: www.elsevier.com/locate/cemconres

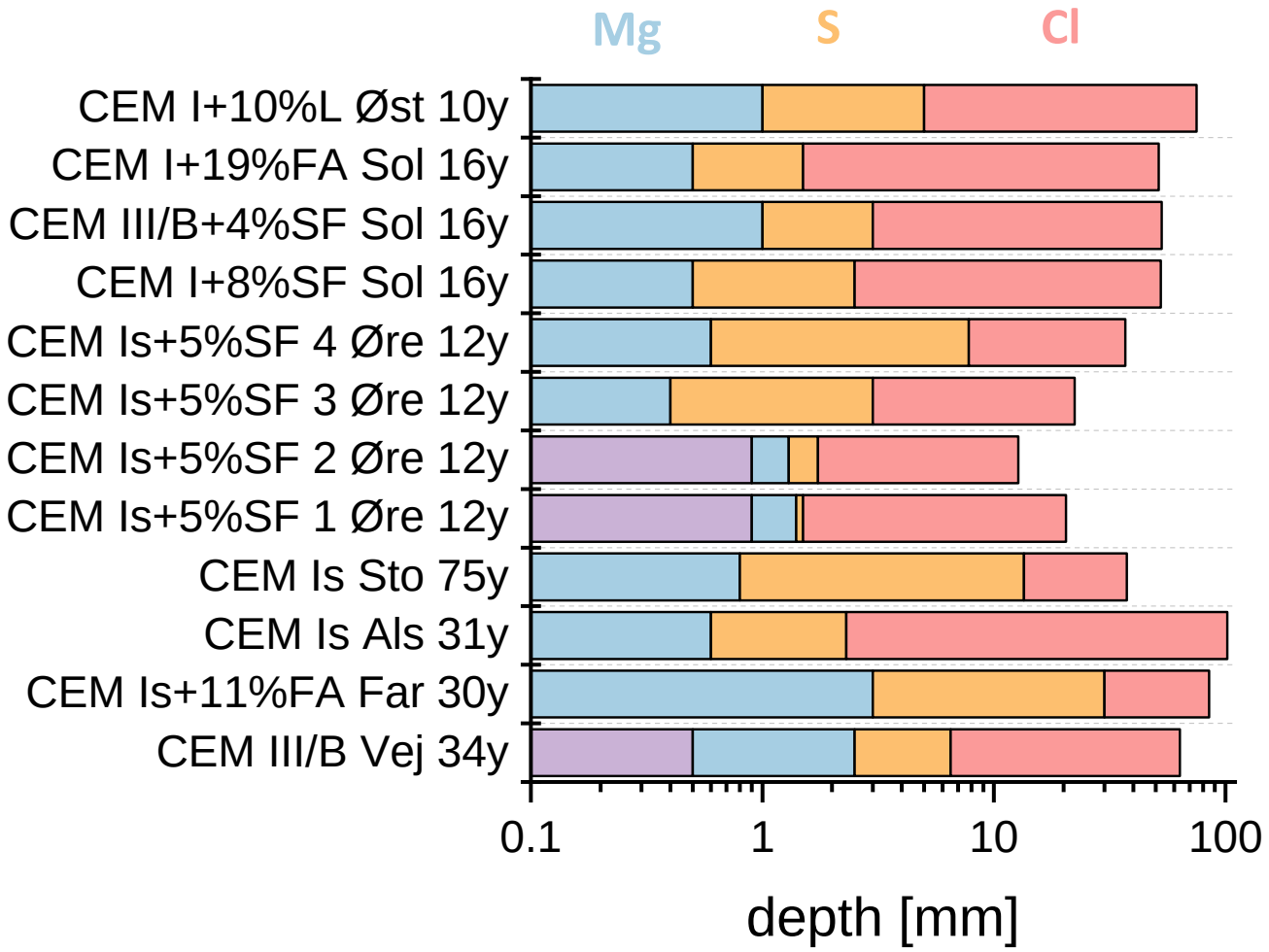
Elemental zonation in marine concrete

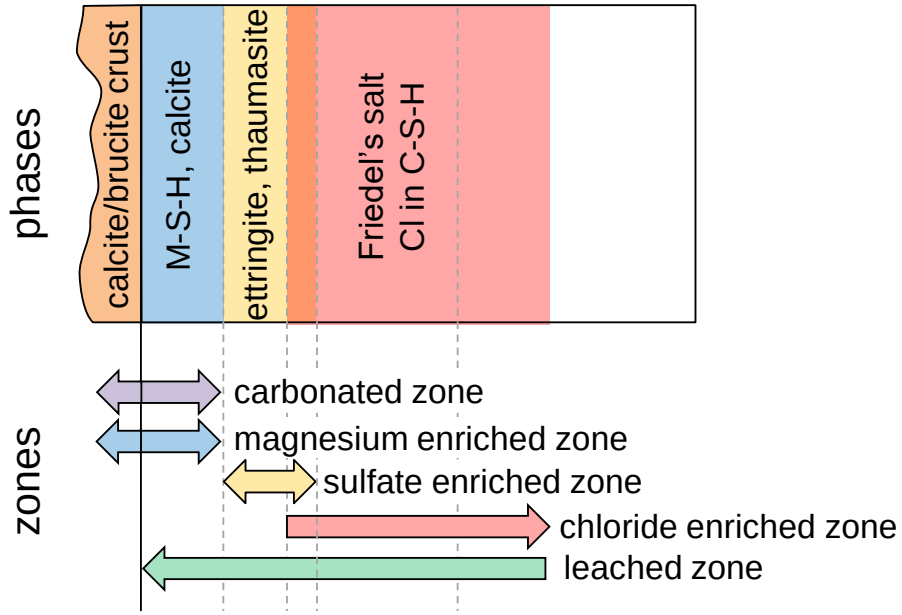
Ulla Hjorth Jakobsen [a], Klaartje De Weerdt [b,*], Mette R. Geiker [b]

[a] Danish Technological Institute, Taastrup, Denmark
[b] NTNU, Department for Structural Engineering, Trondheim, Norway

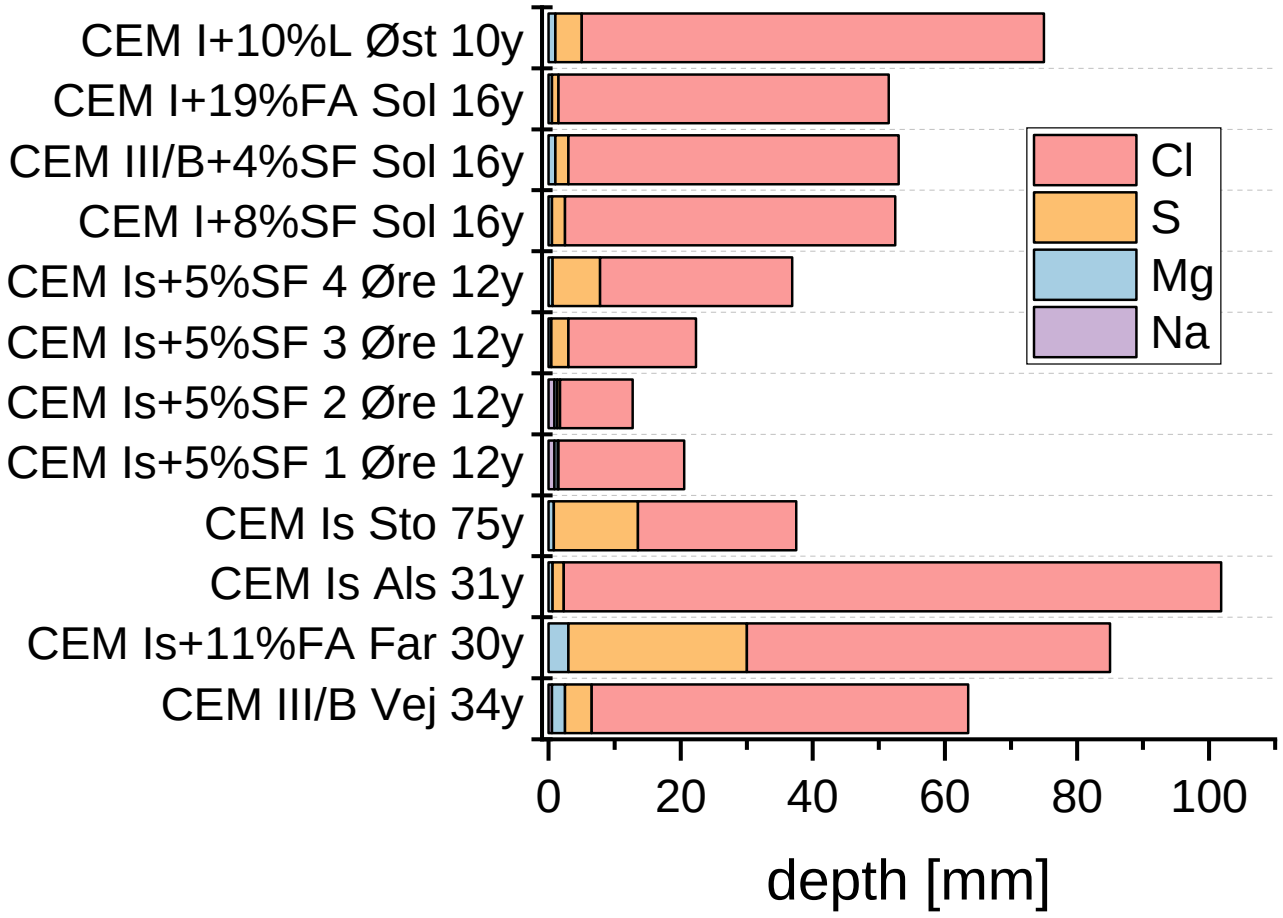


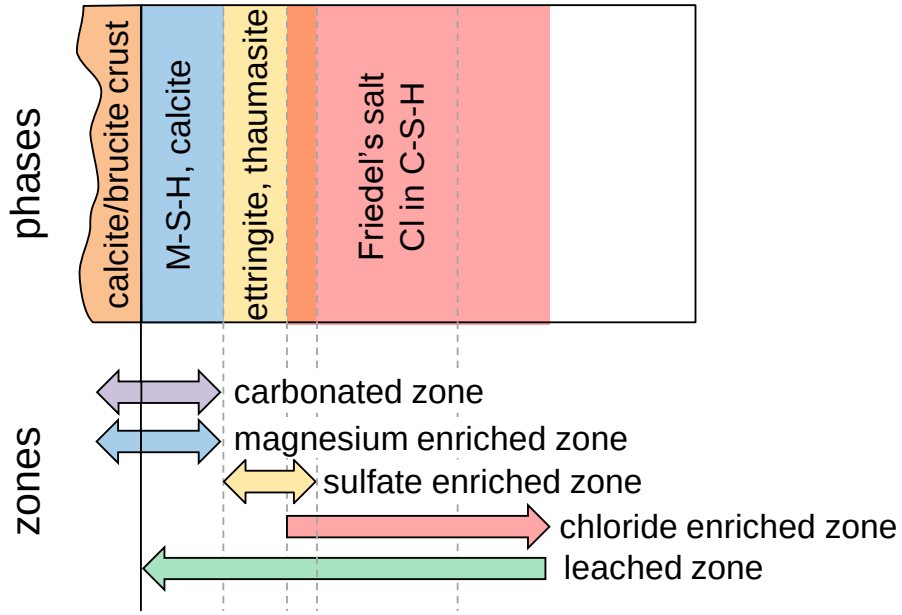
Zonation independent of exposure site/concrete



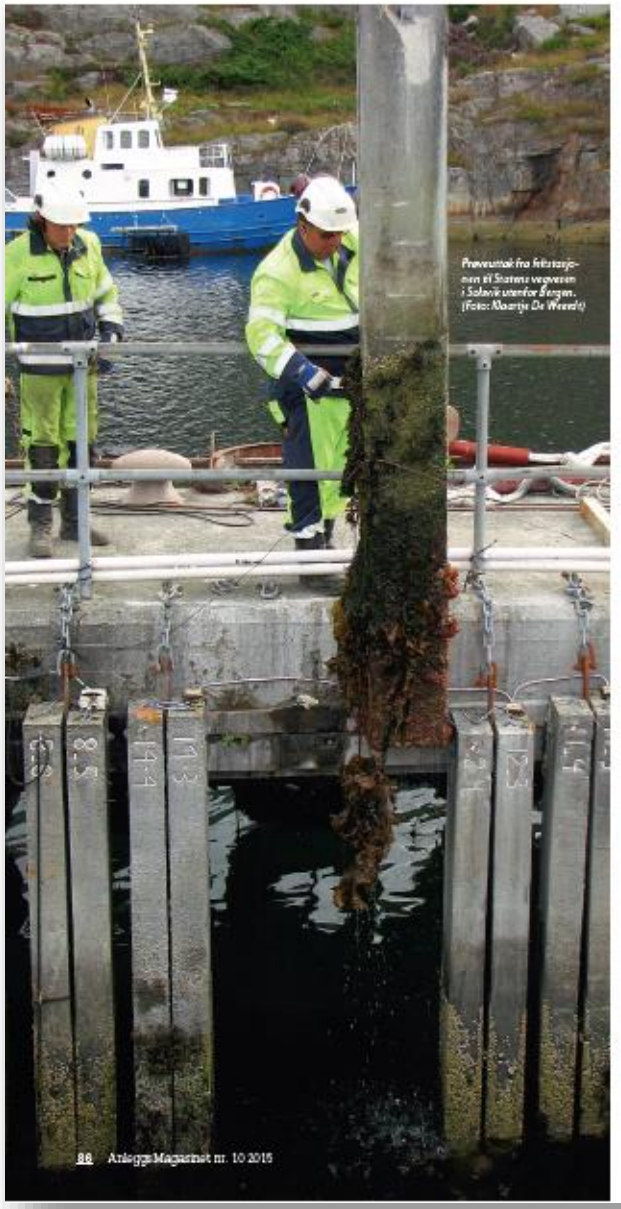


Mainly the outer 10 mm is affected





Marine exposure: 16 years – biological side effects



FAG & FORSKNING

Av Klaartje De Weerdt (t.h.) og Mette R. Geiker, NTNU

Hvor er **kloridene i betong?**

Det er avgjørende viktig å forstå de underliggende mekanismene når klorid trenger inn i betong. Bare da kan vi sørge for miljøvennlige og bærekraftige konstruksjoner, med forutsigbar levetid.

Construction and Building Materials 120 (2016) 418–431

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

ELSEVIER

Towards the understanding of chloride profiles in marine exposed concrete, impact of leaching and moisture content

Klaartje De Weerdt [a,*], Denisa Orsáková [b], Arnaud C.A. Müller [c], Claus K. Larsen [d,a], Bård Pedersen [d], Mette R. Geiker [a]

Hvorfor trengs dette?

Kloridet kun utenfra

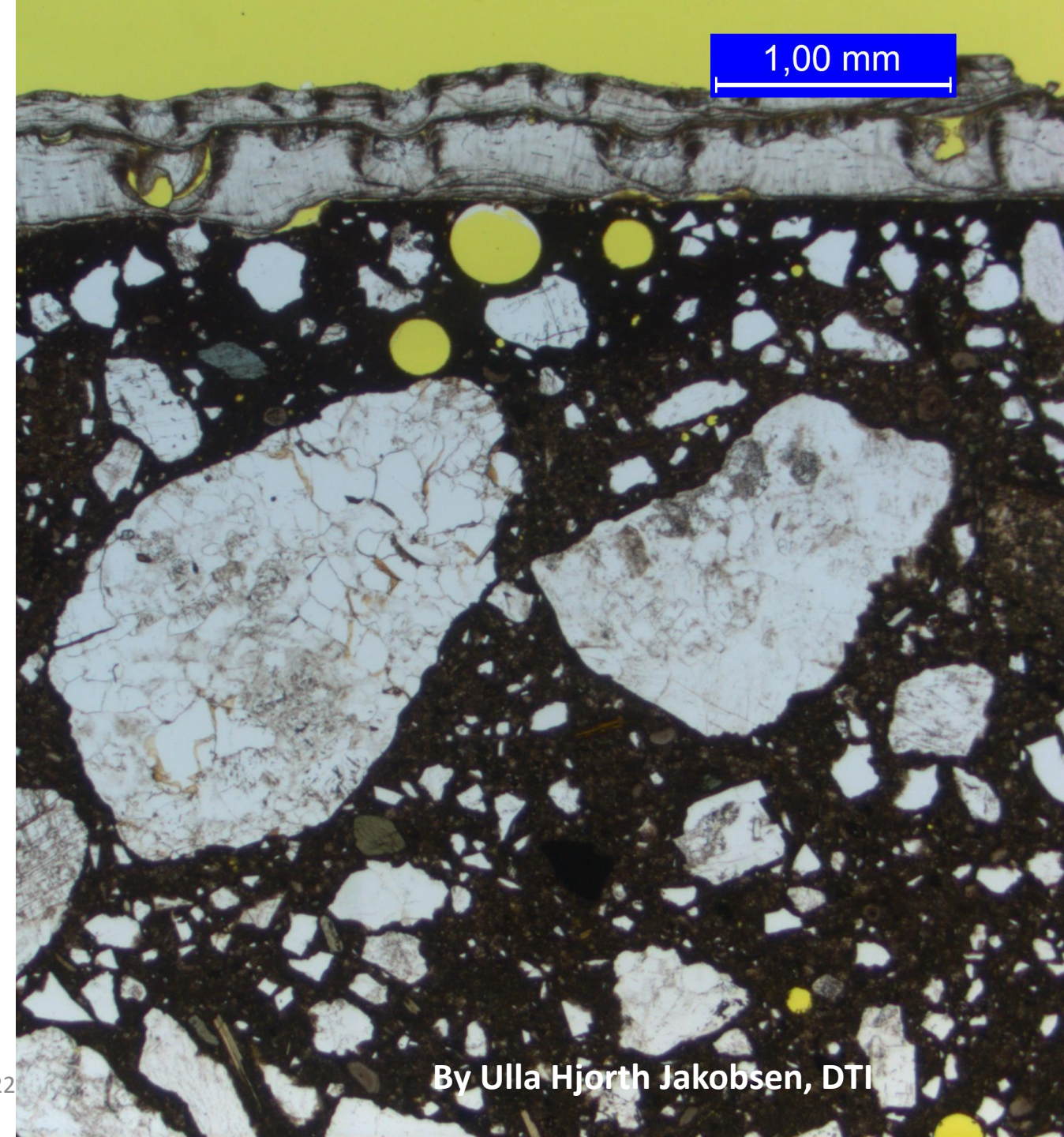
August 2013


9-5
8-5
14-4
14-3
12-4
12-3
11-4
11-3
9-4
9-3

Marine exposure: 16 years – biological side effects

Take home message

- Concrete in seawater is prone to phase changes at the surface
- Though the depth affected is limited to about 10 mm even after 75 years
- The formed calcite and brucite/M-S-H crust seems to form a favorable basis for biological growth.



Thank you for your attention. Any questions?

By Ulla Hjorth Jakobsen, DTI