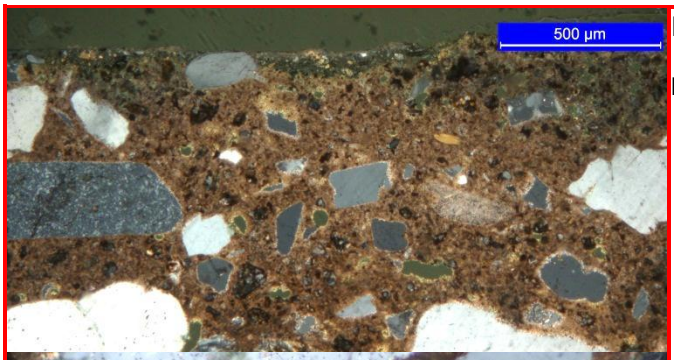
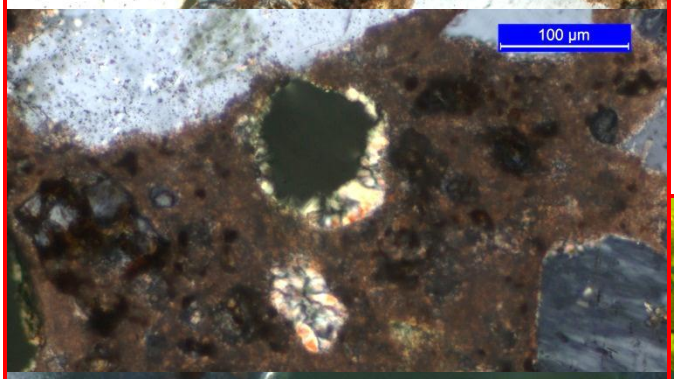
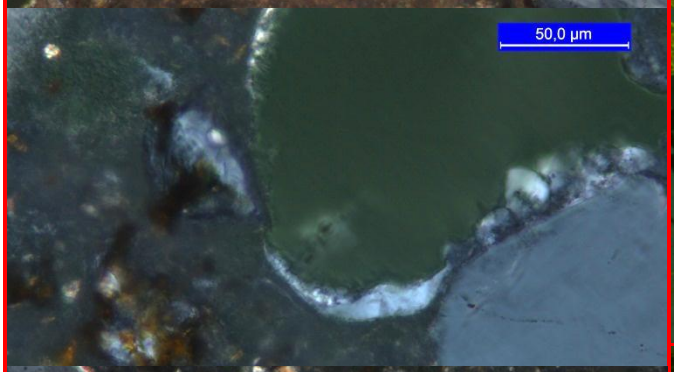
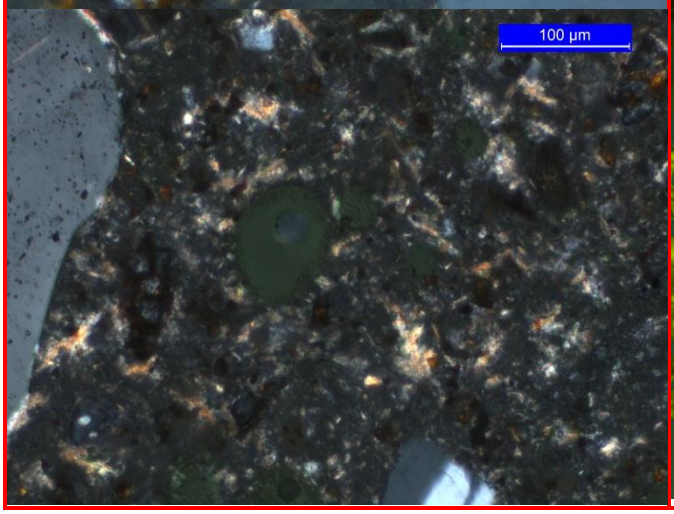
Vejlefjordbroen **Pillar, cote +35** **Age: 1975-80**

Info		Comments
Cement type	SRPC	Core taken in 1995
Fly ash	-	
Microsilica	-	
Slag	-	
W/C, apparent	0.40-0.45	
Air %	5	
		Section No: Niras T681-1top A4





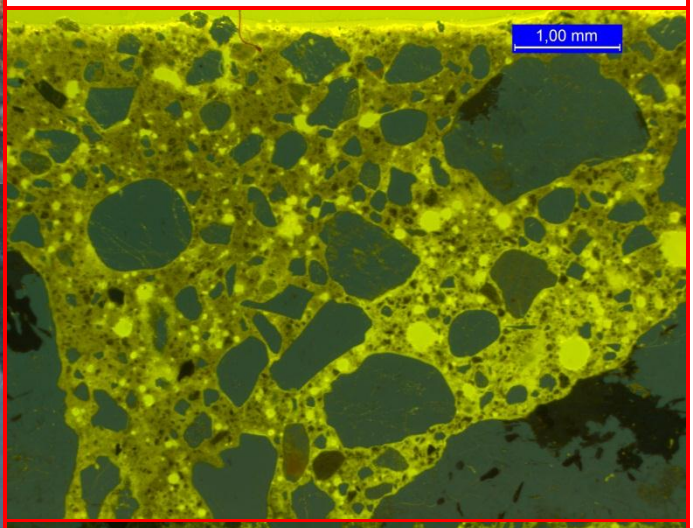


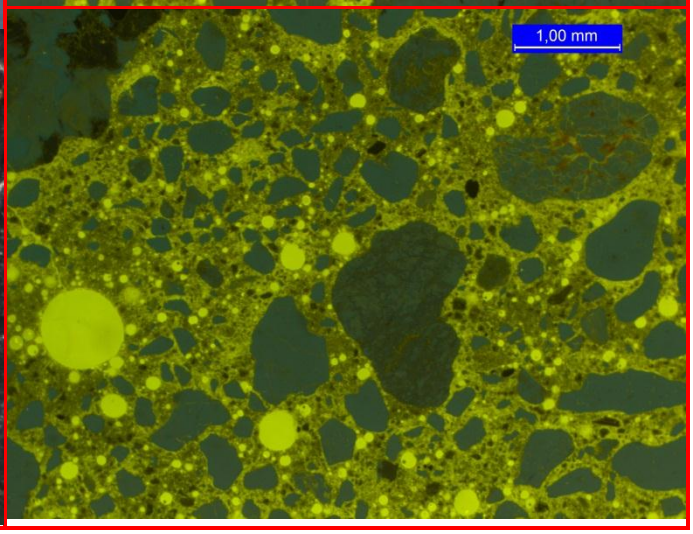


Micro-observations

Micro-structural zoning through concrete:

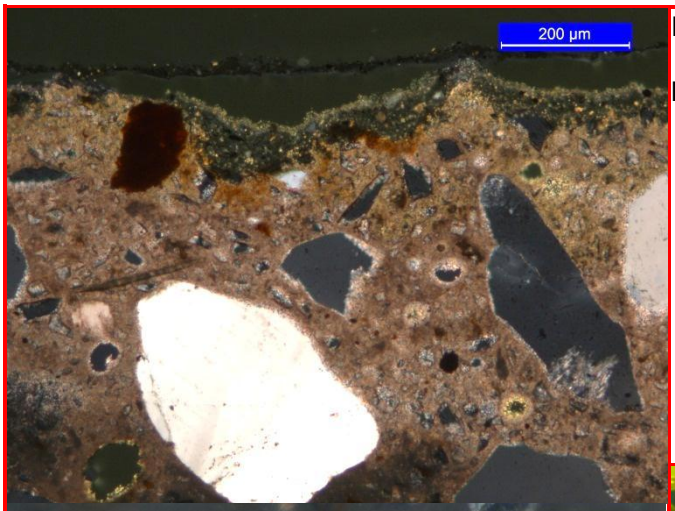
1. 0.08mm: Leached, porous, weakly scaled surface. Sand grains are exposed.
2. 0.8-2.5 (6)mm: Carbonated paste. Cement grains are not carbonated. Deepest along surface cracks.
3. 2.5-4mm: Thin, dense, opaline zone with thaumasite-like phase and gypsum in air voids.
4. Internal paste contains high amount of relatively large CH crystals.

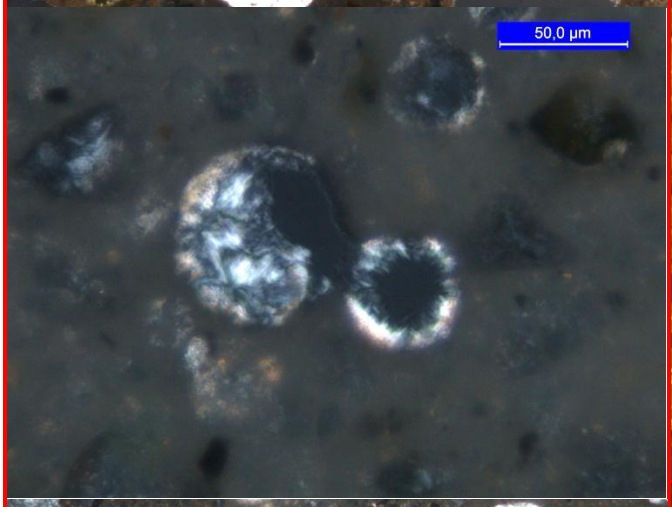




Vejlefjordbroen **Pillar, cote -149** **Age: 1975-80**

Info		Comments
Cement type	Slag	Core taken in 1995
Fly ash	-	
Microsilica	-	
Slag	X	
W/C, apparent	0.30-0.35	
Air %	6	
		Section No: Niras T681-3top C4

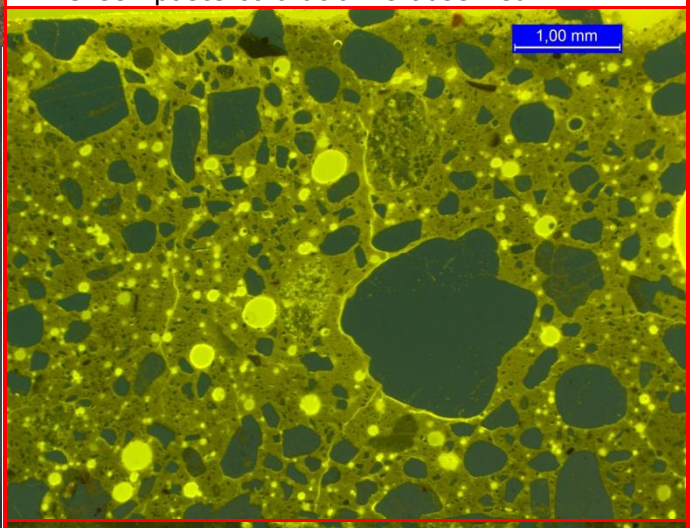


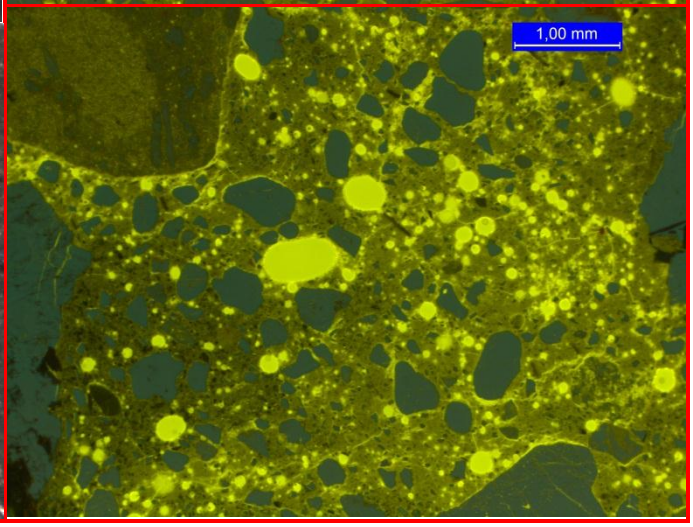


Micro-observations

Micro-structural zoning through concrete:

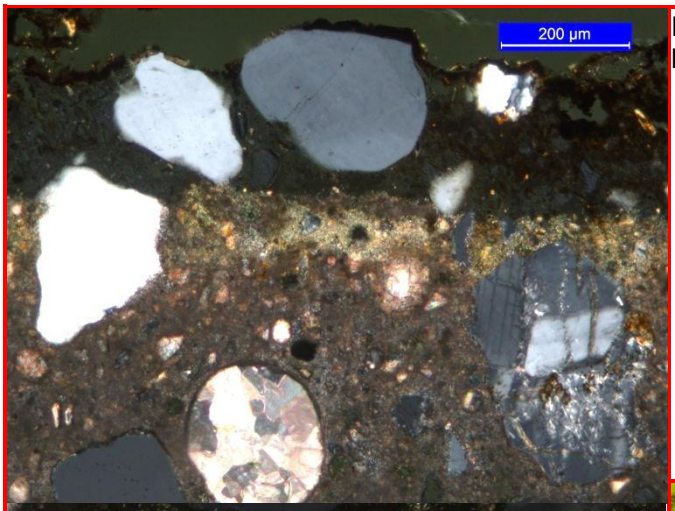
1. 0.08mm: Leached, porous, scaled surface. Sand grains are exposed. Paste appears rusty red and damaged from biological growth.
2. 0.08-0.8mm: Carbonated paste. Slag grains are carbonated. Some microcracking in paste.
3. 0.8-1.2mm: Dense highly opaline zone with thaumasite-like phases in voids.
4. 2-45mm: Internal paste contains low amount of small CH crystals. Paste appears very dark. Green paste coloration is observed.

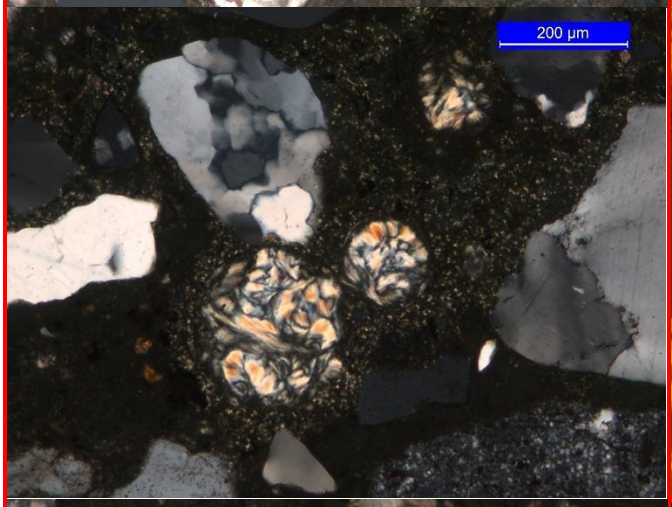


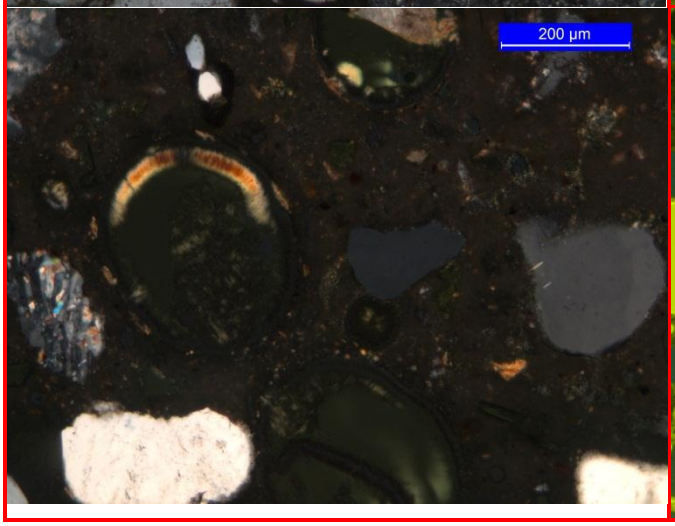


Vejlefjordbroen **Pillar, cote -265** **Age: 1975-80**

Info		**Comments**
Cement type	Slag	Core taken in 1995
Fly ash	-	
Microsilica	-	
Slag	X	
W/C, apparent	0.35-0.40	
Air %	4-5	
		Section No: Niras 681-4top D1



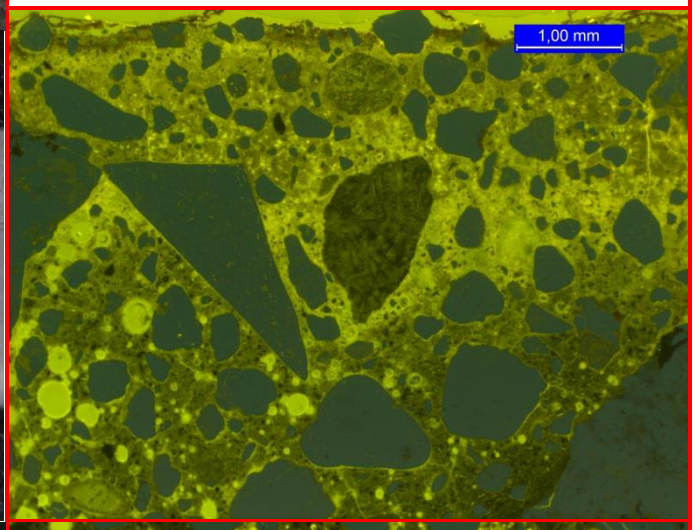


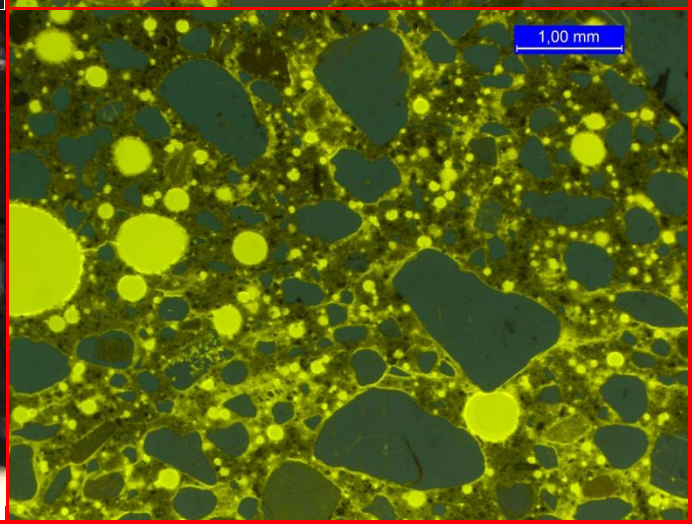


Micro-observations

Micro-structural zoning through concrete:

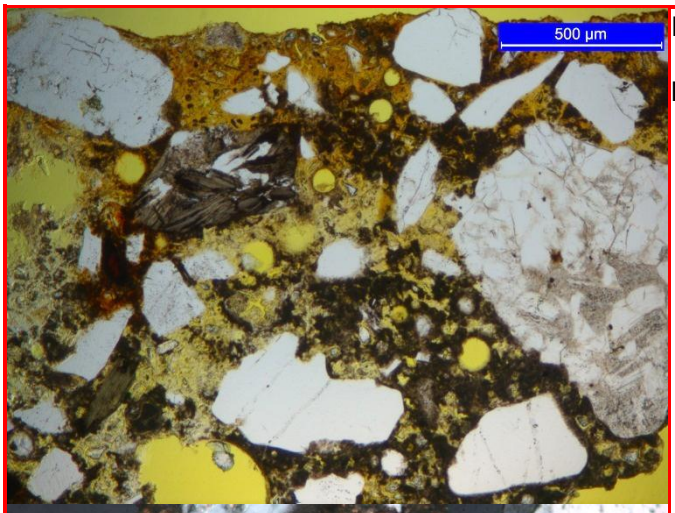
1. 0.2-0.4mm: Leached, porous, scaled surface. Distinct rusty coloration. Sand grains are exposed.
2. 0.4-2.4mm: Partially carbonated zone. Air voids filled with calcite. Slag grains are carbonated. Cracks in paste.
3. 2.4-6mm: Porous, opaline zone with thaumasite-like phases in air voids and maybe also in paste.
4. 6-45mm: Internal paste appears very dark. Almost no CH in paste. Ettringite present in voids in top of zone.

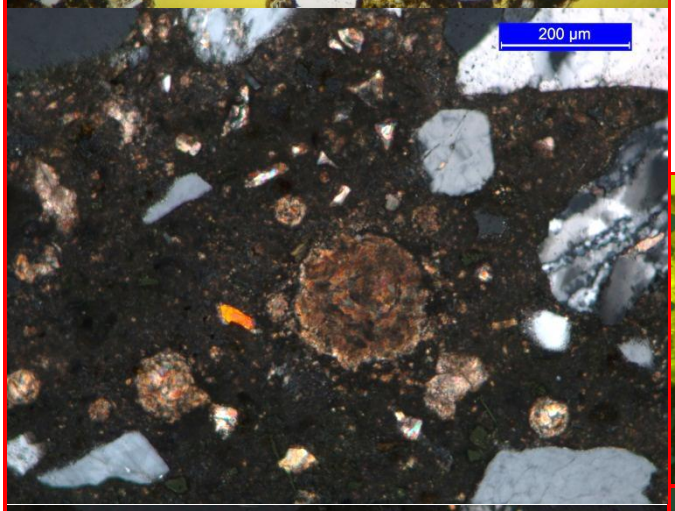


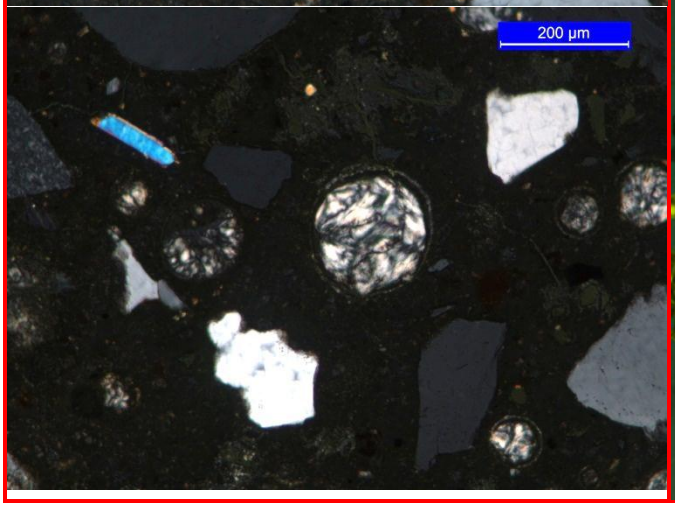


Vejlefjordbroen **Pillar, cote -100, south** **Age: 1975-80**

Info		Comments
Cement type	Slag	Core taken in 2012
Fly ash	-	
Microsilica	-	
Slag	X	
W/C, apparent	0.35	
Air %	5-6	
		Section No: 7206-V1



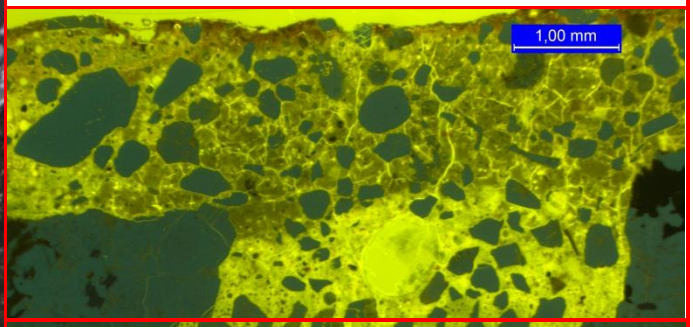


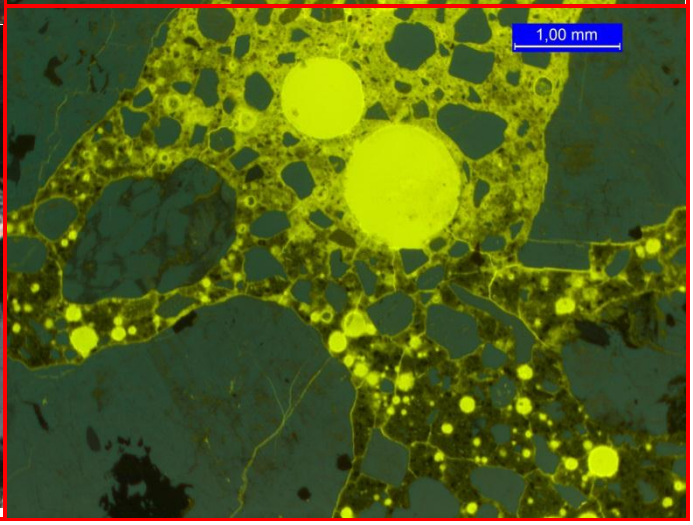


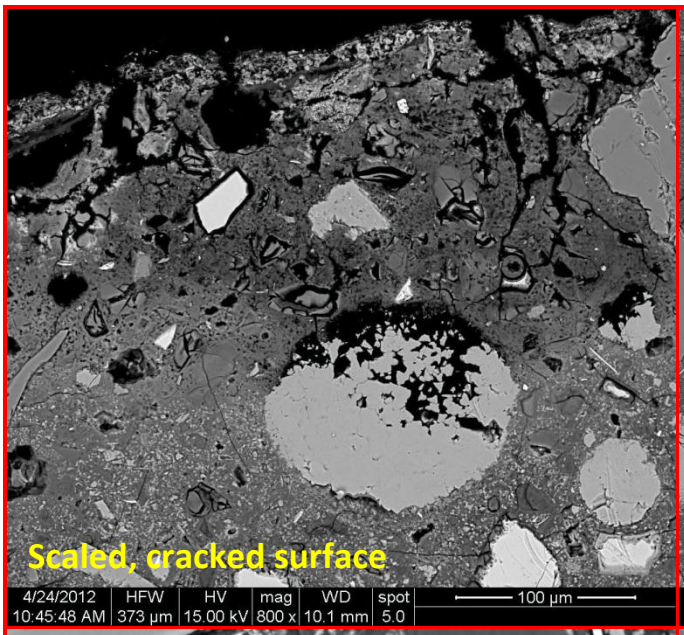
Micro-observations

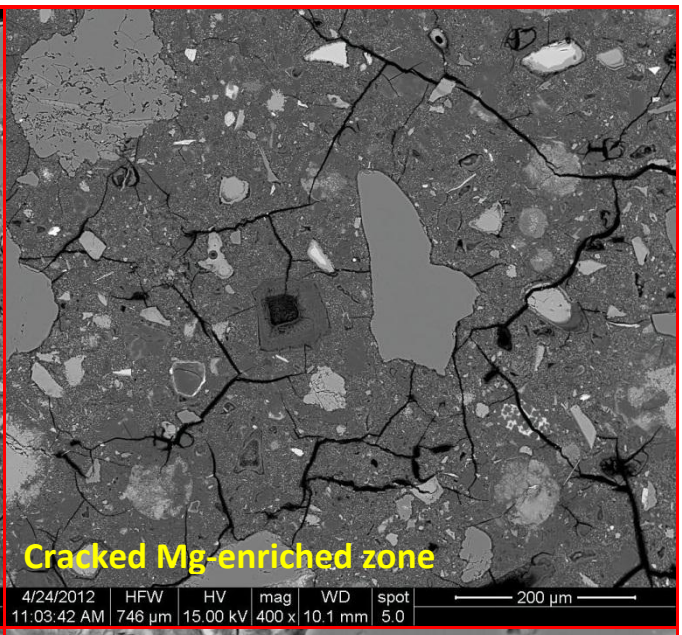
Micro-structural zoning through concrete:

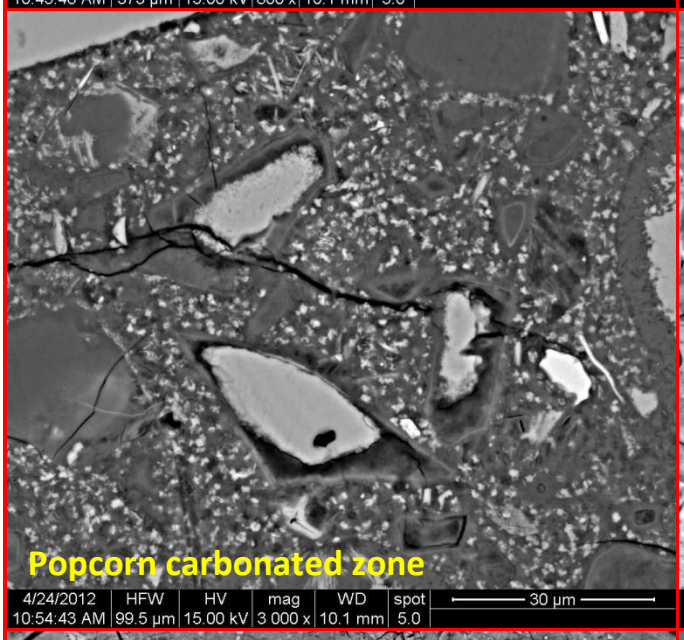
1. Surface: Leached, porous, scaled surface. Distinct rusty coloration. Sand grains are exposed.
2. 0-2mm: Partially, carbonated zone with patchy appearance (popcorn). Dense, cracked paste. Air voids filled with calcite. Slag grains are carbonated. Enriched in Mg.
3. 2-6mm: Porous, opaline zone with thaumasite-like phases and ettringite in air voids and relict after cement grains. Highly increased in S.
4. >6mm: Internal paste appears very dark. Greenish coloration of paste present, throughout. Dense paste with autogeneous micro-cracks. Ettringite in air voids to 18mm. Friedelsalt present in relict of cement grains; increased Cl from 3-60mm.

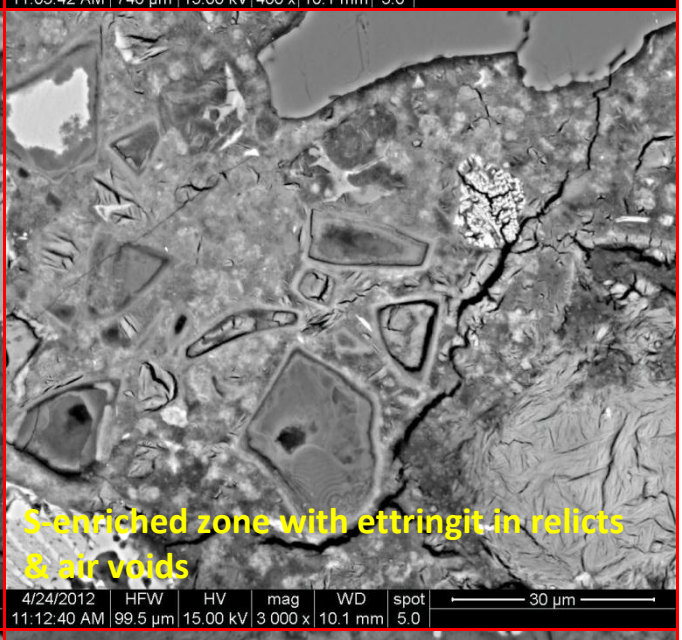


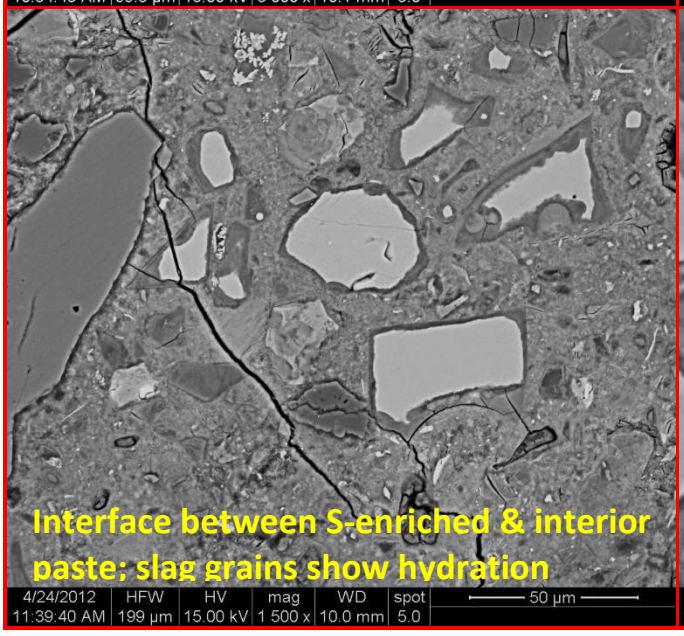



Scaled, cracked surface
4/24/2012 10:45:48 AM | HFW 373 µm | HV 15.00 kV | mag 800 x | WD 10.1 mm | spot 5.0 | 100 µm

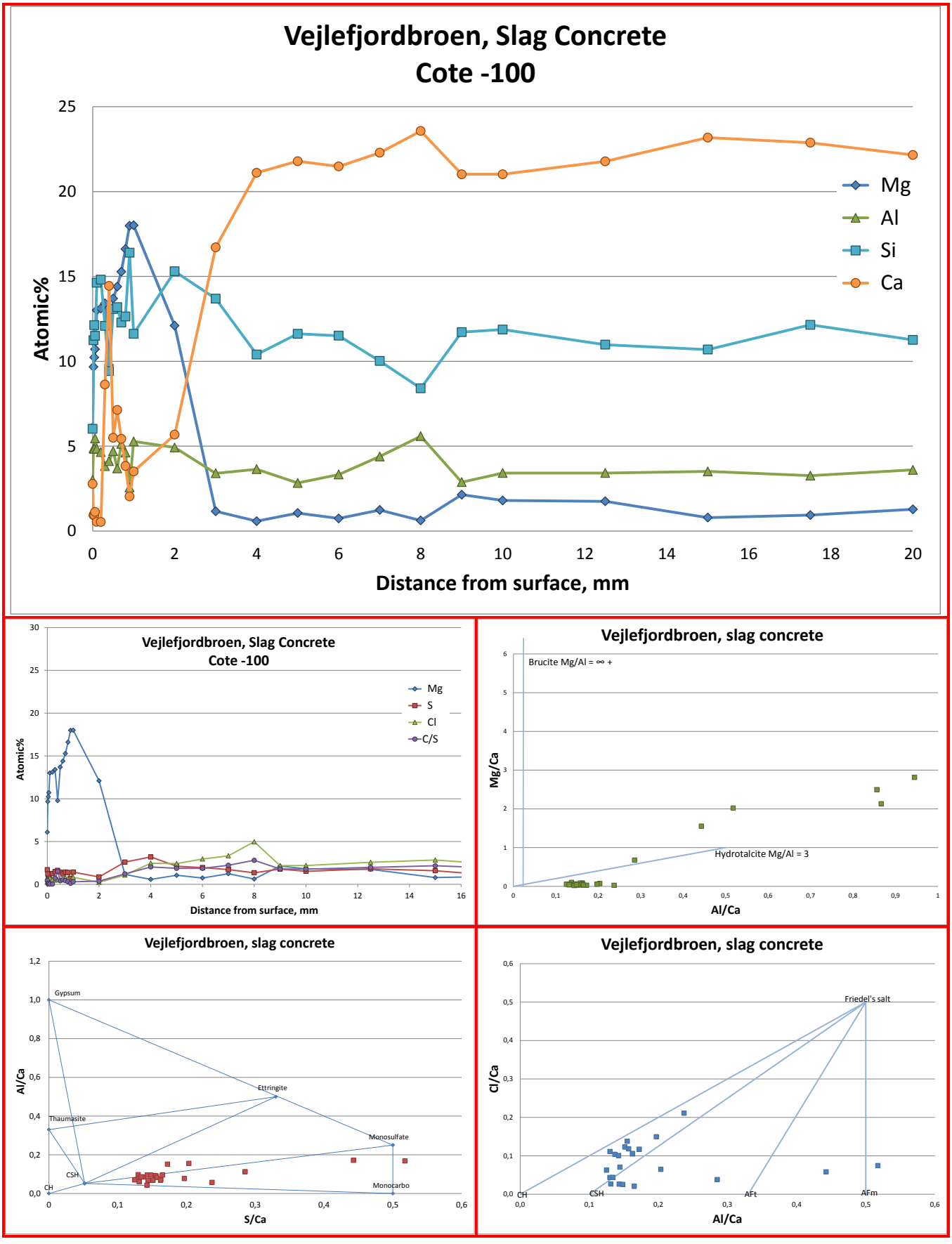

Cracked Mg-enriched zone
4/24/2012 11:03:42 AM | HFW 746 µm | HV 15.00 kV | mag 400 x | WD 10.1 mm | spot 5.0 | 200 µm

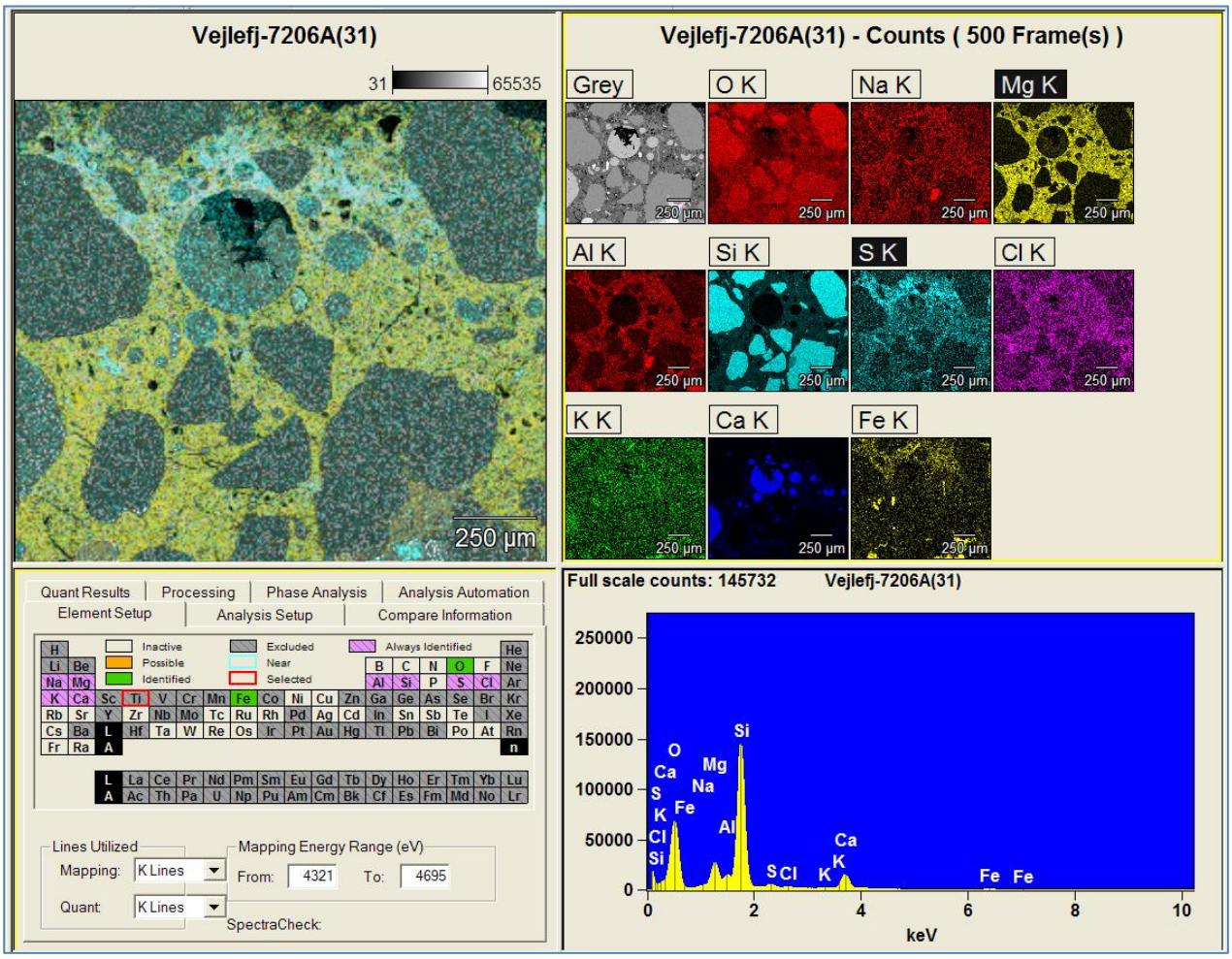

Popcorn carbonated zone
4/24/2012 10:54:43 AM | HFW 99.5 µm | HV 15.00 kV | mag 3 000 x | WD 10.1 mm | spot 5.0 | 30 µm


S-enriched zone with ettringit in relicts & air voids
4/24/2012 11:12:40 AM | HFW 99.5 µm | HV 15.00 kV | mag 3 000 x | WD 10.1 mm | spot 5.0 | 30 µm


Interface between S-enriched & interior paste; slag grains show hydration
4/24/2012 11:39:40 AM | HFW 199 µm | HV 15.00 kV | mag 1 500 x | WD 10.0 mm | spot 5.0 | 50 µm

Friedelsalt appears in relicts in the Cl-zone behind the S-zone
5/2/2012 1:31:21 PM | HFW 49.7 µm | HV 12.50 kV | mag 6 004 x | WD 8.1 mm | spot 5.0 | 10 µm


Vejlefjordbroen, Slag Concrete
Cote -100
Atomic%
Distance from surface, mm
Mg
Al
Si
Ca
Vejlefjordbroen, Slag Concrete
Cote -100
Atomic%
Distance from surface, mm
Mg
S
Cl
C/S
Vejlefjordbroen, slag concrete
Brucite Mg/Al = ∞ +
Hydrotalcite Mg/Al = 3
Mg/Ca
Al/Ca
Vejlefjordbroen, slag concrete
Gypsum
Ettringite
Thaumasite
Monosulfate
CSH
CH
Monocarbo
Al/Ca
S/Ca
Vejlefjordbroen, slag concrete
Friedel's salt
CH
CSH
AFt
AFm
Cl/Ca
Al/Ca

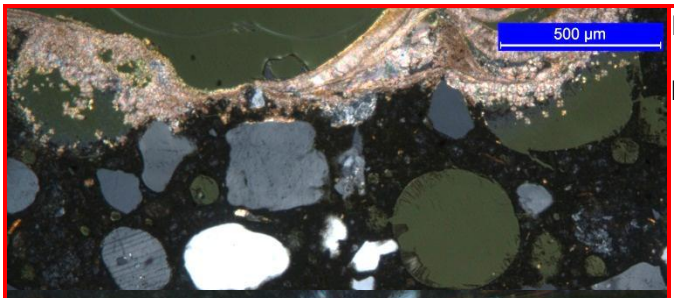


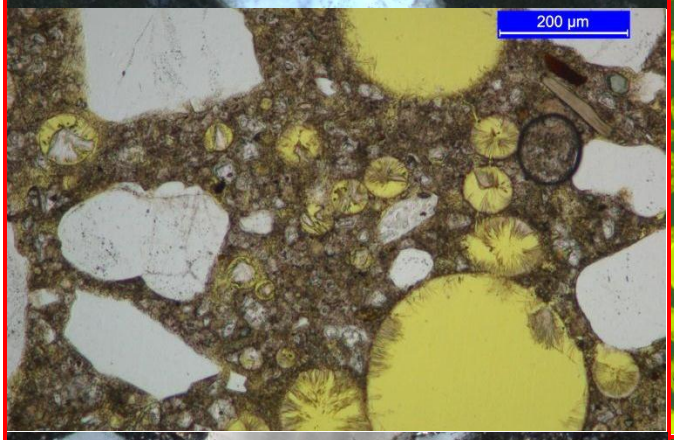
Phase distribution through the surface region of the concrete.

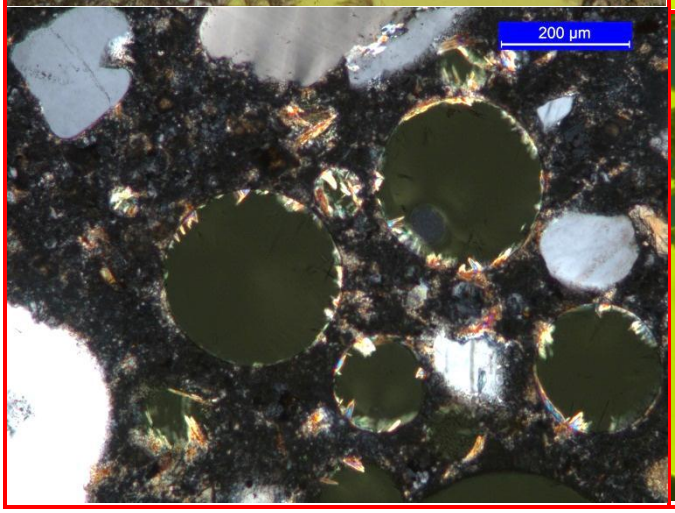
Vejlefjordbroen	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
Vejlefj-7206A(1)	0	OH	3,47	6,10	3,01	6,02	4,74	1,71	0,55	0,36	2,77	0,19	0,08	10,50	0,46
Vejlefj-7206A(2)	0,02	OH	1,39	9,67	4,86	11,24	1,38	1,21	0,63	0,27	0,94	0,66	0,08	7,19	0,08
Vejlefj-7206A(3)	0,04	OH	1,89	10,23	4,84	12,13	1,19	0,58	0,49	0,38	0,93	0,30	0,85	6,48	0,08
Vejlefj-7206A(4)	0,06	OH	1,46	10,71	5,46	11,50	1,39	0,70	0,68	0,13	1,12	0,22	1,04	5,91	0,10
Vejlefj-7206A(5)	0,1	OH	0,93	13,01	4,85	14,63	0,73	0,55	0,73	0,23	0,54	0,12	0,00	3,73	0,04
Vejlefj-7206A(6)	0,2	OH	1,09	13,11	4,65	14,81	0,55	1,26	0,55	0,20	0,53	0,11	0,08	2,68	0,04
Vejlefj-7206A(7)	0,3	OH	0,69	13,41	3,82	12,08	0,13	1,48	0,50	0,25	8,63	0,13	0,18	0,43	0,71
Vejlefj-7206A(8)	0,4	OH	0,92	9,78	4,12	9,42	0,24	1,63	0,55	0,18	14,44	0,13	0,11	1,12	1,53
Vejlefj-7206A(9)	0,5	OH	0,79	13,70	4,70	13,08	0,14	1,42	0,52	0,16	5,49	0,09	0,23	0,71	0,42
Vejlefj-7206A(10)	0,6	OH	0,50	14,40	3,69	13,19	0,14	1,20	0,53	0,16	7,13	0,01	0,08	0,45	0,54
Vejlefj-7206A(11)	0,7	OH	0,34	15,28	5,13	12,28	0,18	1,43	0,78	0,20	5,43	0,10	0,07	0,20	0,44
Vejlefj-7206A(12)	0,8	OH	0,31	16,61	4,62	12,64	0,12	1,39	0,66	0,13	3,83	0,14	0,10	0,70	0,30
Vejlefj-7206A(13)	0,9	OH	0,25	17,99	2,57	16,40	0,02	0,66	0,38	0,16	2,04	0,00	0,04	0,20	0,12
Vejlefj-7206A(14)	1	OH	0,24	18,01	5,28	11,62	0,11	1,43	0,82	0,07	3,51	0,09	0,00	0,51	0,30
Vejlefj-7206A(15)	2	OH	0,50	12,10	4,92	15,30	0,05	0,86	0,24	0,25	5,68	0,13	0,10	0,27	0,37
Vejlefj-7206A(16)	3	OH	1,02	1,16	3,40	13,69	0,03	2,60	1,08	0,18	16,71	0,12	0,05	0,33	1,22
Vejlefj-7206A(17)	4	OH	0,13	0,58	3,64	10,40	0,00	3,20	2,47	0,10	21,11	0,02	0,02	0,23	2,03
Vejlefj-7206A(18)	5	OH	0,18	1,06	2,83	11,62	0,02	2,12	2,42	0,11	21,79	0,00	0,01	0,36	1,88
Vejlefj-7206A(19)	6	OH	0,21	0,74	3,33	11,51	0,02	1,96	2,96	0,26	21,48	0,00	0,15	0,34	1,87
Vejlefj-7206A(20)	7	OH	0,11	1,24	4,39	10,02	0,05	1,72	3,33	0,08	22,29	0,08	0,04	0,37	2,22
Vejlefj-7206A(21)	8	OH	0,20	0,62	5,59	8,41	0,07	1,35	4,97	0,07	23,57	0,06	0,11	0,43	2,80
Vejlefj-7206A(22)	9	OH	0,26	2,14	2,88	11,72	0,00	1,79	2,18	0,15	21,02	0,11	0,09	0,35	1,79
Vejlefj-7206A(23)	10	OH	0,33	1,80	3,42	11,87	0,06	1,52	2,20	0,19	21,02	0,15	0,00	0,20	1,77
Vejlefj-7206A(24)	12,5	OH	0,26	1,75	3,42	10,98	0,03	1,81	2,57	0,10	21,78	0,09	0,17	0,17	1,98
Vejlefj-7206A(25)	15	OH	0,10	0,79	3,51	10,69	0,00	1,59	2,84	0,12	23,18	0,20	0,12	0,33	2,17
Vejlefj-7206A(26)	17,5	OH	0,30	0,94	3,26	12,15	0,00	1,00	2,30	0,17	22,88	0,11	0,13	0,07	1,88
Vejlefj-7206A(27)	20	OH	0,18	1,28	3,60	11,26	0,06	1,53	2,35	0,24	22,16	0,03	0,05	0,32	1,97
Vejlefj-7206A(28)	25	OH	0,28	1,43	3,30	11,30	0,00	1,56	1,61	0,08	22,86	0,09	0,00	0,24	2,02
Vejlefj-7206A(29)	30	OH	0,25	1,22	2,69	13,44	0,04	1,61	0,90	0,24	20,72	0,04	0,12	0,20	1,54
Vejlefj-7206A(30)	33	OH	0,10	0,96	3,02	11,52	0,00	1,94	0,98	0,14	22,52	0,11	0,06	0,53	1,95
Vejlefj-7206B(1)	60	OH	0,00	1,22	2,74	12,87	0,12	1,54	1,37	0,03	21,92	0,01	0,07	0,04	1,70
Vejlefj-7206B(2)	70	OH	0,24	0,44	3,17	12,16	0,09	2,11	0,58	0,19	22,13	0,02	0,00	0,17	1,82
Vejlefj-7206B(3)	80	OH	0,33	0,90	3,32	11,09	0,01	2,13	0,57	0,21	22,39	0,12	0,06	0,55	2,02
Vejlefj-7206B(4)	90	OH	0,27	0,72	3,79	10,93	0,00	2,19	0,47	0,27	22,97	0,00	0,00	0,12	2,10
Vejlefj-7206B(5)	95	OH	0,22	0,79	2,96	12,77	0,02	1,37	0,60	0,20	22,57	0,02	0,00	0,29	1,77
Average			0,56	6,17	3,85	11,91	0,34	1,55	1,35	0,18	14,29	0,11	0,12	1,33	1,26
Average excl. Mg zone															1,93

Alssundbroen **Pillar, cote -150, west** **Age: 1978–81**

Info		Comments
Cement type	CEM I 42,5 SR	Core taken in 2012
Fly ash	-	
Microsilica	-	Cement type: New low alkali, so called ALS
Slag	-	
W/C, apparent	0.45	
Air %	7	
		Section No: 7206-A3



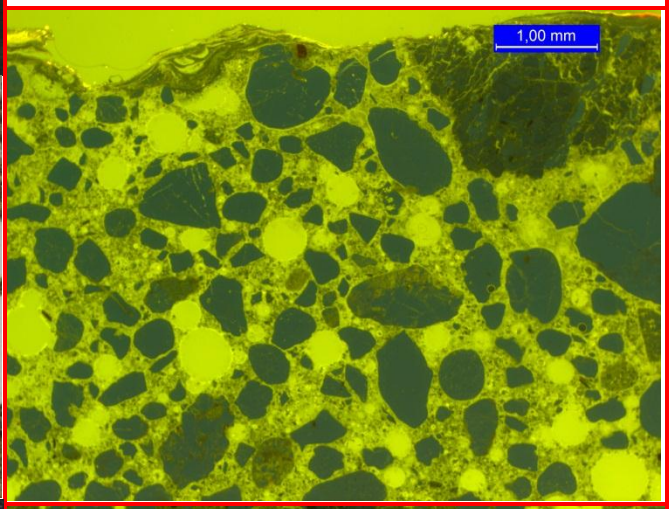


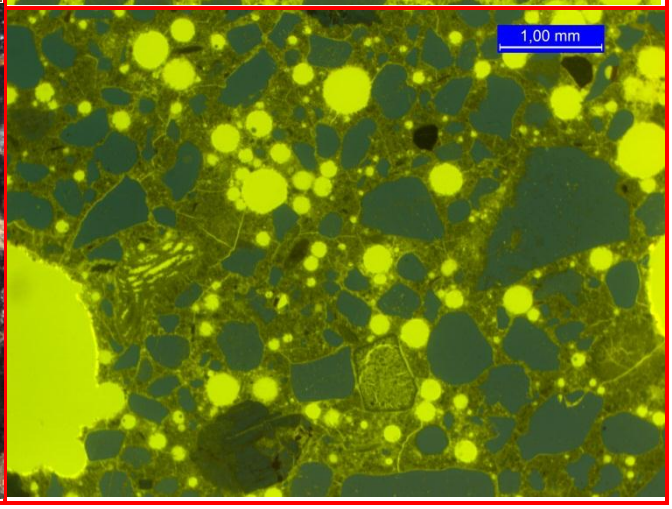


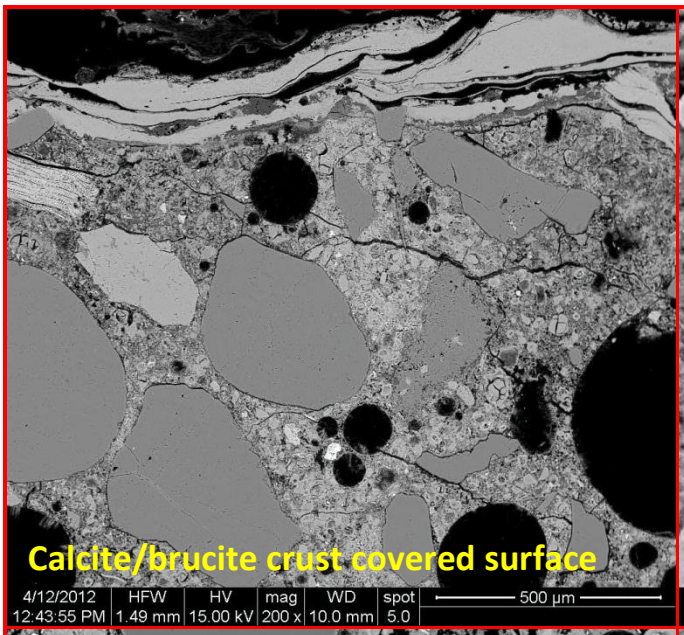
Micro-observations

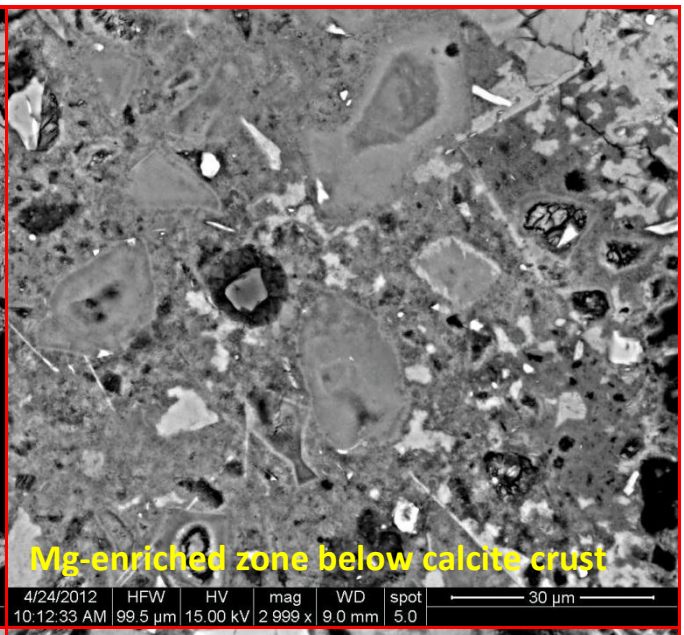
Micro-structural zoning through concrete:

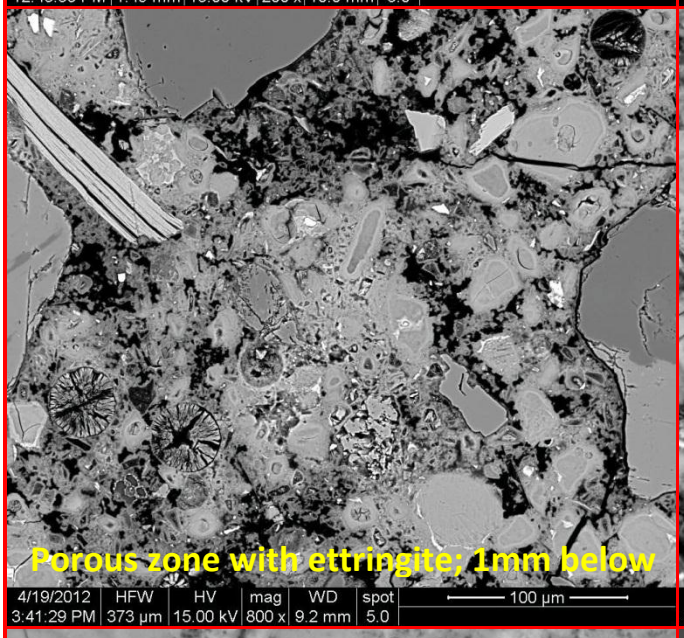
1. Uneven surface, weakly scaled but covered by a thin calcite crust. Brucite is observed.
2. 0-4mm: Porous, cracked and weakly carbonated paste.
3. 4-14mm: Highly porous, completely black paste containing ettringite and a thaumasite-like phase in air voids (especially in outer part).
4. Internal paste contains a high amount of relatively large CH crystals in paste and air voids. Minor ettringite in voids.

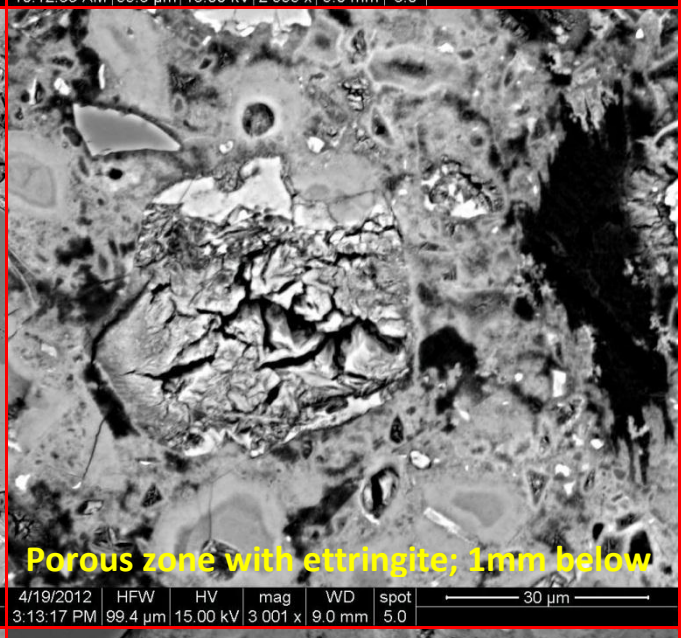




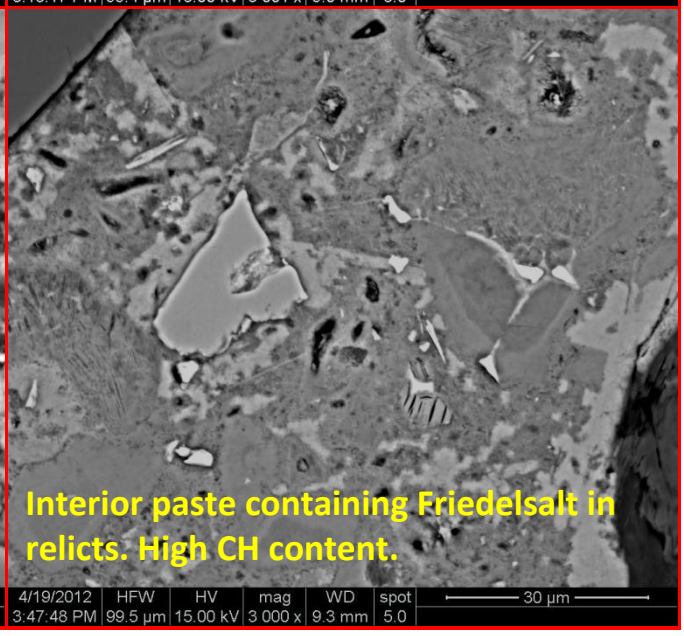

Calcite/brucite crust covered surface
4/12/2012 12:43:55 PM | HFW 1.49 mm | HV 15.00 kV | mag 200 x | WD 10.0 mm | spot 5.0 | 500 µm

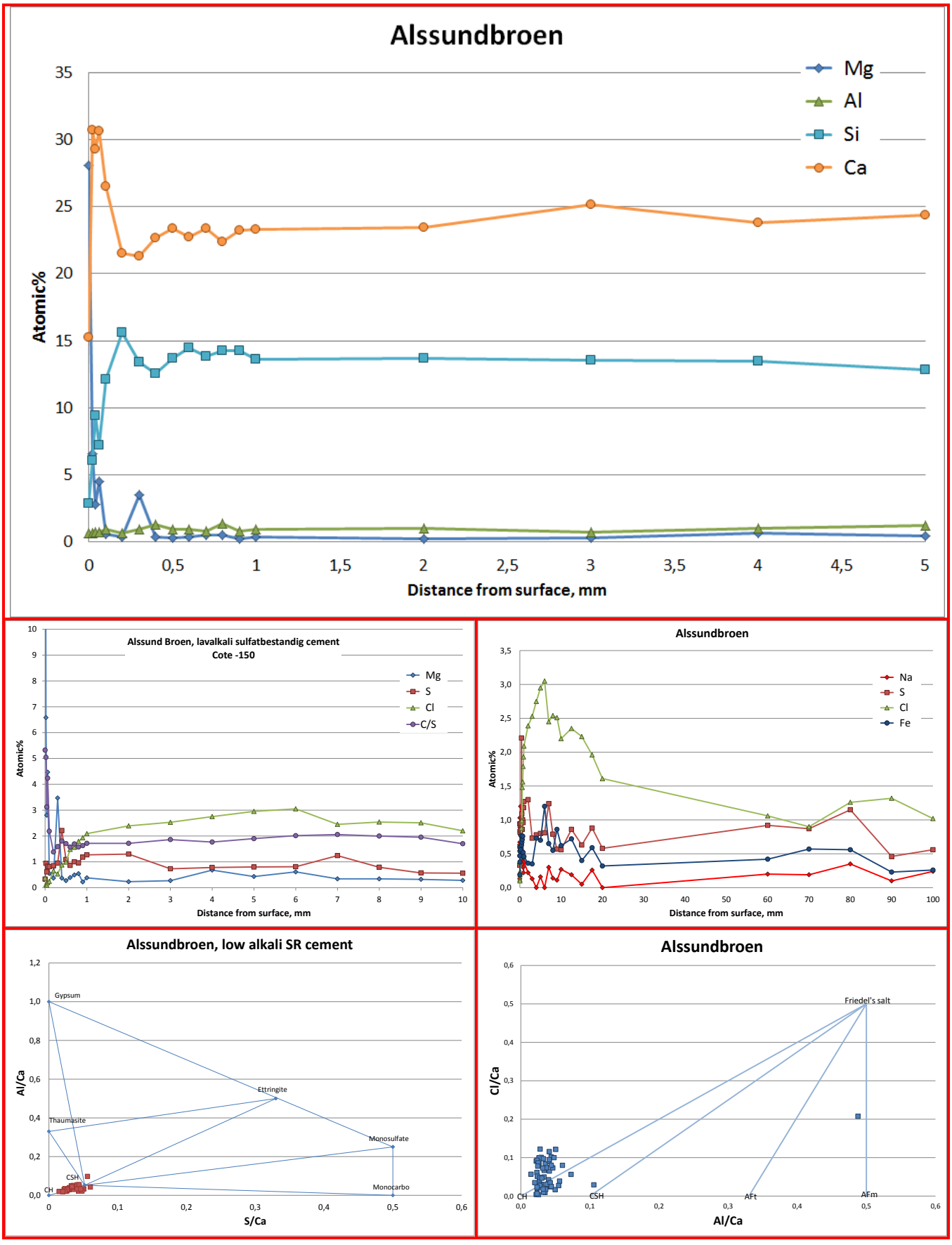

Mg-enriched zone below calcite crust
4/24/2012 10:12:33 AM | HFW 99.5 µm | HV 15.00 kV | mag 2 999 x | WD 9.0 mm | spot 5.0 | 30 µm

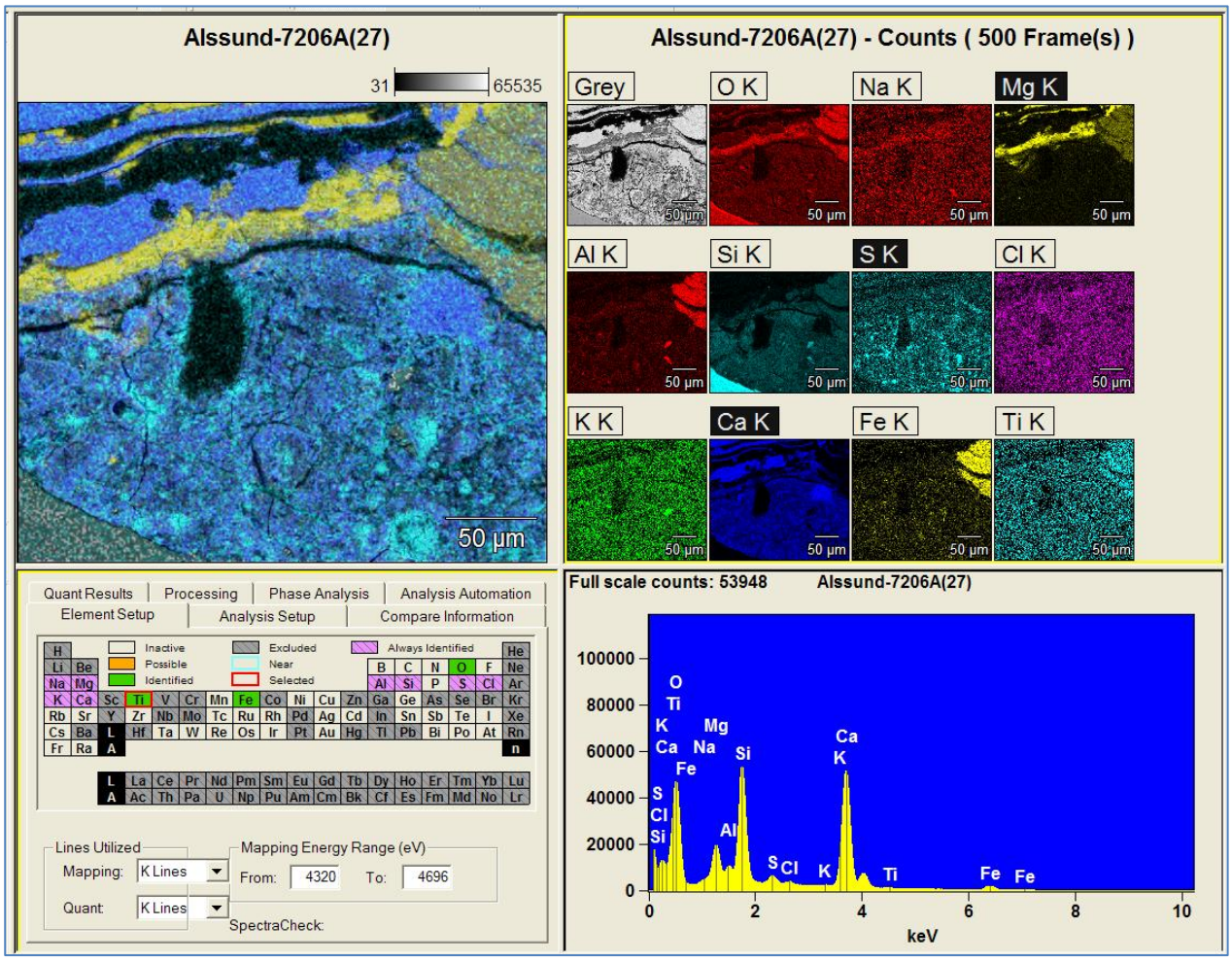

Porous zone with ettringite; 1mm below
4/19/2012 3:41:29 PM | HFW 373 µm | HV 15.00 kV | mag 800 x | WD 9.2 mm | spot 5.0 | 100 µm


Porous zone with ettringite; 1mm below
4/19/2012 3:13:17 PM | HFW 99.4 µm | HV 15.00 kV | mag 3 001 x | WD 9.0 mm | spot 5.0 | 30 µm

Porous zone with ettringite; 1mm below
4/24/2012 10:16:36 AM | HFW 49.7 µm | HV 15.00 kV | mag 6 003 x | WD 9.1 mm | spot 5.0 | 10 µm


Interior paste containing Friedelsalt in relicts. High CH content.
4/19/2012 3:47:48 PM | HFW 99.5 µm | HV 15.00 kV | mag 3 000 x | WD 9.3 mm | spot 5.0 | 30 µm


Alssundbroen
Mg
Al
Si
Ca
Atomic%
Distance from surface, mm
Alssund Broen, lavalkali sulfatbestandig cement
Cote -150
Mg
S
Cl
C/S
Atomic%
Distance from surface, mm
Alssundbroen
Na
S
Cl
Fe
Atomic%
Distance from surface, mm
Alssundbroen, low alkali SR cement
Gypsum
Ettringite
Thaumasite
Monosulfate
CSH
CH
Monocarbo
Al/Ca
S/Ca
Alssundbroen
Friedel's salt
CH
CSH
AFt
AFm
Cl/Ca
Al/Ca

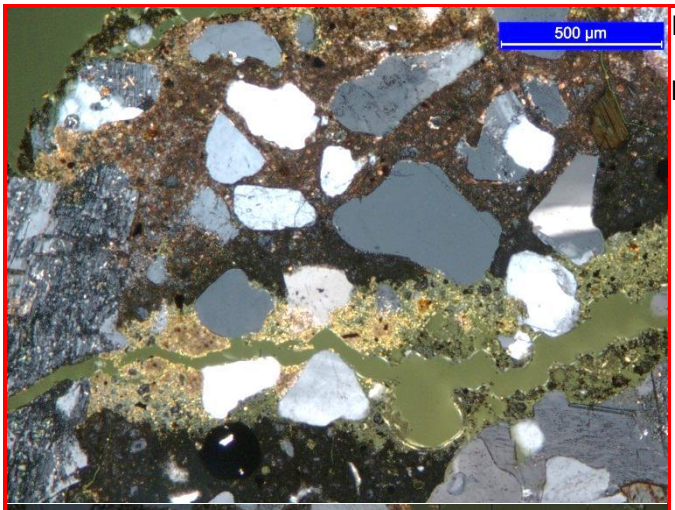


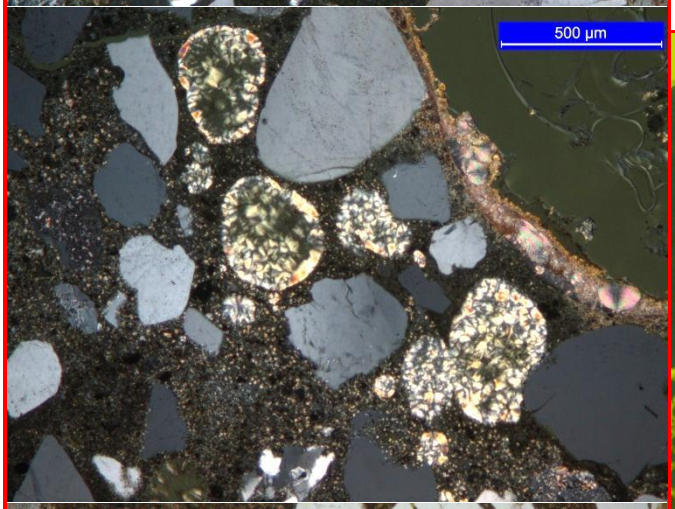
Phase distribution through the surface region of the concrete.

Alssundbroen, LakAlkC, ALS	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
Alssund2-7206A-(2)	0	OH	0,13	28,04	0,66	2,87	0,00	0,33	0,37	0,01	15,28	0,00	0,00	0,47	5,32
Alssund2-7206A-(3)	0,02	OH	0,67	6,58	0,68	6,09	0,00	0,94	0,12	0,05	30,72	0,00	0,00	0,19	5,04
Alssund2-7206A-(4)	0,04	OH	1,03	2,80	0,75	9,38	0,02	0,61	0,10	0,22	29,27	0,00	0,00	0,54	3,12
Alssund2-7206A-(5)	0,06	OH	0,89	4,47	0,72	7,23	0,05	0,83	0,19	0,06	30,64	0,03	0,10	0,38	4,24
Alssund2-7206A-(6)	0,1	OH	1,03	0,55	0,93	12,13	0,07	0,81	0,24	0,29	26,48	0,00	0,00	0,60	2,18
Alssund2-7206A-(7)	0,2	OH	1,20	0,37	0,64	15,61	0,06	0,85	0,65	0,10	21,55	0,01	0,05	0,56	1,38
Alssund2-7206A-(8)	0,3	OH	0,68	3,47	0,94	13,41	0,09	0,95	0,53	0,16	21,30	0,03	0,00	0,77	1,59
Alssund2-7206A-(9)	0,4	OH	0,78	0,37	1,27	12,54	0,02	2,21	0,88	0,08	22,63	0,12	0,08	0,63	1,80
Alssund2-7206A-(10)	0,5	OH	1,03	0,27	0,94	13,71	0,12	1,09	0,99	0,09	23,37	0,00	0,05	0,67	1,70
Alssund2-7206A-(11)	0,6	OH	0,54	0,39	0,94	14,48	0,08	0,86	1,48	0,10	22,73	0,01	0,01	0,71	1,57
Alssund2-7206A-(12)	0,7	OH	0,40	0,49	0,79	13,83	0,14	1,00	1,56	0,04	23,39	0,02	0,03	0,76	1,69
Alssund2-7206A-(13)	0,8	OH	0,30	0,54	1,35	14,24	0,06	0,96	1,79	0,13	22,40	0,07	0,00	0,52	1,57
Alssund2-7206A-(14)	0,9	OH	0,22	0,22	0,82	14,26	0,07	1,18	1,93	0,01	23,20	0,00	0,00	0,45	1,63
Alssund2-7206A-(15)	1	OH	0,38	0,38	0,96	13,60	0,09	1,27	2,09	0,01	23,32	0,03	0,03	0,46	1,71
Alssund2-7206A-(16)	2	OH	0,22	0,23	1,03	13,68	0,00	1,30	2,39	0,06	23,47	0,00	0,02	0,36	1,72
Alssund2-7206A-(17)	3	OH	0,13	0,27	0,74	13,51	0,04	0,73	2,53	0,04	25,13	0,04	0,00	0,35	1,86
Alssund2-7206A-(18)	4	OH	0,00	0,68	0,98	13,48	0,07	0,78	2,75	0,08	23,80	0,04	0,00	0,73	1,77
Alssund2-7206A-(19)	5	OH	0,16	0,43	1,23	12,82	0,15	0,80	2,95	0,09	24,33	0,00	0,07	0,70	1,90
Alssund2-7206A-(20)	6	OH	0,00	0,61	0,70	12,42	0,03	0,81	3,05	0,06	25,01	0,06	0,05	1,20	2,01
Alssund2-7206A-(21)	7	OH	0,30	0,34	0,82	12,25	0,11	1,24	2,45	0,08	25,18	0,00	0,08	0,65	2,06
Alssund2-7206A-(22)	8	OH	0,14	0,34	0,67	12,83	0,11	0,79	2,54	0,05	25,62	0,06	0,00	0,55	2,00
Alssund2-7206A-(23)	9	OH	0,11	0,32	1,21	12,88	0,01	0,57	2,51	0,05	25,14	0,05	0,05	0,86	1,95
Alssund2-7206A-(24)	10	OH	0,27	0,28	0,54	14,23	0,08	0,56	2,20	0,05	24,20	0,09	0,00	0,62	1,70
Alssund2-7206A-(25)	12,5	OH	0,19	0,36	0,59	12,98	0,07	0,86	2,35	0,00	25,23	0,06	0,05	0,72	1,94
Alssund2-7206A-(26)	15	OH	0,05	0,43	0,70	12,79	0,02	0,63	2,23	0,01	26,56	0,00	0,01	0,40	2,08
Alssund2-7206A-(27)	17,5	OH	0,26	0,35	1,24	11,55	0,09	0,88	1,96	0,07	26,77	0,09	0,00	0,59	2,32
Alssund2-7206A-(28)	20	OH	0,00	0,31	0,42	12,14	0,00	0,58	1,61	0,05	28,46	0,06	0,00	0,32	2,34
Alssund-7206B-(1)	60	OH	0,20	0,14	0,73	12,48	0,03	0,92	1,06	0,02	27,05	0,00	0,07	0,42	2,17
Alssund-7206B-(2)	70	OH	0,19	0,36	0,78	10,70	0,09	0,87	0,90	0,05	29,36	0,00	0,00	0,57	2,74
Alssund-7206B-(3)	80	OH	0,35	0,23	0,86	12,76	0,07	1,15	1,26	0,14	25,44	0,00	0,00	0,56	1,99
Alssund-7206B-(4)	90	OH	0,10	0,34	0,50	16,83	0,08	0,46	1,32	0,03	21,60	0,06	0,00	0,23	1,28
Alssund-7206B-(5)	100	OH	0,24	0,38	0,59	11,57	0,00	0,56	1,02	0,06	29,30	0,00	0,05	0,26	2,53
Average			0,38	1,73	0,84	12,35	0,06	0,89	1,56	0,07	24,94	0,03	0,03	0,56	2,22
Average uden Mg zone															1,90

Farøbroen **Pillar, cote -150, south** **Age: 1980-85**

Info		**Comments**
Cement type	LavAlk	Core taken in 2012
Fly ash	X	
Microsilica	-	Cement type: Lavalkali
Slag	-	
W/C, apparent	0.40	
Air %	3-4	
		Section No: 7206-F3

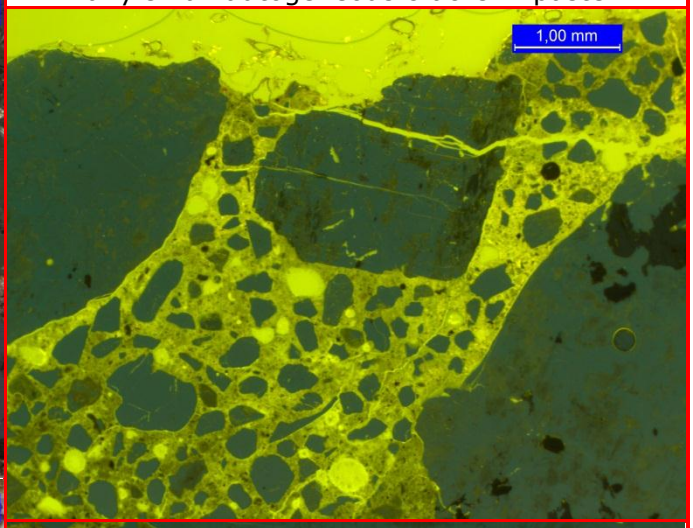


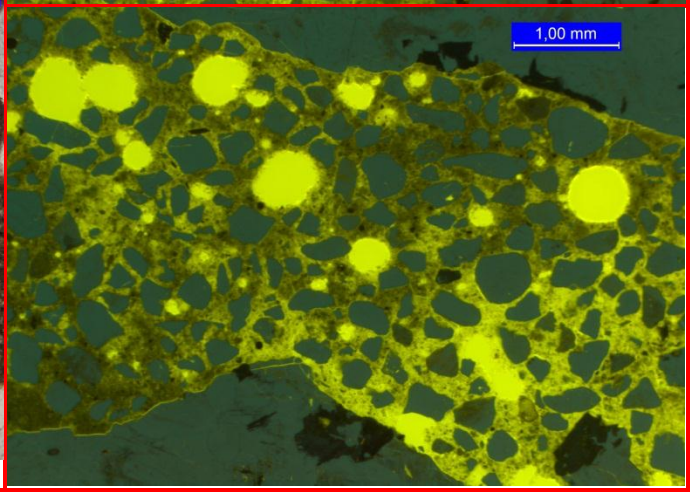


Micro-observations

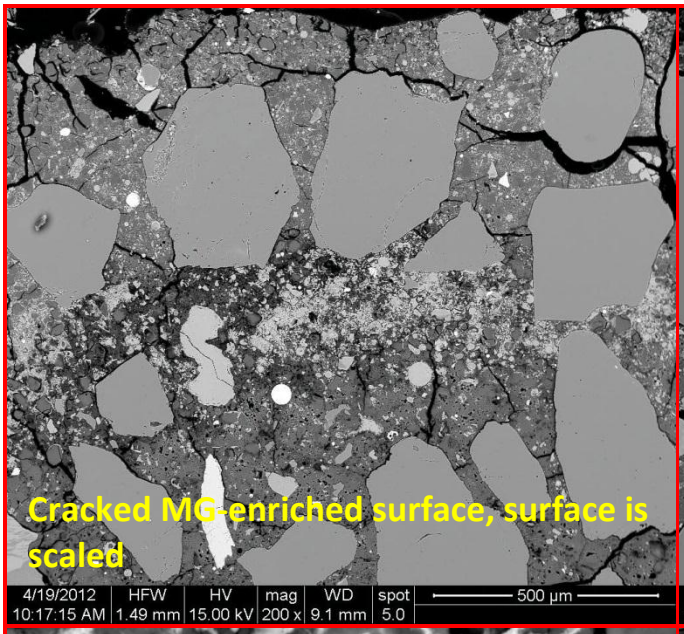
Micro-structural zoning through concrete:

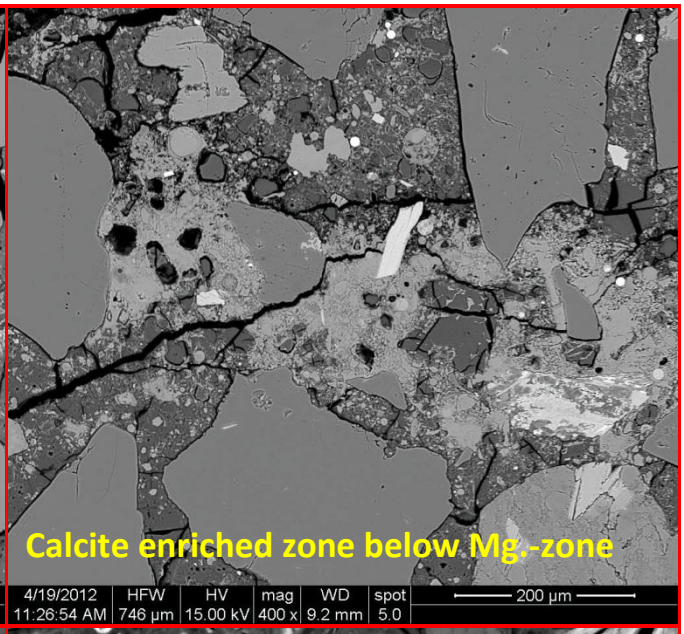
1. Surface is uneven and scaled. A thin calcite crust is occasionally observed, as well a paste damaged by biological growth.
2. 0-3mm: Partially carbonated paste with bands of black paste. Massive ettringite and thaumasite-like phases are observed in air voids. Paste is highly cracked. Popcorn carbonation in the bottom of the zone.
3. 3-10mm: Porous, black paste with ettringite and thaumasite-like phases in air voids.
4. Internal paste contains a relatively high amount of CH. Observed in air voids too. Many small autogeneous cracks in paste.

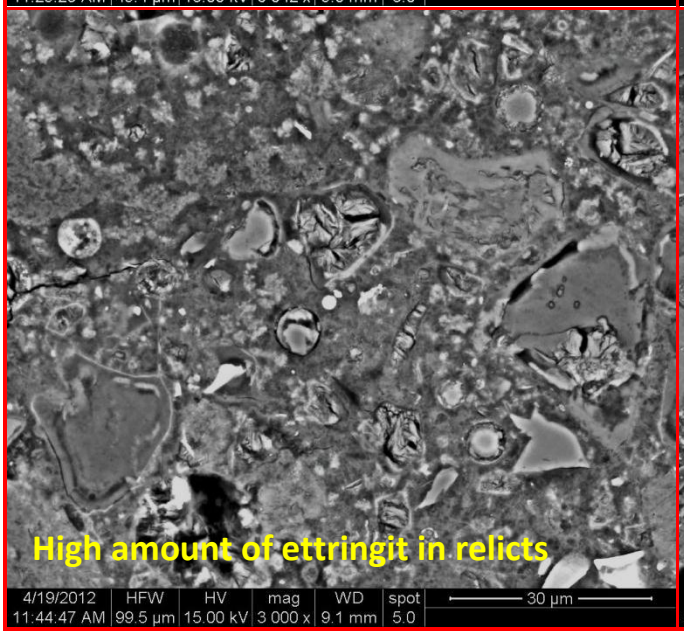


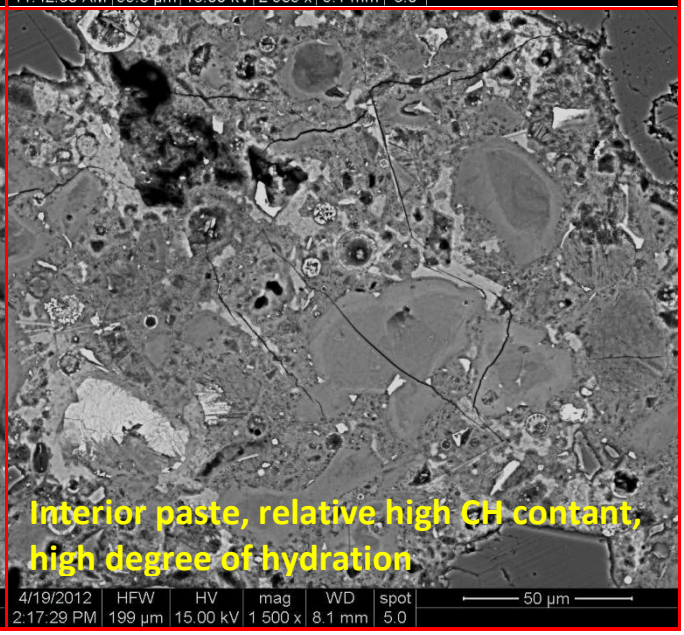


Farøbroen **Pillar, cote -150, south** **Age: 1980-85**

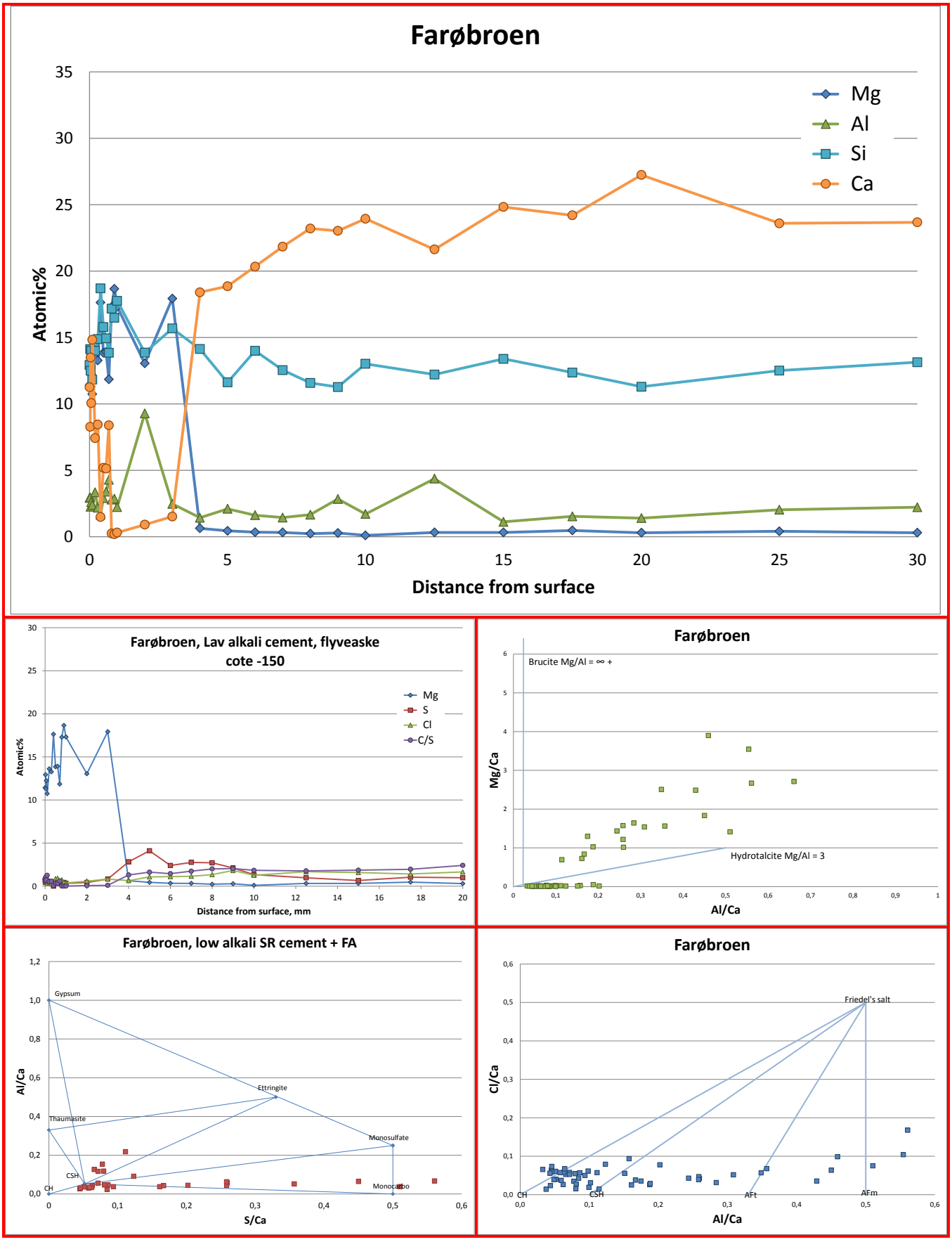


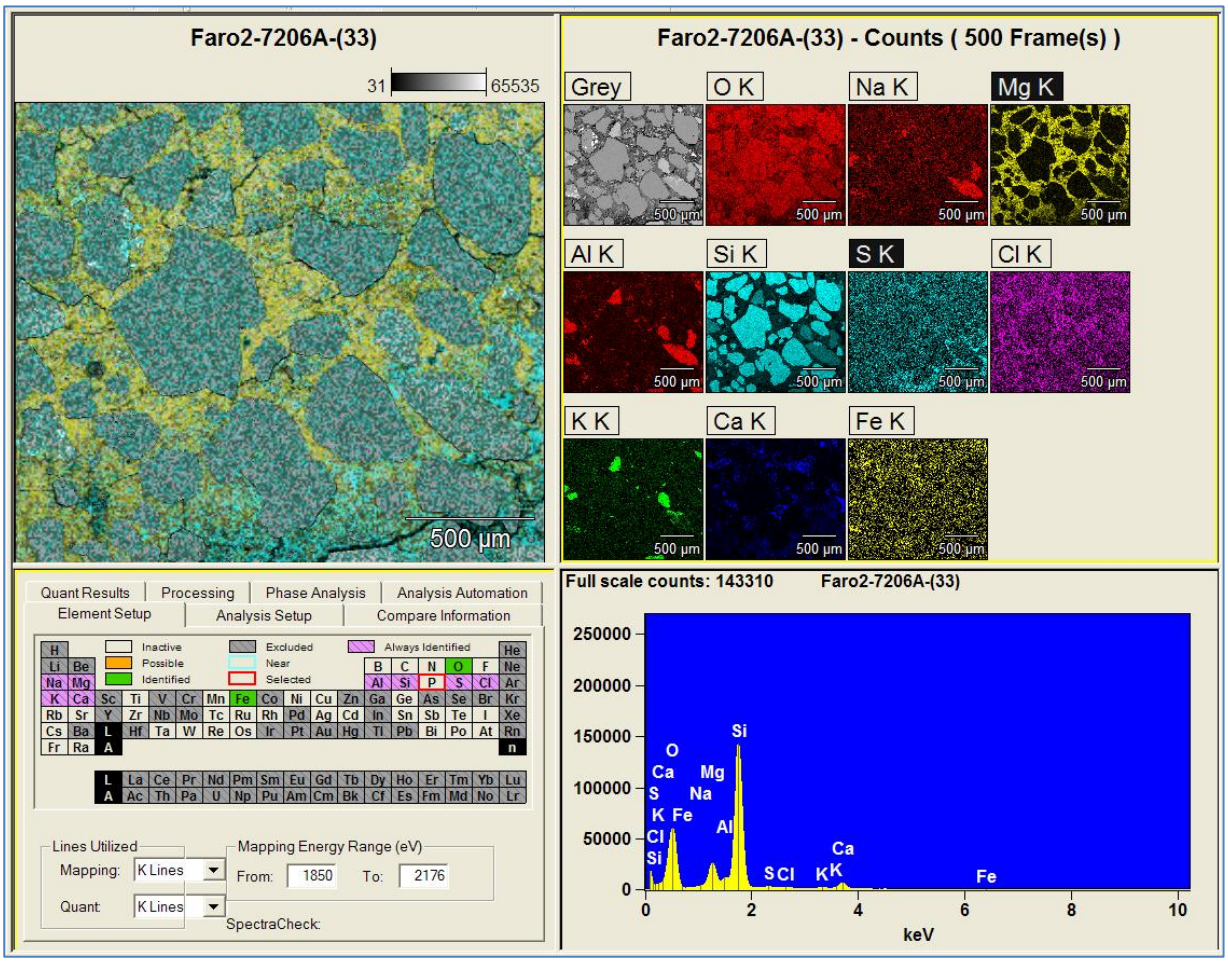






Farøbroen **Pillar, cote -150, south** **Age: 1980-85**

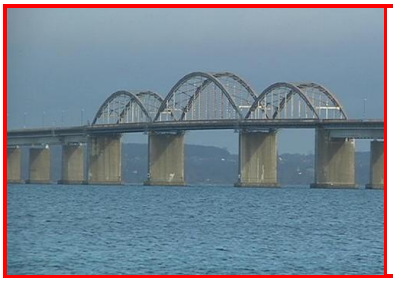




Phase distribution through the surface region of the concrete.

Farøbroen, +FA	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
Faro2-7206A-(1)	0	OH	0,74	11,42	2,92	12,93	0,24	0,65	0,48	0,15	11,26	0,05	0,08	1,22	0,87
Faro2-7206A-(2)	0,02	OH	0,61	12,93	2,95	14,12	0,21	0,43	0,56	0,15	8,27	0,02	0,11	1,39	0,59
Faro2-7206A-(3)	0,04	OH	0,67	11,31	2,25	12,49	0,11	0,58	0,51	0,16	13,49	0,00	0,02	1,13	1,08
Faro2-7206A-(4)	0,06	OH	0,87	12,24	2,60	14,01	0,11	0,44	0,47	0,20	10,06	0,05	0,00	0,99	0,72
Faro2-7206A-(5)	0,1	OH	0,83	10,74	2,39	11,83	0,12	0,56	0,37	0,15	14,83	0,06	0,08	1,03	1,25
Faro2-7206A-(6)	0,2	OH	0,67	13,61	3,34	14,00	0,14	0,48	0,47	0,13	7,42	0,11	0,00	1,29	0,53
Faro2-7206A-(7)	0,3	OH	0,67	13,27	2,18	14,88	0,05	0,53	0,33	0,11	8,44	0,11	0,00	0,94	0,57
Faro2-7206A-(8)	0,4	OH	0,00	17,63	1,66	18,70	0,07	0,00	0,28	0,01	1,48	0,00	0,00	0,40	0,08
Faro2-7206A-(9)	0,5	OH	0,03	13,85	2,91	15,79	0,00	0,35	0,87	0,09	5,19	0,15	0,03	1,72	0,33
Faro2-7206A-(10)	0,6	OH	0,42	13,91	3,39	14,94	0,00	0,46	0,90	0,06	5,13	0,12	0,13	1,81	0,34
Faro2-7206A-(11)	0,7	OH	0,49	11,85	4,28	13,85	0,04	0,32	0,63	0,24	8,39	0,03	0,04	1,57	0,61
Faro2-7206A-(12)	0,8	OH	0,51	17,29	2,79	17,17	0,03	0,35	0,73	0,13	0,24	0,04	0,02	1,25	0,01
Faro2-7206A-(13)	0,9	OH	0,62	18,66	2,86	16,48	0,04	0,43	0,45	0,05	0,19	0,07	0,00	0,88	0,01
Faro2-7206A-(14)	1	OH	0,83	17,31	2,23	17,76	0,07	0,33	0,37	0,11	0,31	0,02	0,05	0,98	0,02
Faro2-7206A-(15)	2	OH	0,41	13,05	9,28	13,86	0,19	0,43	0,58	0,12	0,91	0,10	0,00	1,31	0,07
Faro2-7206A-(16)	3	OH	0,31	17,93	2,47	15,68	0,05	0,83	0,83	0,10	1,52	0,13	0,06	0,98	0,10
Faro2-7206A-(17)	4	OH	0,98	0,63	1,43	14,13	0,05	2,83	0,64	0,00	18,40	0,06	0,00	0,89	1,30
Faro2-7206A-(18)	5	OH	0,51	0,44	2,10	11,62	0,16	4,11	1,08	0,18	18,86	0,11	0,00	0,74	1,62
Faro2-7206A-(19)	6	OH	0,26	0,34	1,62	14,00	0,03	2,40	1,11	0,01	20,34	0,03	0,00	0,52	1,45
Faro2-7206A-(20)	7	OH	0,25	0,32	1,44	12,54	0,00	2,76	1,15	0,14	21,84	0,00	0,07	0,62	1,74
Faro2-7206A-(21)	8	OH	0,24	0,23	1,66	11,58	0,02	2,71	1,34	0,11	23,21	0,06	0,00	0,51	2,00
Faro2-7206A-(22)	9	OH	0,12	0,28	2,84	11,27	0,00	2,11	1,82	0,25	23,03	0,02	0,00	0,64	2,04
Faro2-7206A-(23)	10	OH	0,22	0,10	1,71	13,02	0,18	1,34	1,26	0,02	23,94	0,00	0,02	0,37	1,84
Faro2-7206A-(24)	12,5	OH	0,30	0,32	4,37	12,21	0,06	0,97	1,68	0,11	21,63	0,02	0,00	0,84	1,77
Faro2-7206A-(25)	15	OH	0,29	0,32	1,12	13,39	0,08	0,66	1,58	0,02	24,83	0,05	0,00	0,65	1,85
Faro2-7206A-(26)	17,5	OH	0,28	0,47	1,53	12,36	0,34	1,04	1,41	0,10	24,20	0,11	0,08	0,77	1,96
Faro2-7206A-(27)	20	OH	0,18	0,30	1,40	11,29	0,00	0,98	1,65	0,14	27,24	0,05	0,01	0,53	2,41
Faro2-7206A-(28)	25	OH	0,38	0,41	2,03	12,51	0,12	1,10	1,34	0,07	23,60	0,04	0,10	0,89	1,89
Faro2-7206A-(29)	30	OH	0,28	0,30	2,22	13,14	0,04	0,89	1,18	0,11	23,67	0,02	0,00	0,63	1,80
Faro2-7206A-(30)	33	OH	0,26	0,32	1,14	13,59	0,02	0,76	1,47	0,10	24,90	0,07	0,00	0,24	1,83
Faro2-7206B-(1)	60	OH	0,23	0,52	1,38	13,66	0,00	0,75	1,37	0,20	23,93	0,01	0,08	0,57	1,75
Faro2-7206B-(2)	70	OH	0,33	0,17	1,54	13,40	0,04	0,82	0,65	0,14	24,73	0,02	0,11	0,44	1,85
Faro2-7206B-(3)	80	OH	0,58	0,04	1,96	14,57	0,00	0,53	0,99	0,11	23,16	0,07	0,00	0,26	1,59
Faro2-7206B-(4)	90	OH	0,25	0,36	1,42	13,73	0,14	0,81	0,89	0,12	23,93	0,00	0,00	0,59	1,74
Faro2-7206B-(5)	93	OH	0,00	0,24	1,95	13,13	0,06	1,11	0,66	0,11	24,04	0,00	0,00	0,67	1,83
Average			0,42	6,66	2,44	13,82	0,08	1,02	0,92	0,11	15,33	0,05	0,03	0,86	1,18
Average uden Mg zone															1,80

Storstrømsbroen **Pillar, cote UV** **Age: 1933-37**



Info	
Cement type	PC?
Fly ash	-
Microsilica	-
Slag	-
W/C, apparent	
Air %	

Comments

Cores taken in 2012 (Rambøll)

Cement type: PC (?)

Section: RAMBØLL 7234-7UV

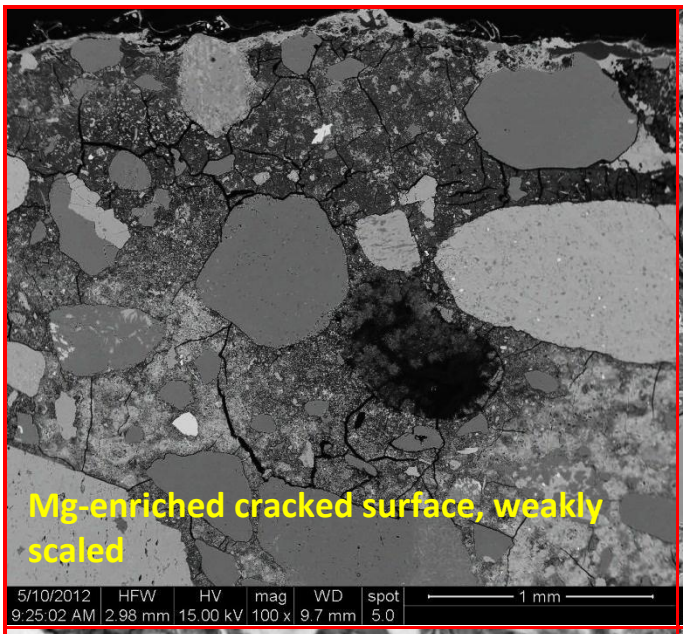
No optical polarizing microscopy has been performed by DTI

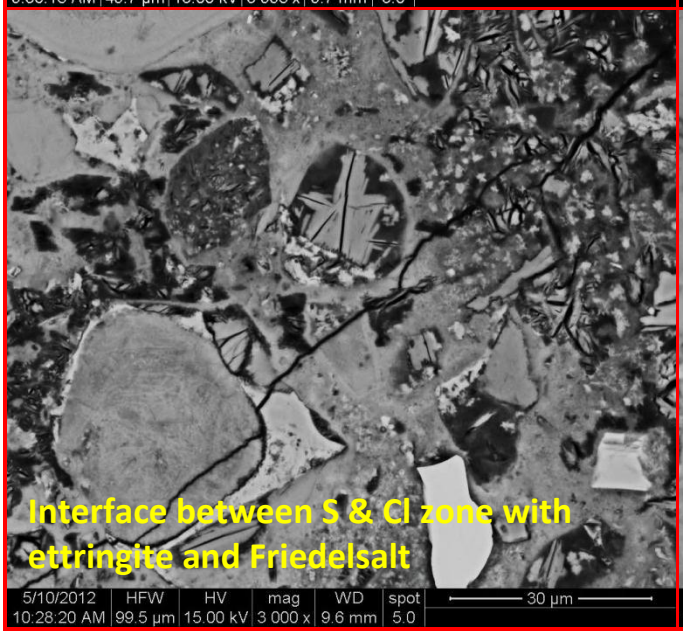
Micro-observations (SEM-EDX)

Micro-structural zoning through concrete:

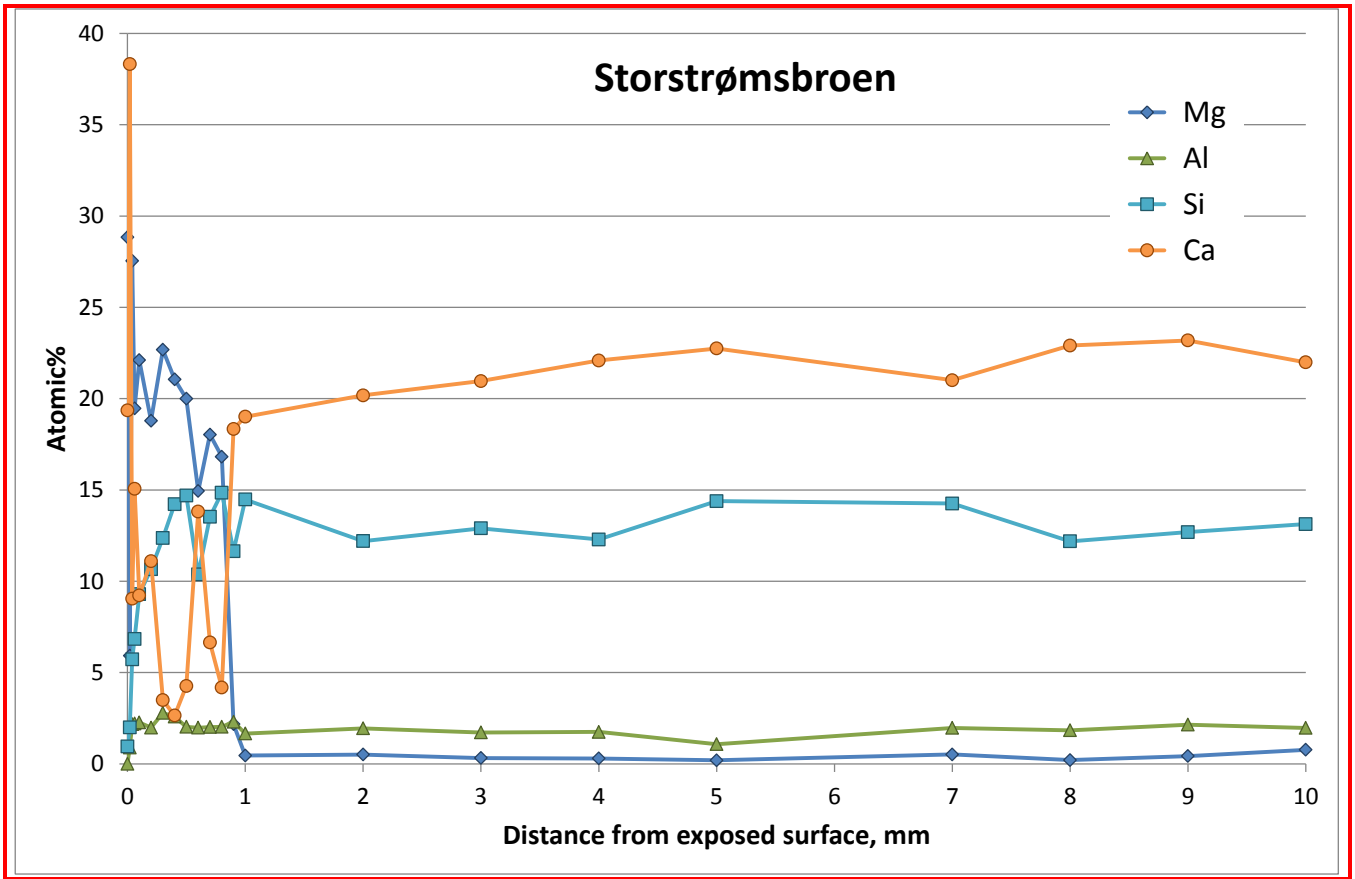
1. Surface is uneven and weakly scaled. A calcite crust is typically observed at the surface.
2. 0-0.7mm: Cracked decalcified paste highly enriched in Mg. Calcite appears intermixed in the decalcified paste. Popcorn carbonation appears in the bottom of the zone.
3. 0.8-13mm: Zone containing a high amount of ettringite in small cracks, air void and in relicts after cement grains. Some cracking of paste.
4. 9->33mm: A very high amount of Friedelsalt is present in relicts after cement grains.

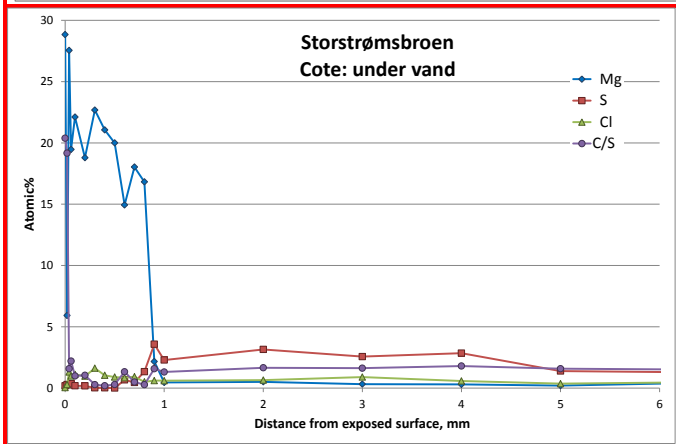
Storstrømsbroen **Pillar, cote UV** **Age: 1933-37**

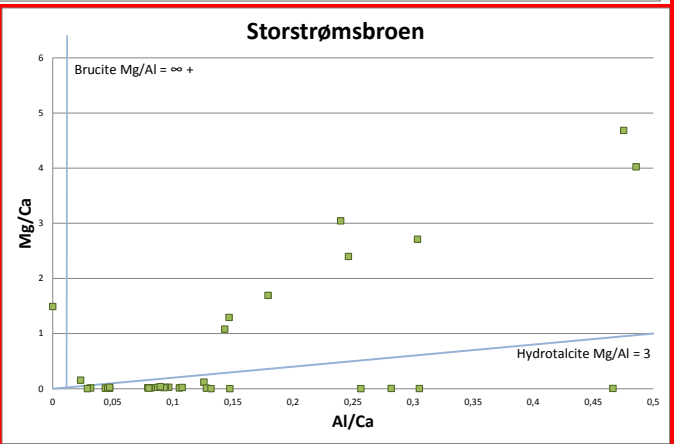


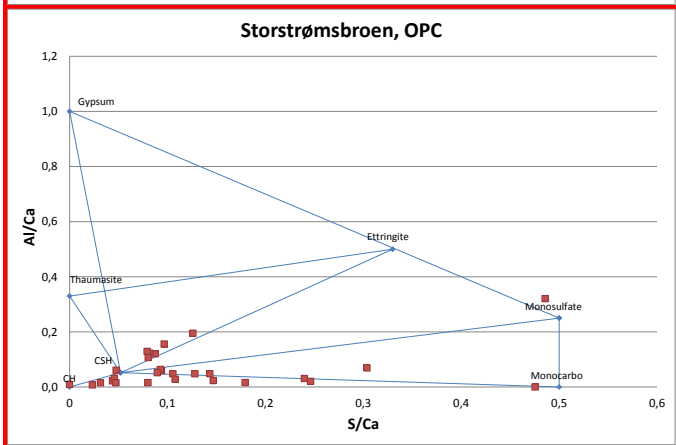


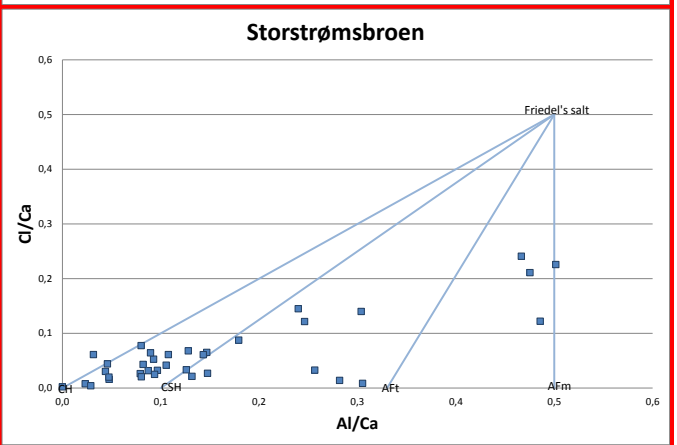
Storstrømsbroen **Pillar, cote UV** **Age: 1933-37**



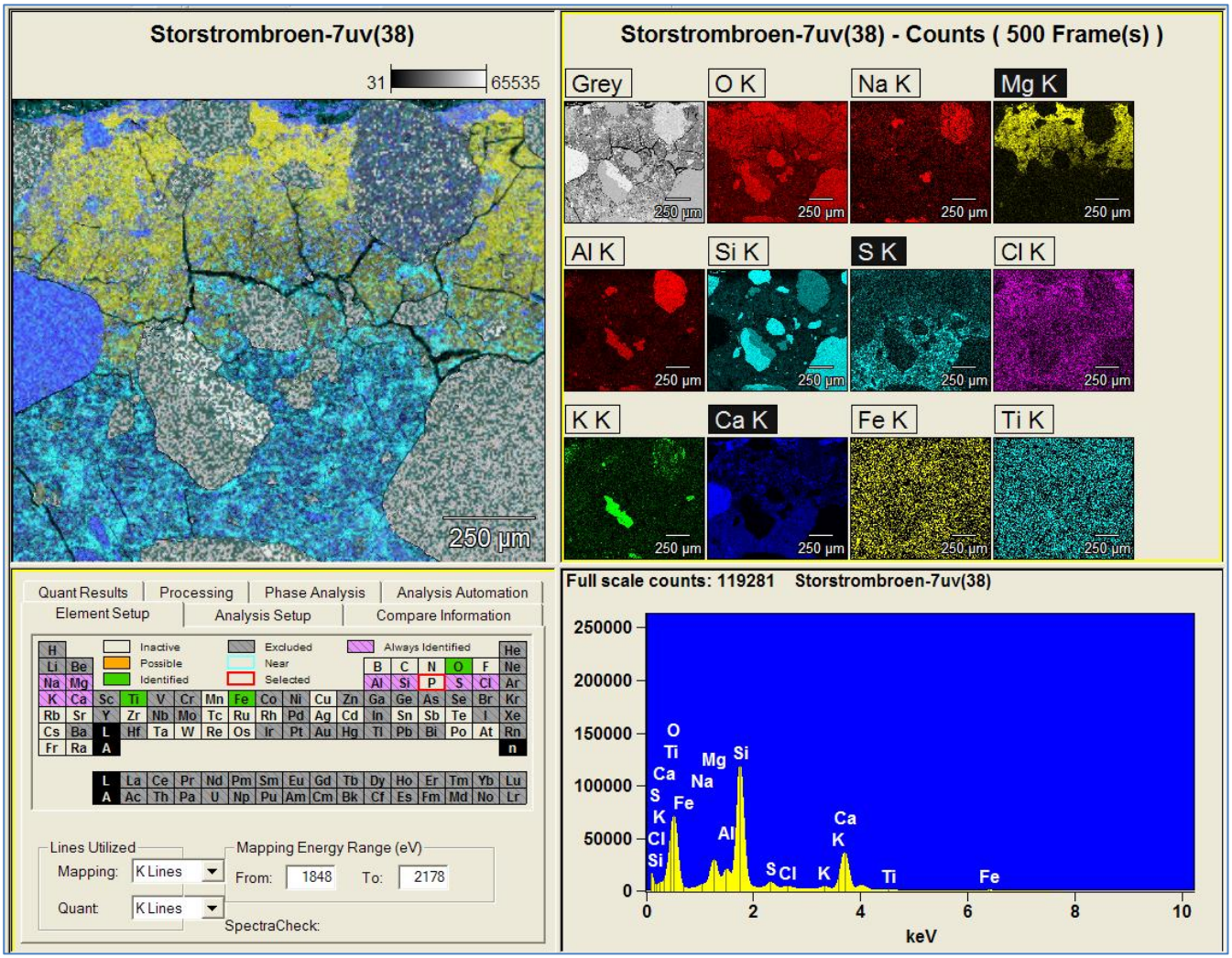








Storstrømsbroen **Pillar, cote UV** **Age: 1933-37**

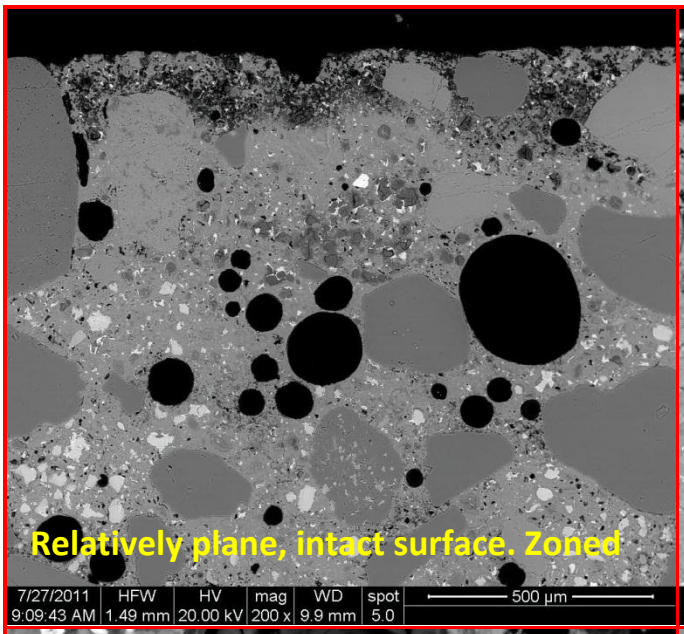


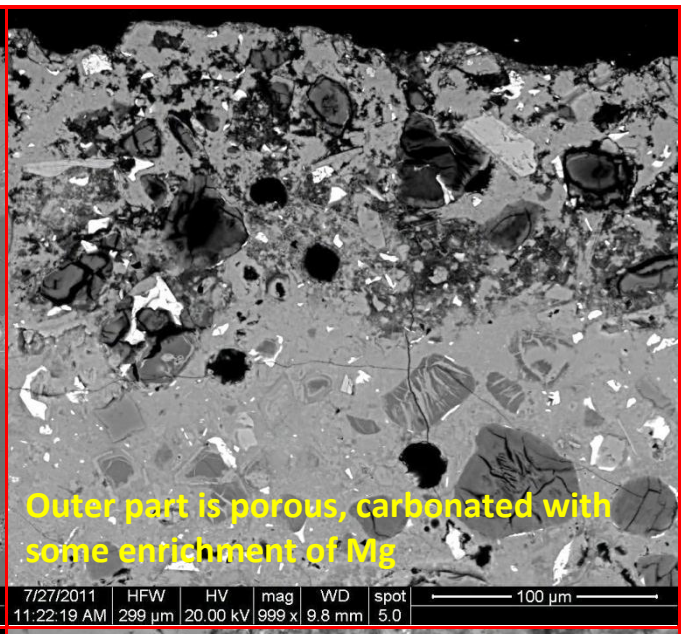
Phase distribution through the surface region of the concrete.

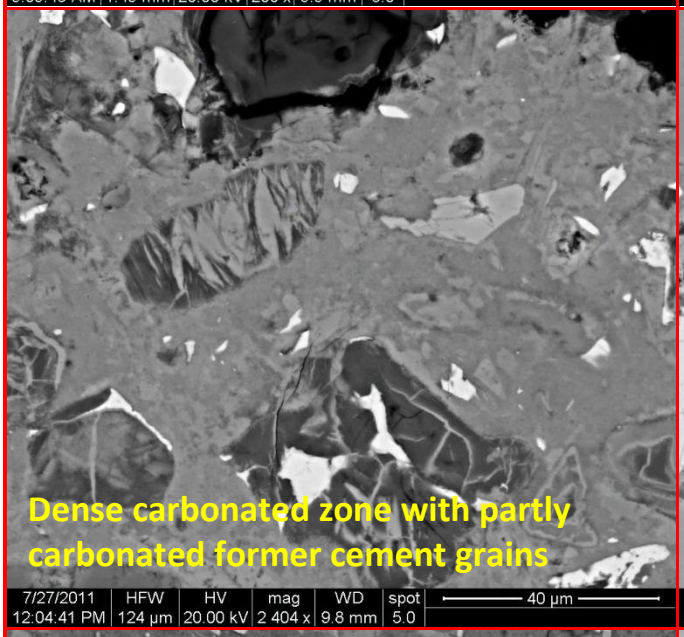
Storstrømsbroen	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
Storstrombroen-7uv(1)	0	OH	0,00	28,84	0,00	0,95	0,00	0,18	0,04	0,01	19,36	0,00	0,00	0,00	20,38
Storstrombroen-7uv(2)	0,02	OH	0,57	5,92	0,89	2,00	0,00	0,29	0,29	0,06	38,32	0,07	0,00	0,27	19,16
Storstrombroen-7uv(3)	0,04	OH	0,00	27,55	2,17	5,72	0,03	0,28	1,31	0,04	9,05	0,05	0,00	0,57	1,58
Storstrombroen-7uv(4)	0,06	OH	0,00	19,47	2,21	6,84	0,05	0,35	0,98	0,16	15,06	0,04	0,00	0,78	2,20
Storstrombroen-7uv(5)	0,1	OH	0,00	22,11	2,27	9,29	0,05	0,19	1,12	0,04	9,22	0,08	0,04	0,54	0,99
Storstrombroen-7uv(6)	0,2	OH	0,00	18,79	1,99	10,66	0,00	0,18	0,97	0,14	11,10	0,05	0,04	0,46	1,04
Storstrombroen-7uv(7)	0,3	OH	0,00	22,68	2,79	12,37	0,07	0,02	1,62	0,07	3,49	0,07	0,00	0,52	0,28
Storstrombroen-7uv(8)	0,4	OH	0,00	21,06	2,59	14,22	0,14	0,02	1,04	0,12	2,65	0,00	0,00	0,66	0,19
Storstrombroen-7uv(9)	0,5	OH	0,00	20,00	2,03	14,69	0,00	0,00	0,90	0,13	4,27	0,04	0,00	0,44	0,29
Storstrombroen-7uv(10)	0,6	OH	0,10	14,94	1,98	10,38	0,11	0,67	0,84	0,06	13,82	0,06	0,00	0,80	1,33
Storstrombroen-7uv(11)	0,7	OH	0,13	18,03	2,02	13,53	0,00	0,46	0,93	0,14	6,65	0,03	0,05	0,64	0,49
Storstrombroen-7uv(12)	0,8	OH	0,09	16,82	2,03	14,85	0,11	1,34	0,51	0,09	4,18	0,02	0,07	0,64	0,28
Storstrombroen-7uv(13)	0,9	OH	0,47	2,17	2,31	11,65	0,17	3,58	0,61	0,22	18,34	0,00	0,09	0,62	1,57
Storstrombroen-7uv(14)	1	OH	0,85	0,46	1,66	14,48	0,13	2,29	0,60	0,10	19,01	0,14	0,00	0,58	1,31
Storstrombroen-7uv(15)	2	OH	0,91	0,51	1,95	12,20	0,11	3,15	0,65	0,07	20,18	0,06	0,00	0,76	1,65
Storstrombroen-7uv(16)	3	OH	0,70	0,32	1,72	12,90	0,19	2,57	0,90	0,16	20,96	0,04	0,05	0,43	1,62
Storstrombroen-7uv(17)	4	OH	0,31	0,30	1,75	12,29	0,07	2,85	0,58	0,15	22,09	0,01	0,00	0,42	1,80
Storstrombroen-7uv(18)	5	OH	0,39	0,20	1,08	14,39	0,09	1,39	0,36	0,02	22,75	0,00	0,04	0,52	1,58
Storstrombroen-7uv(20)	7	OH	0,38	0,52	1,97	14,26	0,16	1,24	0,52	0,33	21,01	0,07	0,00	0,77	1,47
Storstrombroen-7uv(21)	8	OH	0,25	0,21	1,84	12,19	0,12	2,45	0,47	0,05	22,91	0,06	0,13	0,42	1,88
Storstrombroen-7uv(22)	9	OH	0,22	0,43	2,15	12,69	0,09	1,48	1,22	0,08	23,19	0,06	0,00	0,51	1,83
Storstrombroen-7uv(23)	10	OH	0,12	0,77	1,97	13,13	0,17	1,14	1,41	0,18	21,99	0,27	0,07	0,87	1,67
Storstrombroen-7uv(24)	11	OH	0,00	0,26	2,48	12,99	0,08	1,13	0,98	0,08	23,51	0,00	0,01	0,55	1,81
Storstrombroen-7uv(25)	13,5	OH	0,33	0,25	3,13	11,50	0,04	1,17	1,66	0,14	24,46	0,00	0,12	0,32	2,13
Storstrombroen-7uv(26)	15	OH	0,25	0,52	2,61	12,32	0,10	0,68	1,48	0,08	24,23	0,06	0,00	0,71	1,97
Storstrombroen-7uv(27)	17,5	OH	0,28	0,26	1,07	14,27	0,16	0,54	0,74	0,15	24,45	0,00	0,00	0,40	1,71
Storstrombroen-7uv(28)	20	OH	0,06	0,34	1,11	13,96	0,13	0,77	1,07	0,23	24,26	0,02	0,04	0,41	1,74
Storstrombroen-7uv(29)	25	OH	0,13	0,28	0,77	14,76	0,14	0,38	1,49	0,09	24,39	0,02	0,00	0,24	1,65
Storstrombroen-7uv(30)	30	OH	0,14	0,64	1,19	13,59	0,11	0,39	0,50	0,28	25,11	0,01	0,04	0,61	1,85
Storstrombroen-7uv(31)	33	OH	0,00	0,28	2,08	12,52	0,00	0,41	2,01	0,10	25,99	0,00	0,00	0,36	2,08
Average															2,65
Average uden Mg zone															1,74

Info		**Comments**
Cement type	CEM I 42,5 SR	4 cores taken in 2011
Fly ash	-	Core F16-17 above water
Microsilica	X	Core H23 above water
Slag	-	Core J28 below water
W/C, apparent		
Air %		Cement type: Swedish
		Section No: 7090

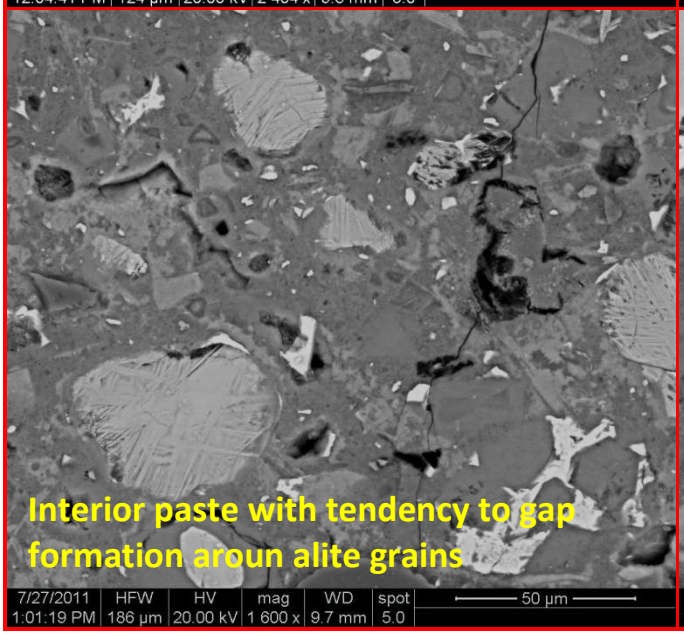
No optical polarizing microscopy has been performed by DTI

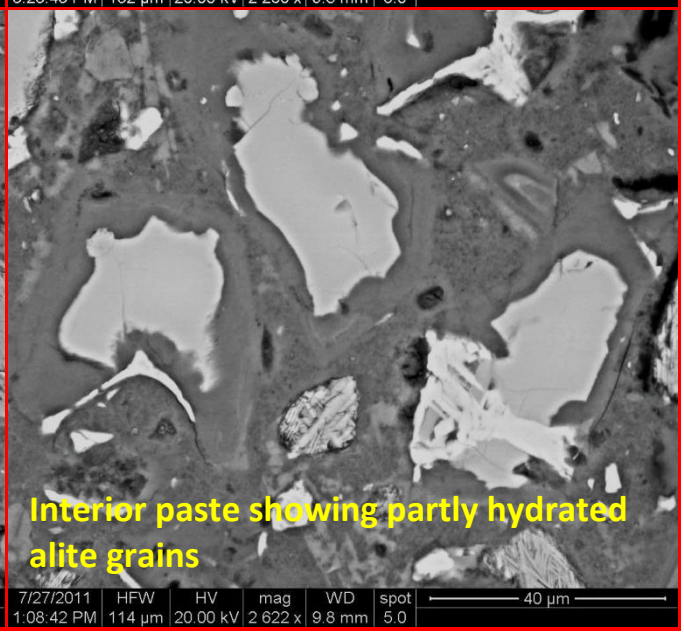

Relatively plane, intact surface. Zoned
7/27/2011 9:09:43 AM | HFW 1.49 mm | HV 20.00 kV | mag 200 x | WD 9.9 mm | spot 5.0 | 500 µm

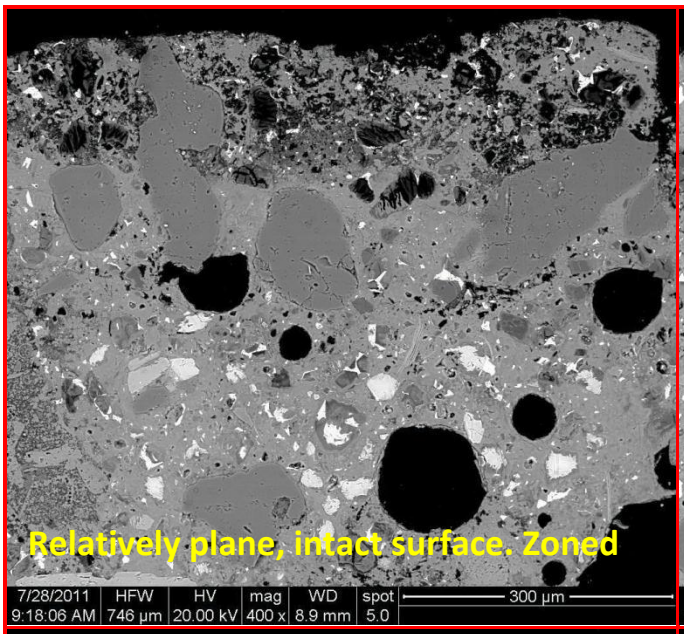

Outer part is porous, carbonated with some enrichment of Mg
7/27/2011 11:22:19 AM | HFW 299 µm | HV 20.00 kV | mag 999 x | WD 9.8 mm | spot 5.0 | 100 µm

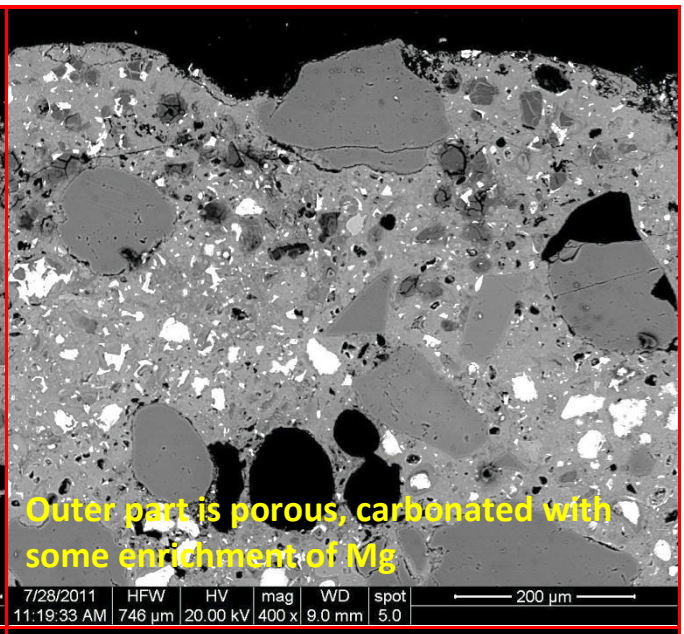

Dense carbonated zone with partly carbonated former cement grains
7/27/2011 12:04:41 PM | HFW 124 µm | HV 20.00 kV | mag 2 404 x | WD 9.8 mm | spot 5.0 | 40 µm

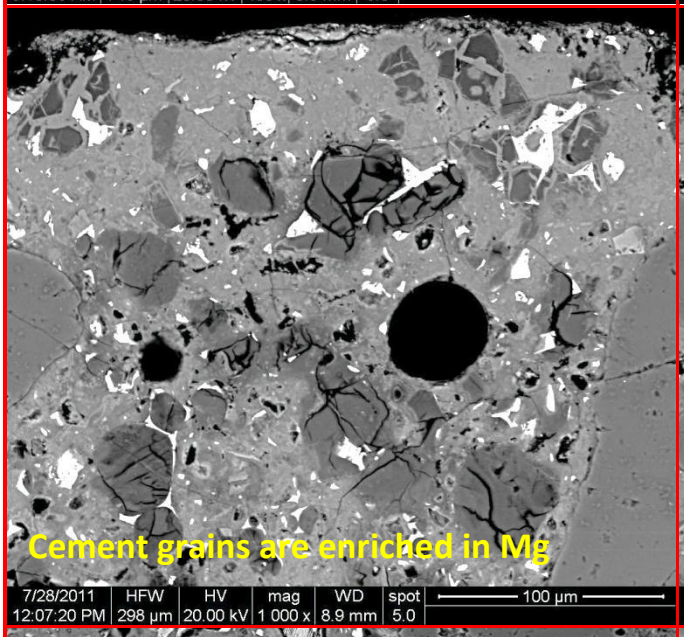
Interface between Mg and S zone
7/27/2011 3:23:43 PM | HFW 132 µm | HV 20.00 kV | mag 2 260 x | WD 9.8 mm | spot 5.0 | 50 µm

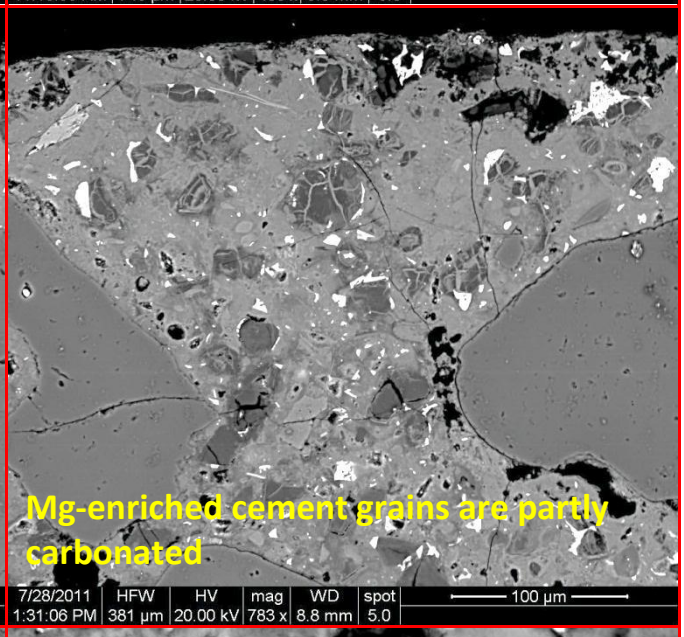

Interior paste with tendency to gap formation aroun alite grains
7/27/2011 1:01:19 PM | HFW 186 µm | HV 20.00 kV | mag 1 600 x | WD 9.7 mm | spot 5.0 | 50 µm

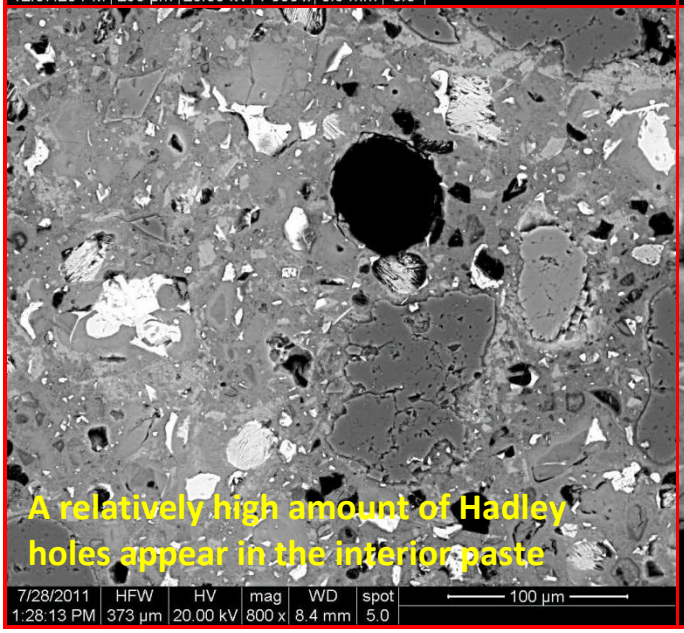

Interior paste showing partly hydrated alite grains
7/27/2011 1:08:42 PM | HFW 114 µm | HV 20.00 kV | mag 2 622 x | WD 9.8 mm | spot 5.0 | 40 µm


Relatively plane, intact surface. Zoned
7/28/2011 9:18:06 AM | HFW 746 µm | HV 20.00 kV | mag 400 x | WD 8.9 mm | spot 5.0 | 300 µm

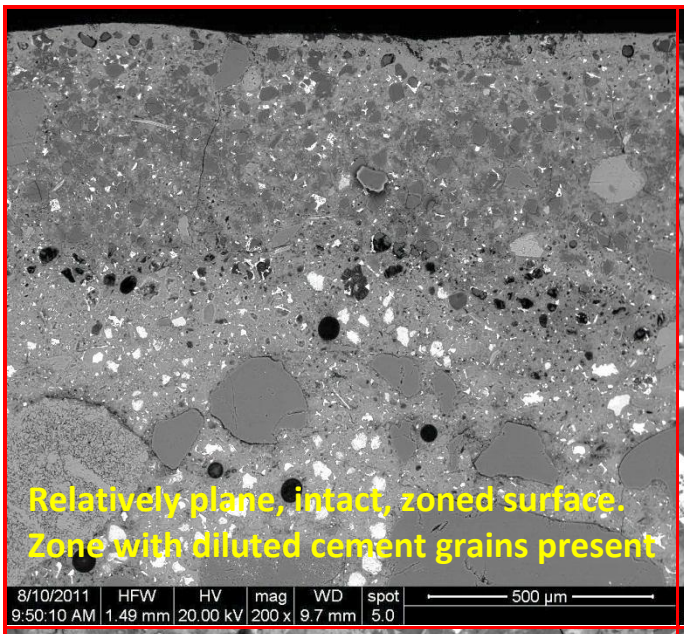

Outer part is porous, carbonated with some enrichment of Mg
7/28/2011 11:19:33 AM | HFW 746 µm | HV 20.00 kV | mag 400 x | WD 9.0 mm | spot 5.0 | 200 µm

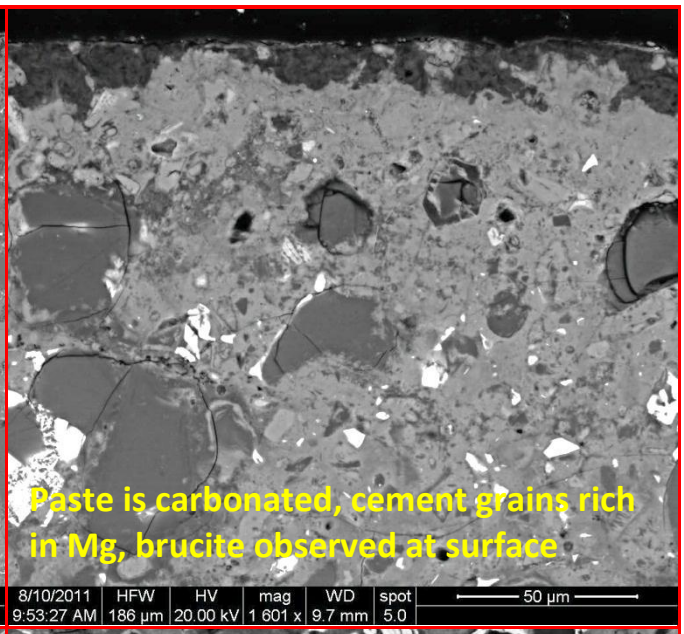

Cement grains are enriched in Mg
7/28/2011 12:07:20 PM | HFW 298 µm | HV 20.00 kV | mag 1 000 x | WD 8.9 mm | spot 5.0 | 100 µm

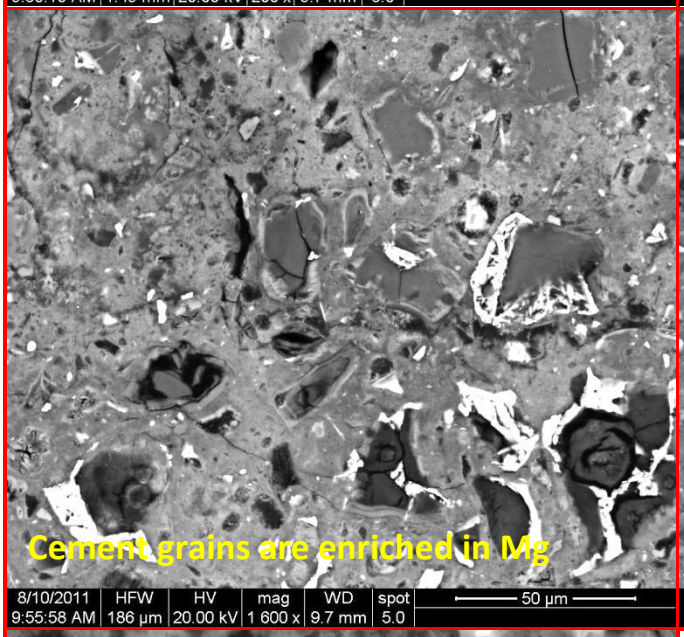

Mg-enriched cement grains are partly carbonated
7/28/2011 1:31:06 PM | HFW 381 µm | HV 20.00 kV | mag 783 x | WD 8.8 mm | spot 5.0 | 100 µm

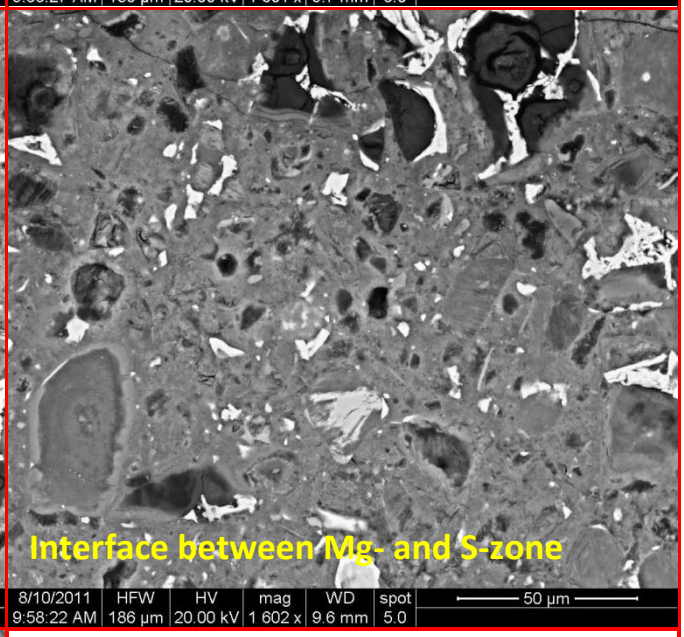

A relatively high amount of Hadley holes appear in the interior paste
7/28/2011 1:28:13 PM | HFW 373 µm | HV 20.00 kV | mag 800 x | WD 8.4 mm | spot 5.0 | 100 µm

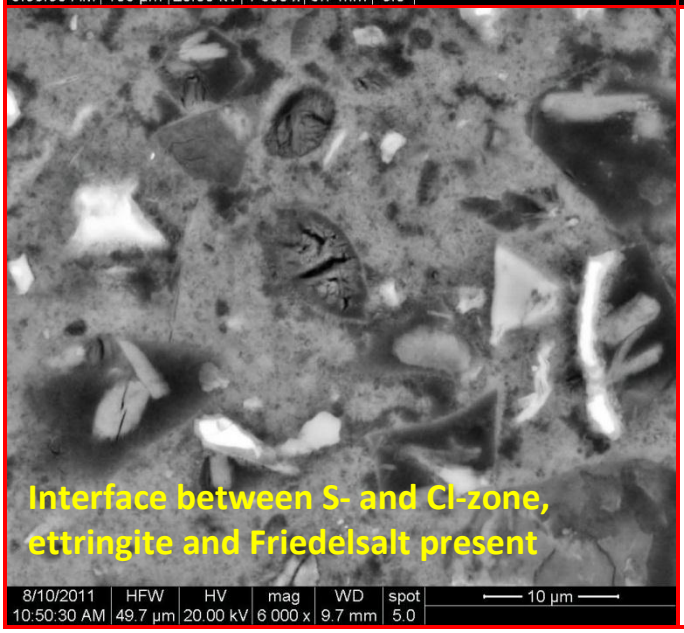
Cl-zone containing hydrated alite grains
7/28/2011 1:39:23 PM | HFW 70.3 µm | HV 20.00 kV | mag 4 243 x | WD 8.8 mm | spot 5.0 | 20 µm

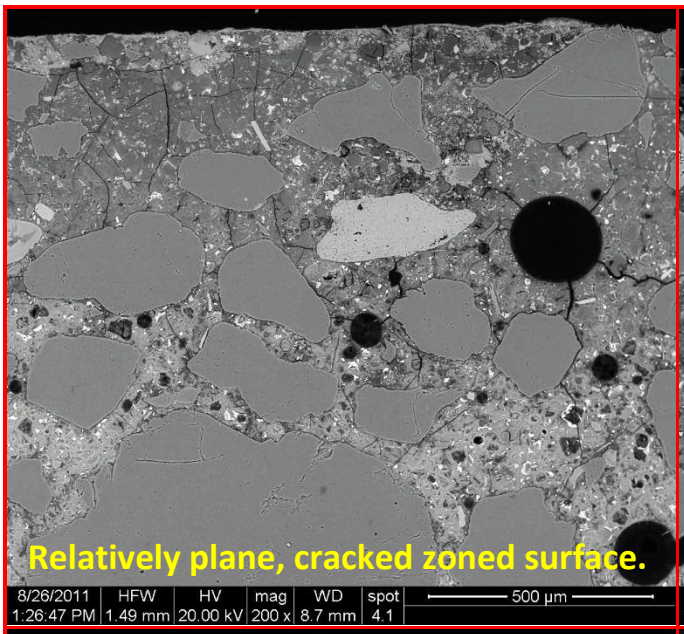

Relatively plane, intact, zoned surface.
Zone with diluted cement grains present
8/10/2011 9:50:10 AM | HFW 1.49 mm | HV 20.00 kV | mag 200 x | WD 9.7 mm | spot 5.0 | 500 µm

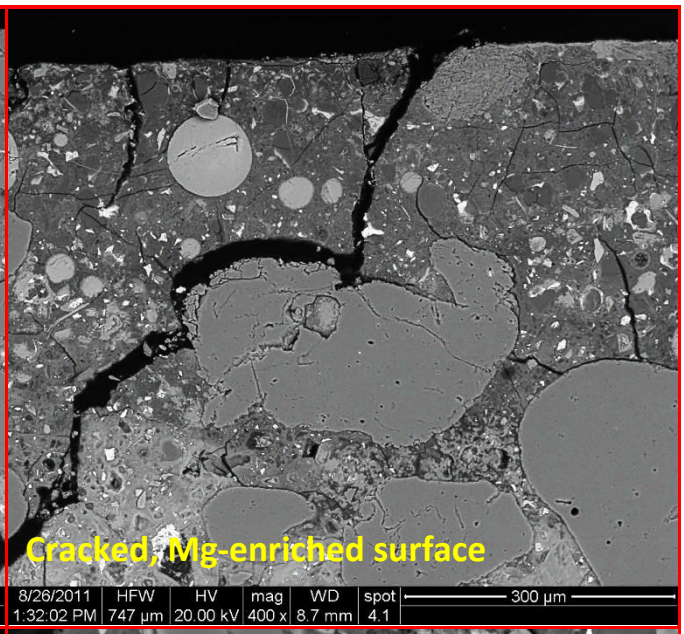

Paste is carbonated, cement grains rich
in Mg, brucite observed at surface
8/10/2011 9:53:27 AM | HFW 186 µm | HV 20.00 kV | mag 1 601 x | WD 9.7 mm | spot 5.0 | 50 µm

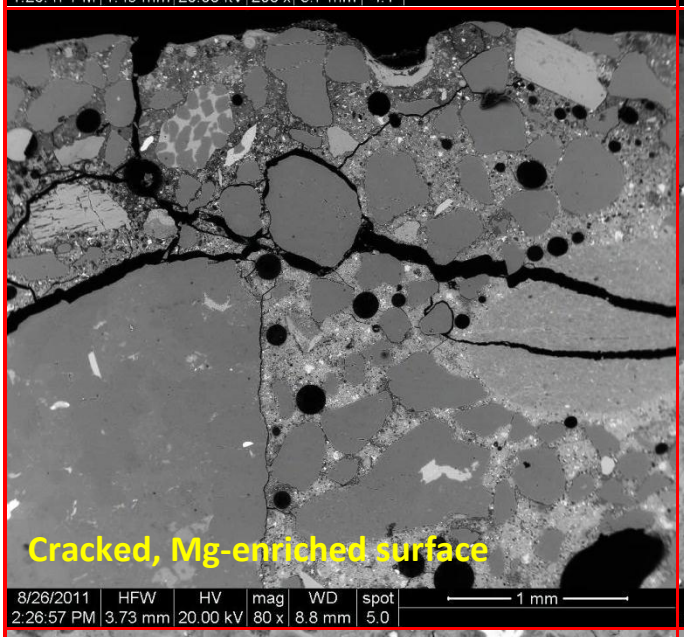

Cement grains are enriched in Mg
8/10/2011 9:55:58 AM | HFW 186 µm | HV 20.00 kV | mag 1 600 x | WD 9.7 mm | spot 5.0 | 50 µm

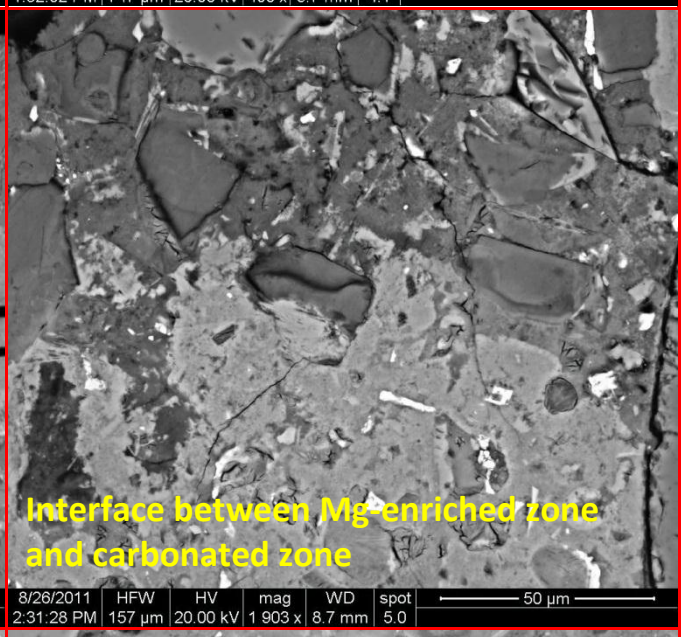

Interface between Mg- and S-zone
8/10/2011 9:58:22 AM | HFW 186 µm | HV 20.00 kV | mag 1 602 x | WD 9.6 mm | spot 5.0 | 50 µm

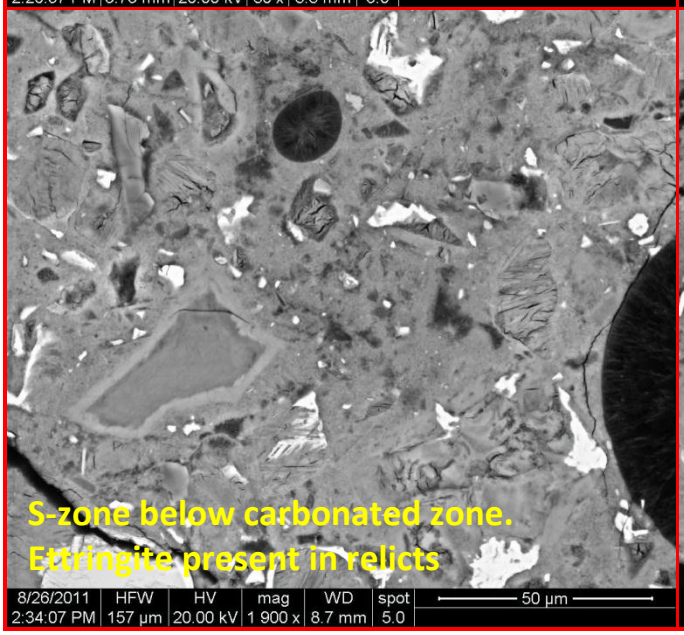

Interface between S- and Cl-zone,
ettringite and Friedelsalt present
8/10/2011 10:50:30 AM | HFW 49.7 µm | HV 20.00 kV | mag 6 000 x | WD 9.7 mm | spot 5.0 | 10 µm


Relatively plane, cracked zoned surface.
8/26/2011 1:26:47 PM | HFW 1.49 mm | HV 20.00 kV | mag 200 x | WD 8.7 mm | spot 4.1 | 500 µm


Cracked, Mg-enriched surface
8/26/2011 1:32:02 PM | HFW 747 µm | HV 20.00 kV | mag 400 x | WD 8.7 mm | spot 4.1 | 300 µm

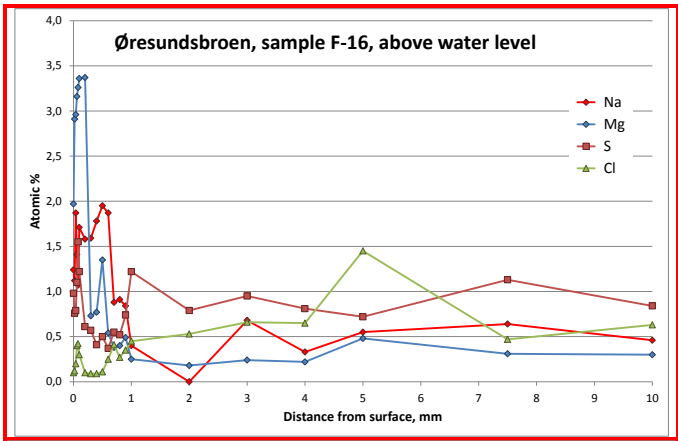

Cracked, Mg-enriched surface
8/26/2011 2:26:57 PM | HFW 3.73 mm | HV 20.00 kV | mag 80 x | WD 8.8 mm | spot 5.0 | 1 mm

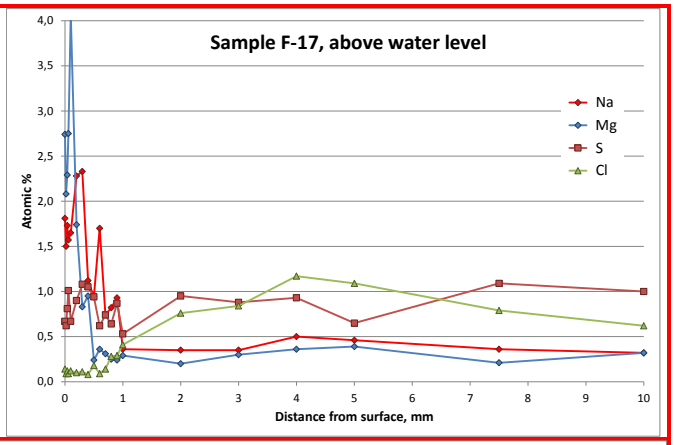

Interface between Mg-enriched zone and carbonated zone
8/26/2011 2:31:28 PM | HFW 157 µm | HV 20.00 kV | mag 1 903 x | WD 8.7 mm | spot 5.0 | 50 µm

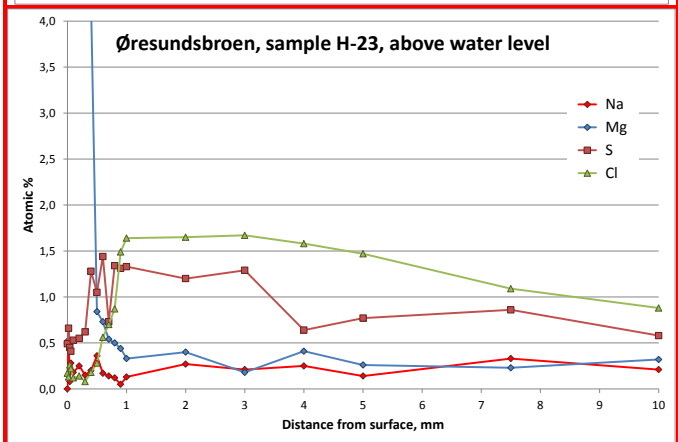

S-zone below carbonated zone.
Ettringite present in relicts
8/26/2011 2:34:07 PM | HFW 157 µm | HV 20.00 kV | mag 1 900 x | WD 8.7 mm | spot 5.0 | 50 µm

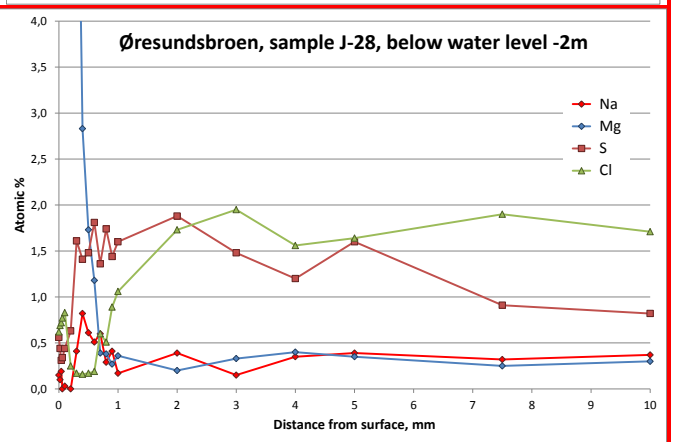
Interior paste with CH in air voids
8/26/2011 2:23:57 PM | HFW 157 µm | HV 20.00 kV | mag 1 901 x | WD 8.8 mm | spot 5.0 | 50 µm

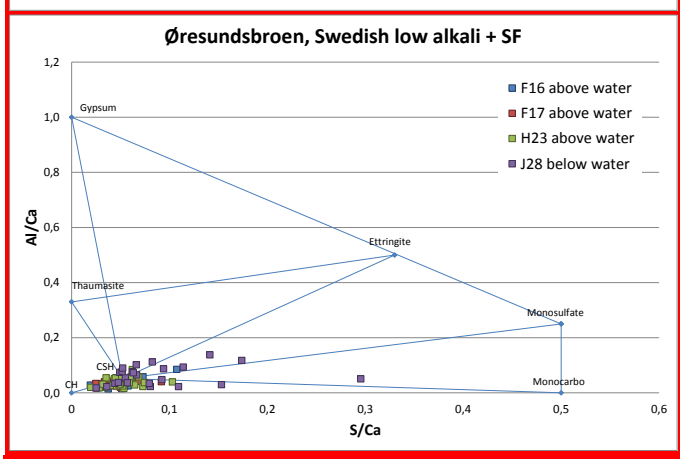
Øresundsbroen Caisson, above/below water Age: 1993-2000

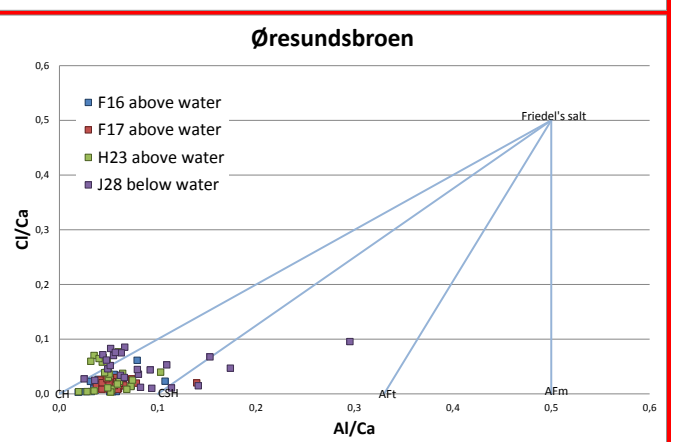


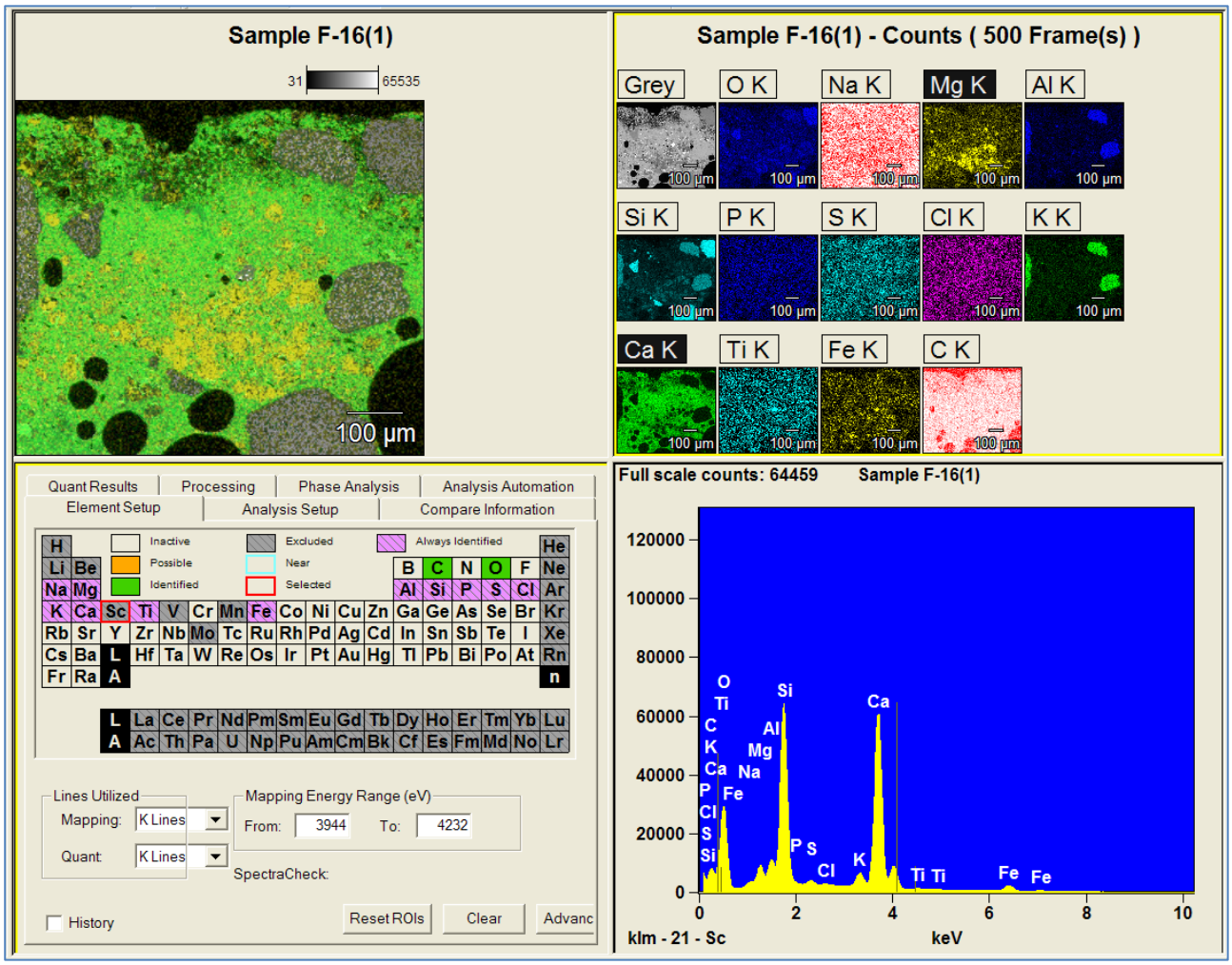






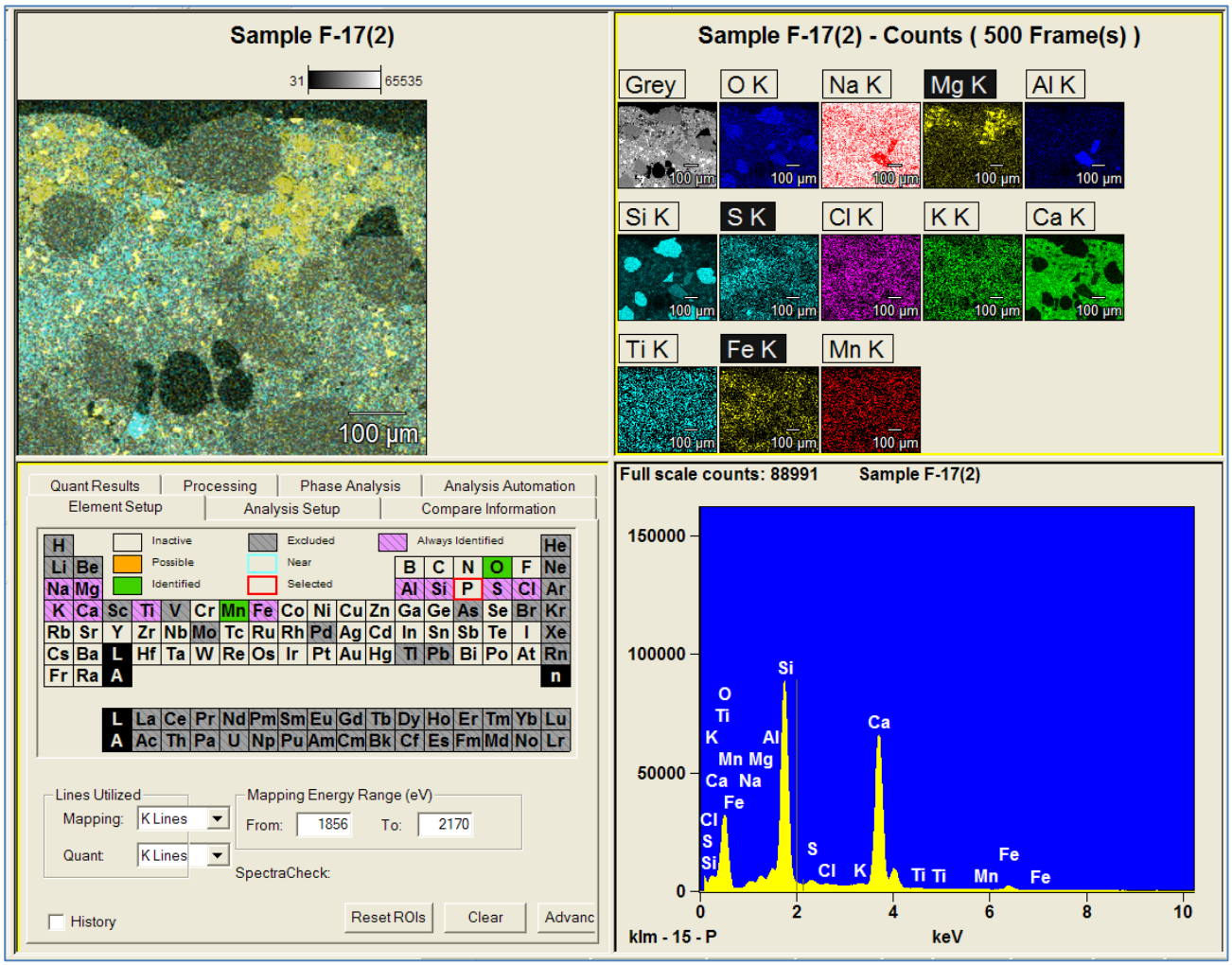






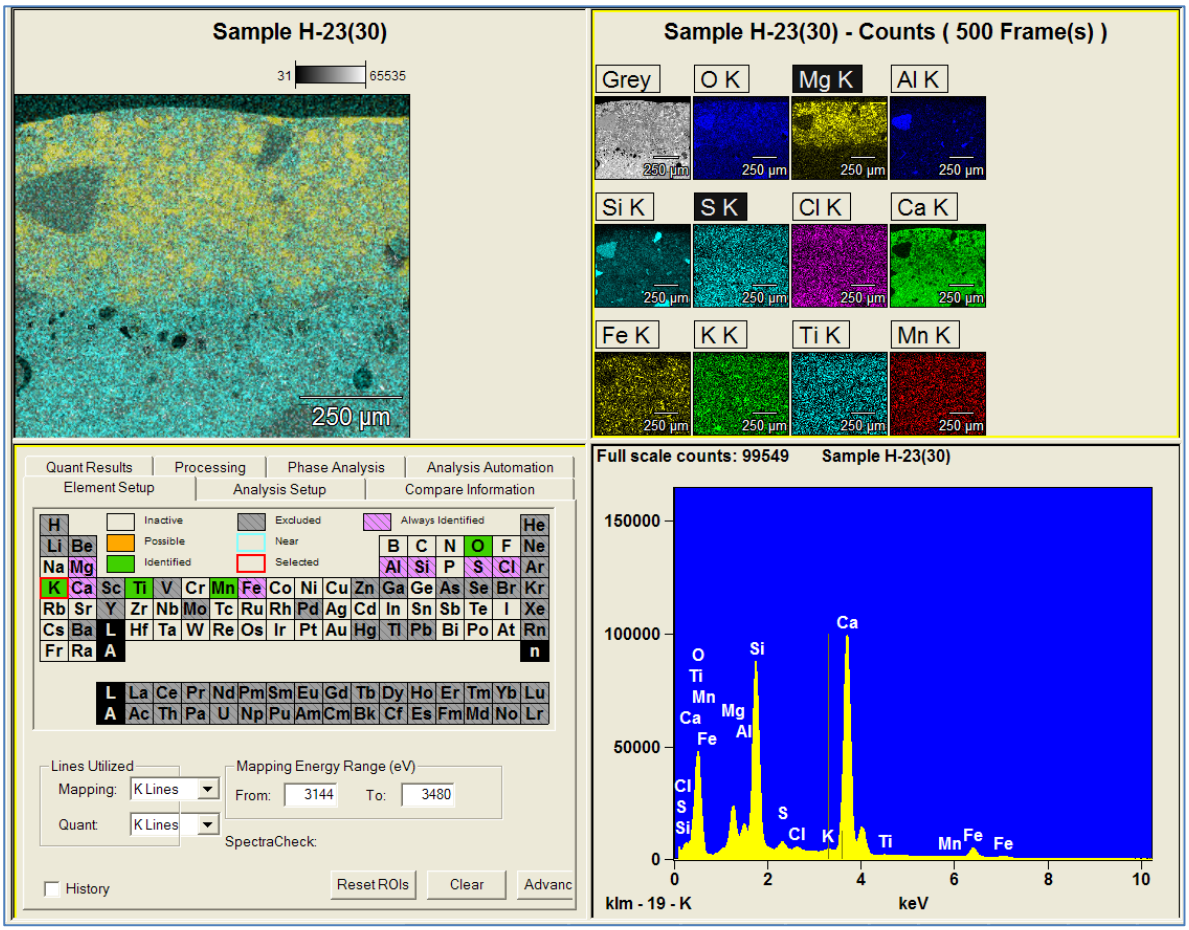
Phase distribution through the surface region of the concrete.

Øresund	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
SampleF-16travers(1)	0	OH	1,24	1,97	0,67	5,76	0,00	0,98	0,10	0,17	34,99	0,01		0,38	6,07
SampleF-16travers(2)	0,02	OH	1,12	2,91	0,98	8,15	0,08	0,76	0,12	0,26	30,08	0,01		0,62	3,69
SampleF-16travers(3)	0,04	OH	1,87	2,96	1,06	8,23	0,01	0,79	0,20	0,22	29,13	0,00		0,76	3,54
SampleF-16travers(4)	0,06	OH	1,41	3,16	1,56	10,38	0,02	1,10	0,40	0,35	23,94	0,03		1,25	2,31
SampleF-16travers(5)	0,08	OH	1,07	3,26	1,96	12,80	0,26	1,55	0,42	0,44	18,25	0,15		1,38	1,43
SampleF-16travers(6)	0,1	OH	1,71	3,36	1,53	12,11	0,08	1,22	0,30	0,31	20,97	0,08		0,98	1,73
SampleF-16travers(7)	0,2	OH	1,58	3,37	1,42	11,16	0,08	0,61	0,10	0,22	24,58	0,09		0,51	2,20
SampleF-16travers(8)	0,3	OH	1,59	0,73	1,25	13,81	0,00	0,57	0,09	0,44	23,10	0,06		0,87	1,67
SampleF-16travers(9)	0,4	OH	1,78	0,77	1,36	11,55	0,06	0,41	0,09	0,46	26,56	0,03		0,77	2,30
SampleF-16travers(10)	0,5	OH	1,95	1,35	0,74	10,58	0,08	0,50	0,11	0,26	28,23	0,00		0,64	2,67
SampleF-16travers(11)	0,6	OH	1,87	0,54	0,97	12,41	0,12	0,37	0,25	0,17	25,97	0,02		0,81	2,09
SampleF-16travers(12)	0,7	OH	0,88	0,38	0,98	16,17	0,07	0,55	0,41	0,09	21,34	0,05		0,46	1,32
SampleF-16travers(13)	0,8	OH	0,91	0,40	0,93	12,75	0,02	0,52	0,27	0,14	26,49	0,03		0,62	2,08
SampleF-16travers(14)	0,9	OH	0,84	0,49	1,18	13,49	0,00	0,74	0,35	0,18	24,36	0,05		0,75	1,81
SampleF-16travers(15)	1	OH	0,40	0,25	1,03	14,52	0,09	1,22	0,45	0,11	22,58	0,03		0,68	1,56
SampleF-16travers(16)	2	OH	0,00	0,18	0,74	15,21	0,01	0,79	0,53	0,11	23,45	0,04		0,50	1,54
SampleF-16travers(17)	3	OH	0,68	0,24	1,16	13,04	0,12	0,95	0,66	0,27	24,58	0,08		0,71	1,88
SampleF-16travers(18)	4	OH	0,33	0,22	0,97	13,78	0,06	0,81	0,65	0,16	24,62	0,00		0,70	1,79
SampleF-16travers(19)	5	OH	0,55	0,48	1,87	13,25	0,05	0,72	1,45	0,22	23,65	0,03		0,63	1,78
SampleF-16travers(20)	7,5	OH	0,64	0,31	1,20	15,29	0,06	1,13	0,47	0,28	20,50	0,12		1,03	1,34
SampleF-16travers(21)	10	OH	0,46	0,30	1,18	13,82	0,11	0,84	0,63	0,30	24,01	0,01		0,57	1,74
SampleF-16travers(22)	12,5	OH	0,14	0,25	1,27	14,38	0,03	1,01	0,81	0,10	22,82	0,11		0,75	1,59
SampleF-16travers(23)	15	OH	0,36	0,22	1,32	12,20	0,00	0,96	0,64	0,28	25,95	0,02		0,64	2,13
SampleF-16travers(24)	20	OH	0,23	0,20	1,23	13,01	0,05	0,98	0,57	0,17	25,15	0,04		0,72	1,93
SampleF-16travers(25)	30	OH	0,31	0,70	1,24	13,26	0,03	1,05	0,37	0,19	24,11	0,07		0,76	1,82
Average			0,96	1,16	1,19	12,44	0,06	0,85	0,42	0,24	24,78	0,05		0,74	2,16
Average excl. Mg zone															1,76



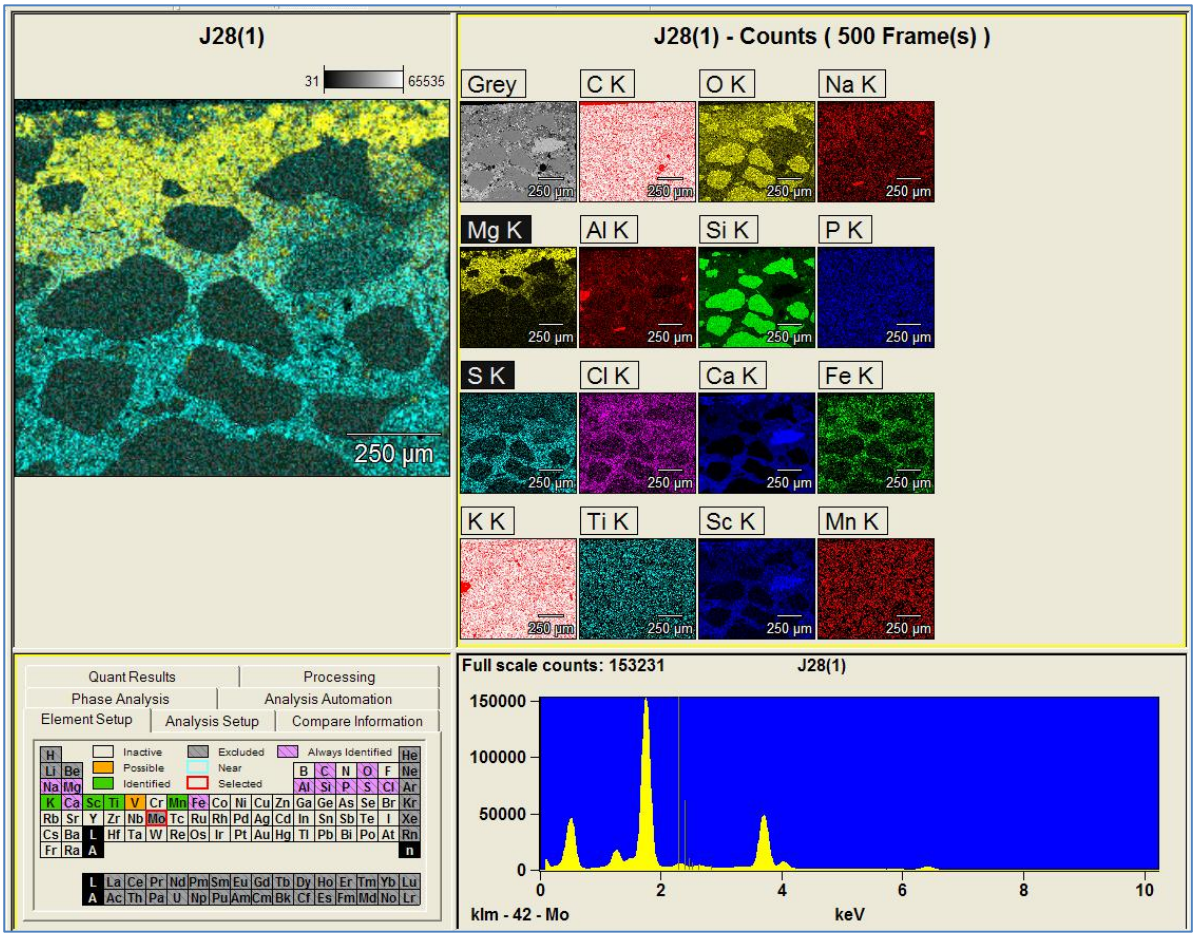
Phase distribution through the surface region of the concrete.

Øresund	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
SampleF-17-traverse(1)	0	OH	1,81	2,74	0,82	6,68		0,67	0,14	0,27	32,62	0,00		0,49	4,88
SampleF-17-traverse(2)	0,02	OH	1,50	2,08	0,82	6,75		0,62	0,09	0,27	33,30	0,01		0,67	4,93
SampleF-17-traverse(3)	0,04	OH	1,73	2,29	0,81	8,59		0,81	0,12	0,30	29,97	0,00		0,51	3,49
SampleF-17-traverse(4)	0,06	OH	1,57	2,75	0,74	8,28		1,01	0,09	0,27	29,74	0,02		0,56	3,59
SampleF-17-traverse(5)	0,1	OH	1,65	4,07	1,05	11,08		0,67	0,12	0,35	24,17	0,02		0,72	2,18
SampleF-17-traverse(6)	0,2	OH	2,28	1,74	2,04	12,27		0,90	0,10	0,68	22,26	0,03		0,74	1,81
SampleF-17-traverse(7)	0,3	OH	2,33	0,83	1,38	13,52		1,08	0,11	0,29	21,41	0,08		1,15	1,58
SampleF-17-traverse(8)	0,4	OH	1,12	0,95	0,89	11,55		1,05	0,08	0,39	26,48	0,03		0,64	2,29
SampleF-17-traverse(9)	0,5	OH	0,94	0,24	1,12	13,09		0,94	0,18	0,22	24,69	0,00		0,95	1,89
SampleF-17-traverse(10)	0,6	OH	1,70	0,36	1,08	13,34		0,62	0,09	0,30	24,38	0,07		0,81	1,83
SampleF-17-traverse(11)	0,7	OH	0,74	0,31	0,87	13,20		0,74	0,14	0,13	25,74	0,05		0,64	1,95
SampleF-17-traverse(12)	0,8	OH	0,82	0,25	0,93	12,55		0,64	0,28	0,18	26,79	0,00		0,64	2,13
SampleF-17-traverse(13)	0,9	OH	0,93	0,24	0,90	11,15		0,87	0,29	0,08	28,49	0,07		0,54	2,56
SampleF-17-traverse(14)	1	OH	0,36	0,29	1,27	13,28		0,53	0,41	0,26	25,51	0,06		0,69	1,92
SampleF-17-traverse(15)	2	OH	0,35	0,20	1,06	14,56		0,95	0,76	0,21	23,20	0,02		0,56	1,59
SampleF-17-traverse(16)	3	OH	0,35	0,30	1,08	13,03		0,88	0,84	0,17	25,44	0,00		0,63	1,95
SampleF-17-traverse(17)	4	OH	0,50	0,36	0,88	14,47		0,93	1,17	0,13	23,23	0,04		0,51	1,61
SampleF-17-traverse(18)	5	OH	0,46	0,39	0,87	13,68		0,65	1,09	0,20	24,73	0,11		0,61	1,81
SampleF-17-traverse(19)	7,5	OH	0,36	0,21	1,24	13,48		1,09	0,79	0,23	23,56	0,09		1,04	1,75
SampleF-17-traverse(20)	10	OH	0,32	0,32	1,23	11,47		1,00	0,62	0,33	27,41	0,05		0,52	2,39
SampleF-17-traverse(21)	12,5	OH	0,61	0,25	1,71	12,30		1,03	0,94	0,25	25,00	0,02		0,76	2,03
SampleF-17-traverse(22)	15	OH	0,51	0,44	1,06	13,10		1,04	0,59	0,20	24,58	0,07		0,79	1,88
SampleF-17-traverse(23)	20	OH	0,66	0,26	1,02	14,22		0,84	0,57	0,20	23,78	0,03		0,55	1,67
SampleF-17-traverse(24)	30	OH	0,32	0,29	1,17	13,69		0,83	0,23	0,13	24,73	0,03		0,67	1,81
Average			1,00	0,92	1,09	12,06		0,85	0,41	0,25	25,88	0,04		0,68	2,31
Average excl. Mg zone															1,92



Phase distribution through the surface region of the concrete.

Øresund	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
Sample H-23(1)	0	OH	0,00	38,26	0,36	2,46	0,10	0,49	0,17	0,06	5,81	0,00	0,00	0,33	2,36
Sample H-23(2)	0,02	OH	0,53	6,53	0,66	3,77	0,13	0,66	0,13	0,14	33,63	0,10	0,00	0,87	8,92
Sample H-23(3)	0,04	OH	0,08	11,68	1,43	9,69	0,16	0,45	0,26	0,12	19,63	0,04	0,00	0,63	2,03
Sample H-23(4)	0,06	OH	0,28	9,41	1,36	7,39	0,14	0,41	0,22	0,06	25,46	0,00	0,04	0,71	3,45
Sample H-23(5)	0,1	OH	0,18	5,91	0,83	7,56	0,06	0,53	0,12	0,04	29,47	0,00	0,06	0,63	3,90
Sample H-23(6)	0,2	OH	0,25	6,32	0,95	8,39	0,12	0,55	0,14	0,09	26,86	0,07	0,05	1,01	3,20
Sample H-23(7)	0,3	OH	0,15	5,98	1,29	9,87	0,06	0,62	0,08	0,13	24,68	0,01	0,04	1,01	2,50
Sample H-23(8)	0,4	OH	0,20	4,20	1,52	11,20	0,18	1,28	0,18	0,14	22,15	0,06	0,05	1,19	1,98
Sample H-23(9)	0,5	OH	0,36	0,84	1,28	11,77	0,07	1,05	0,28	0,11	26,01	0,00	0,07	0,84	2,21
Sample H-23(10)	0,6	OH	0,17	0,73	1,51	11,91	0,10	1,44	0,56	0,07	24,78	0,03	0,02	0,92	2,08
Sample H-23(11)	0,7	OH	0,14	0,54	1,17	14,23	0,09	0,73	0,70	0,05	23,51	0,08	0,12	0,63	1,65
Sample H-23(12)	0,8	OH	0,12	0,50	1,22	12,88	0,00	1,34	0,87	0,24	24,11	0,08	0,06	0,78	1,87
Sample H-23(13)	0,9	OH	0,05	0,44	1,12	11,86	0,02	1,31	1,49	0,11	25,72	0,06	0,03	0,81	2,17
Sample H-23(14)	1	OH	0,13	0,33	1,11	12,38	0,06	1,33	1,64	0,09	24,83	0,02	0,03	0,84	2,01
Sample H-23(15)	2	OH	0,27	0,40	1,29	14,47	0,03	1,20	1,65	0,05	21,56	0,05	0,05	0,88	1,49
Sample H-23(16)	3	OH	0,21	0,18	0,84	13,36	0,10	1,29	1,67	0,11	23,86	0,03	0,00	0,74	1,79
Sample H-23(17)	4	OH	0,25	0,41	0,99	13,79	0,03	0,64	1,58	0,05	24,51	0,03	0,04	0,58	1,78
Sample H-23(18)	5	OH	0,14	0,26	0,79	13,90	0,01	0,77	1,47	0,09	24,70	0,05	0,00	0,53	1,78
Sample H-23(19)	7,5	OH	0,33	0,23	1,17	13,93	0,07	0,86	1,09	0,11	23,55	0,06	0,06	0,76	1,69
Sample H-23(20)	10	OH	0,21	0,32	1,05	14,99	0,07	0,58	0,88	0,22	22,84	0,06	0,05	0,68	1,52
Sample H-23(21)	12,5	OH	0,94	0,28	2,36	12,94	0,08	0,91	0,91	0,18	22,93	0,01	0,02	0,90	1,77
Sample H-23(22)	15	OH	0,35	0,22	1,13	14,57	0,03	0,69	1,35	0,19	23,29	0,04	0,09	0,45	1,60
Sample H-23(23)	20	OH	0,68	0,37	1,53	12,86	0,06	0,68	0,89	0,30	23,75	0,08	0,02	1,52	1,85
Sample H-23(24)	30	OH	0,73	0,19	1,29	15,17	0,00	0,80	0,39	0,22	21,88	0,12	0,05	0,65	1,44
Sample H-23(25)	32	OH	0,75	0,57	1,69	13,49	0,00	0,85	0,57	0,17	22,73	0,09	0,02	1,22	1,68
Average			0,30	3,80	1,20	11,55	0,07	0,86	0,77	0,13	23,69	0,05	0,04	0,80	2,35
Average excl. Mg zone															1,79

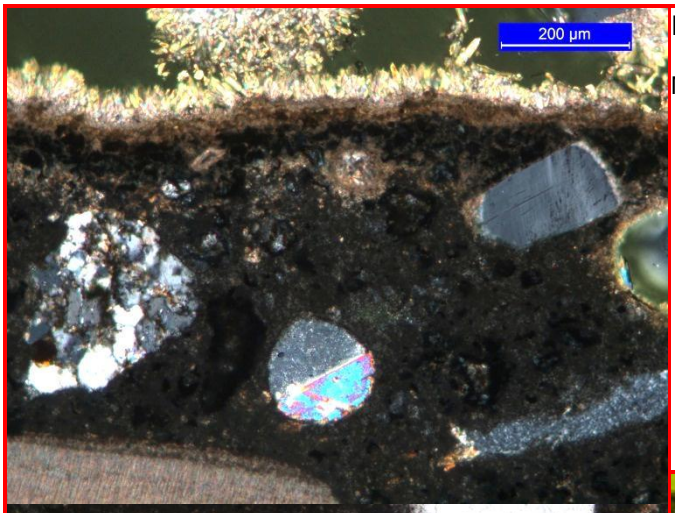


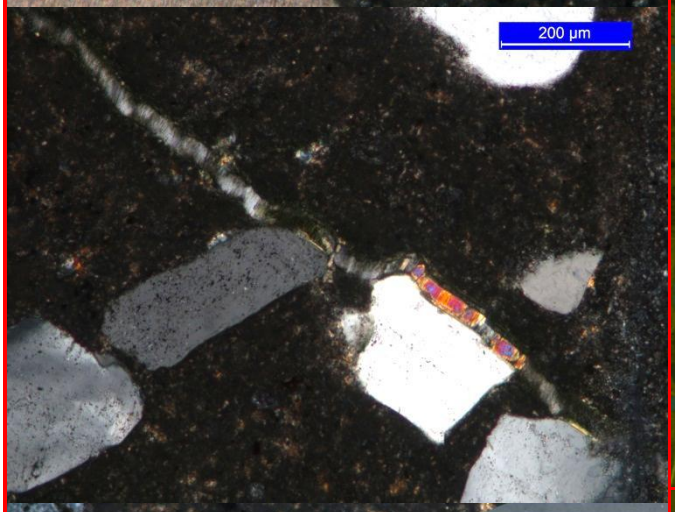
Phase distribution through the surface region of the concrete.

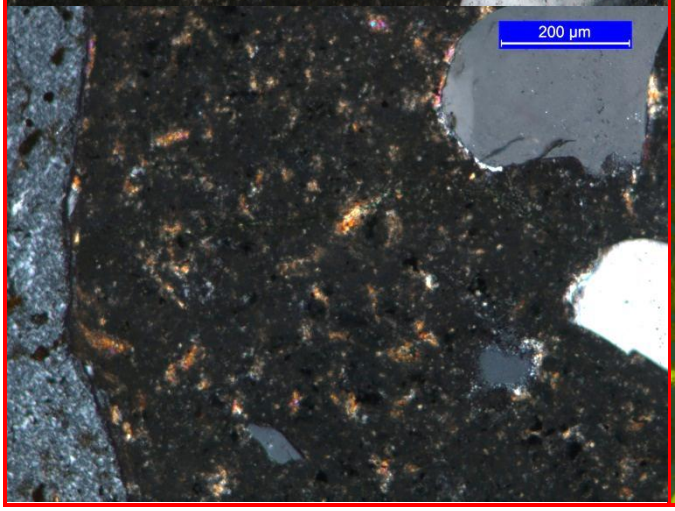
Øresund	Dist	Phase	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	C/S
Sample J-28(1)	0	OH	0,15	10,56	0,91	5,44	0,09	0,56	0,62	0,07	25,25	0,22	0,20	1,99	4,64
Sample J-28(2)	0,02	OH	0,10	13,51	1,55	8,17	0,01	0,44	0,69	0,08	19,27		0,06	1,30	2,36
Sample J-28(3)	0,04	OH	0,19	15,81	1,49	10,67	0,07	0,31	0,72	0,08	13,64		0,00	1,05	1,28
Sample J-28(4)	0,06	OH	0,00	16,73	1,75	11,40	0,11	0,34	0,77	0,12	11,43		0,03	0,92	1,00
Sample J-28(5)	0,1	OH	0,03	17,16	2,57	12,16	0,15	0,44	0,83	0,07	8,70		0,04	0,74	0,72
Sample J-28(6)	0,2	OH	0,00	14,42	0,93	17,62	0,07	0,63	0,25	0,17	5,35		0,07	0,67	0,30
Sample J-28(7)	0,3	OH	0,41	7,19	1,65	15,84	0,12	1,61	0,17	0,20	11,68		0,12	0,97	0,74
Sample J-28(8)	0,4	OH	0,82	2,83	1,72	16,28	0,07	1,41	0,16	0,36	15,09		0,08	1,21	0,93
Sample J-28(9)	0,5	OH	0,61	1,73	1,60	15,92	0,07	1,48	0,17	0,38	17,03		0,13	1,06	1,07
Sample J-28(10)	0,6	OH	0,51	1,18	1,33	16,84	0,08	1,81	0,19	0,33	16,13		0,01	0,99	0,96
Sample J-28(11)	0,7	OH	0,60	0,39	1,10	17,16	0,06	1,36	0,60	0,17	17,70		0,00	0,82	1,03
Sample J-28(12)	0,8	OH	0,29	0,38	1,13	17,38	0,09	1,74	0,51	0,10	17,11		0,05	0,61	0,98
Sample J-28(13)	0,9	OH	0,41	0,27	0,96	16,15	0,01	1,44	0,89	0,08	19,47		0,05	0,81	1,21
Sample J-28(14)	1	OH	0,17	0,36	1,06	14,93	0,04	1,60	1,06	0,13	20,51		0,11	1,02	1,37
Sample J-28(15)	2	OH	0,39	0,20	1,09	14,35	0,05	1,88	1,73	0,11	20,89		0,06	0,64	1,46
Sample J-28(16)	3	OH	0,15	0,33	1,52	13,05	0,02	1,48	1,95	0,12	22,86		0,03	0,91	1,75
Sample J-28(17)	4	OH	0,35	0,40	1,23	13,97	0,06	1,20	1,56	0,12	22,36		0,05	0,82	1,60
Sample J-28(18)	5	OH	0,39	0,35	1,38	13,47	0,04	1,60	1,64	0,06	21,91	0,11	0,00	0,97	1,63
Sample J-28(19)	7,5	OH	0,32	0,25	1,43	12,49	0,02	0,91	1,90	0,14	25,11	0,08	0,10	0,56	2,01
Sample J-28(20)	10	OH	0,37	0,30	1,06	13,64	0,04	0,82	1,71	0,18	23,95		0,03	0,74	1,76
Sample J-28(21)	12,5	OH	0,39	0,27	1,17	13,08	0,05	0,92	1,51	0,33	24,50		0,05	0,66	1,87
Sample J-28(22)	15	OH	0,48	0,38	0,79	9,33	0,06	0,56	0,86	0,10	31,50		0,01	0,84	3,38
Sample J-28(23)	20	OH	0,91	0,29	1,99	13,56	0,04	1,03	0,94	0,68	21,56	0,14	0,04	0,97	1,59
Sample J-28(24)	30	OH	0,53	0,22	1,86	13,58	0,00	0,81	1,04	0,54	23,45		0,06	0,48	1,73
Average			0,36	4,40	1,39	13,60	0,06	1,10	0,94	0,20	19,02	0,14	0,06	0,91	1,56
Average excl. Mg zone															1,67

Vilsundbroen **Pillar, sea floor** **Age: 1937-39**

Info		Comments
Cement type	?	Core taken in 1995
Fly ash	-	
Microsilica	-	Pillar found on bottom of fjord
Slag	X	ASR
W/C, apparent	0.30	
Air %	1	
		UHJ section (rap188)



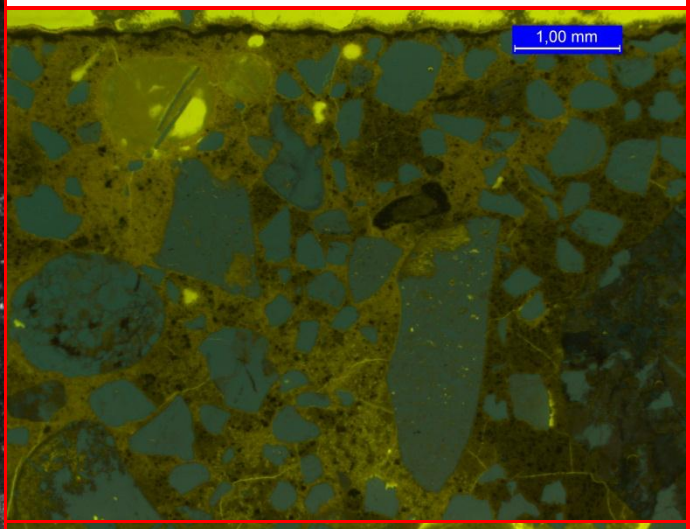


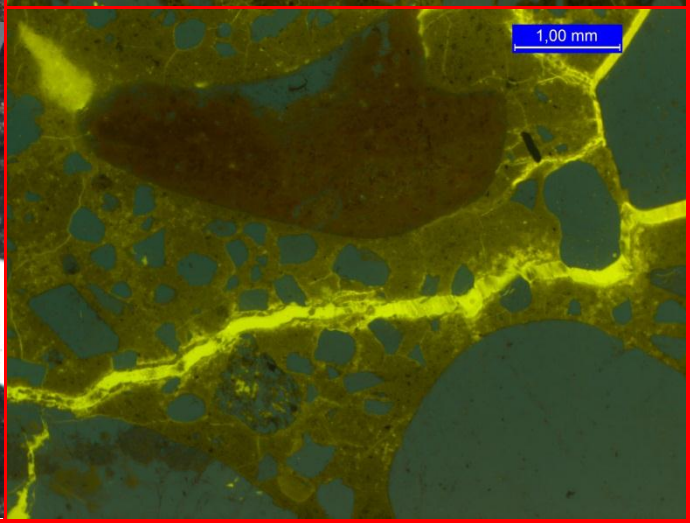


Micro-observations

Micro-structural zoning through concrete:

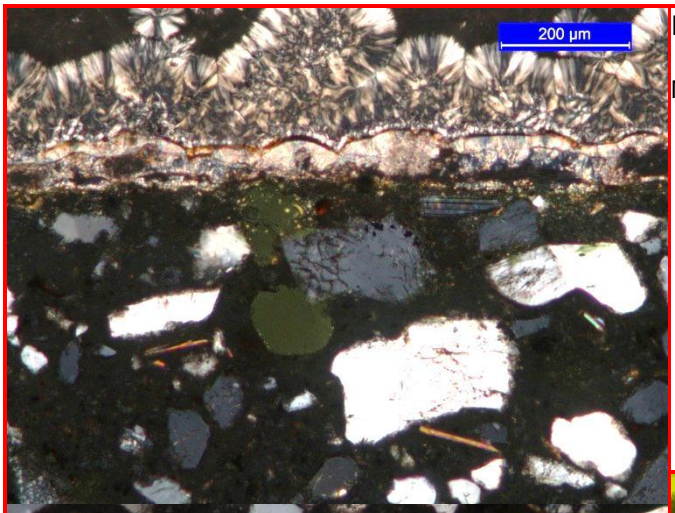
1. Surface is intact and covered by a crust of fine sand cemented together by calcite.
2. 0-0.8mm: Thin carbonated zone
3. 0.8-0.4 (5)mm: Leached paste without CH; deepest where fine surface cracks appear. Increased porosity.
4. 5-45mm: Paste containing well distributed CH. CH is filling air voids. The concrete is heavily cracked from ASR; gel, CH and ettringite are present in cracks.

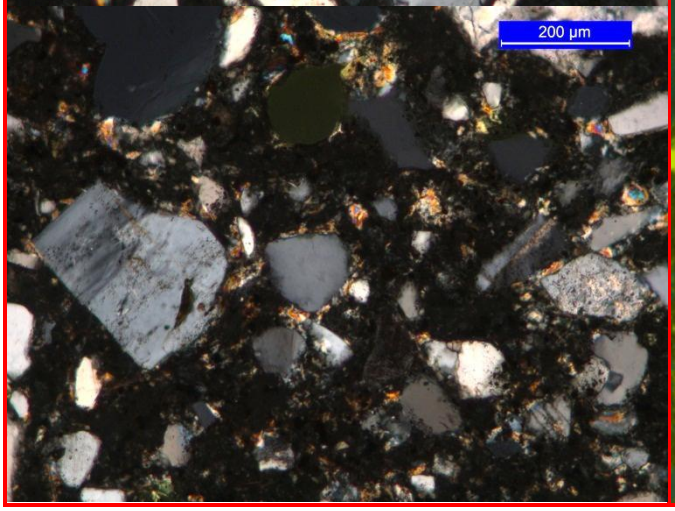




Vilsundbroen **Pillar, submersed** **Age: 1937-39**

Info		Comments
Cement type	PC (R)	Core taken in 1995
Fly ash	-	Concrete mix 1:2:3
Microsilica	-	Local aggregate with porous flint
Slag	-	
W/C, apparent	0.35	
Air %	<1	
		UHJ section (rap137)

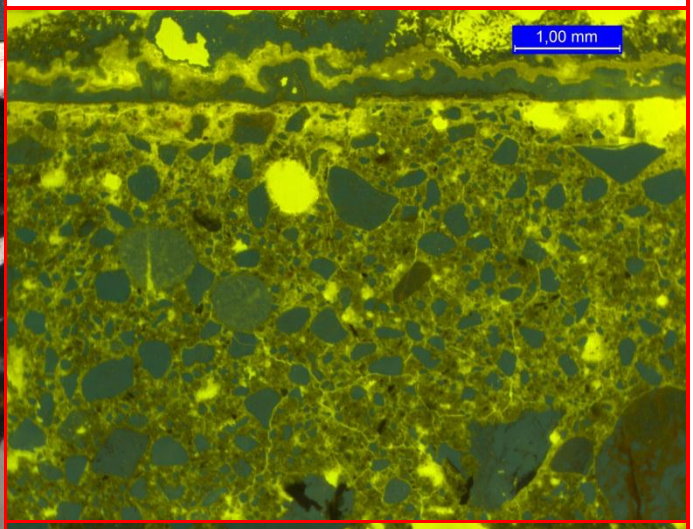


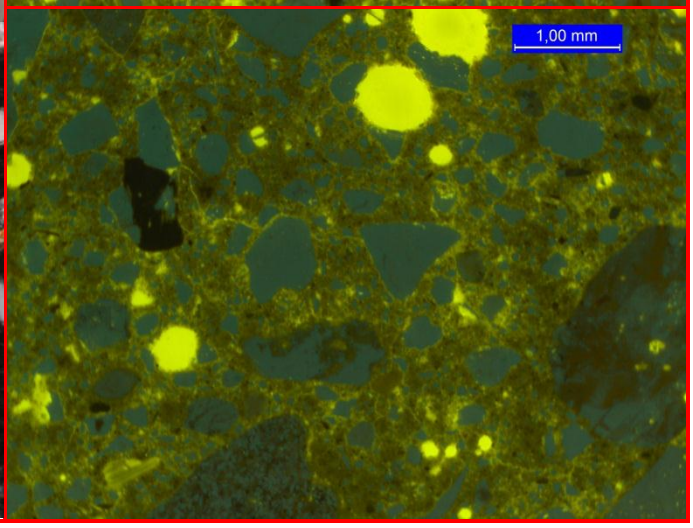


Micro-observations

Micro-structural zoning through concrete:

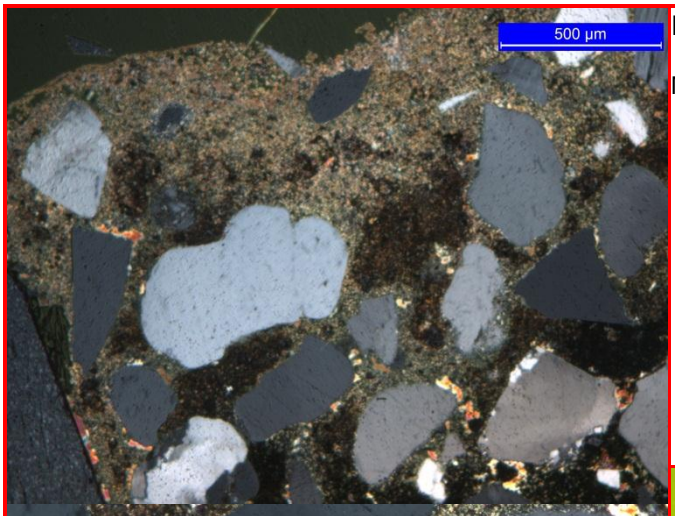
1. Surface is intact and covered by a layer of alternating calcite and brucite, $Mg(OH)_2$
2. 0-28mm: Leached porous paste with ettringite/brucite/thaumasite in air voids. Increased paste porosity. Some micro cracking of paste.
3. 28-45mm: Paste containing very large CH crystals in voids spaces and air voids.

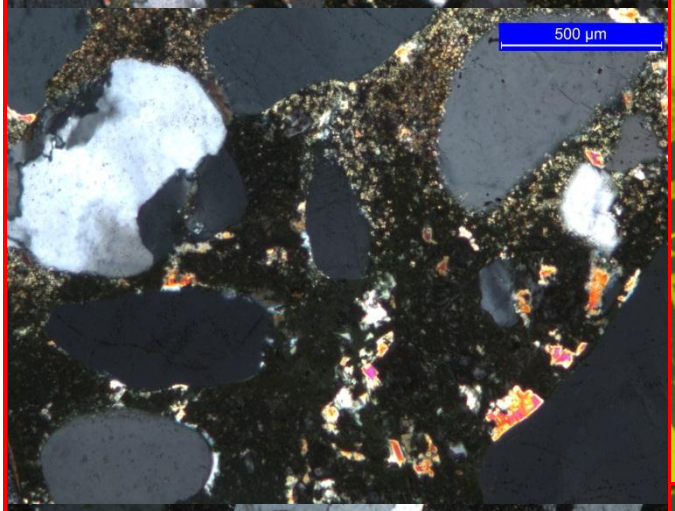




Oddesundbroen **Pylon, above sea level, behind granite** **Age: 1934-38**

Info		Comments
Cement type	PC (A)	Core taken in 1992
Fly ash	-	Na_2O of cement: 0.6-0.8
Microsilica	-	Concrete mix 1:2:3
Slag	-	Local aggregate with porous flint
W/C, apparent	0.40-0.60	
Air %	<1	
		UHJ section (rap108)

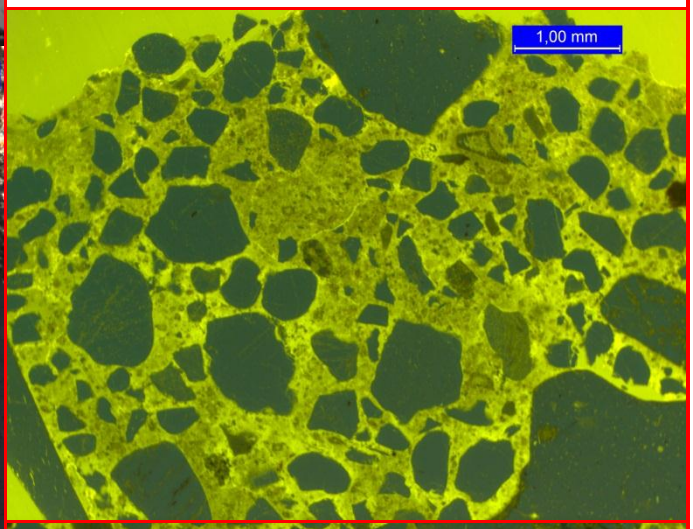


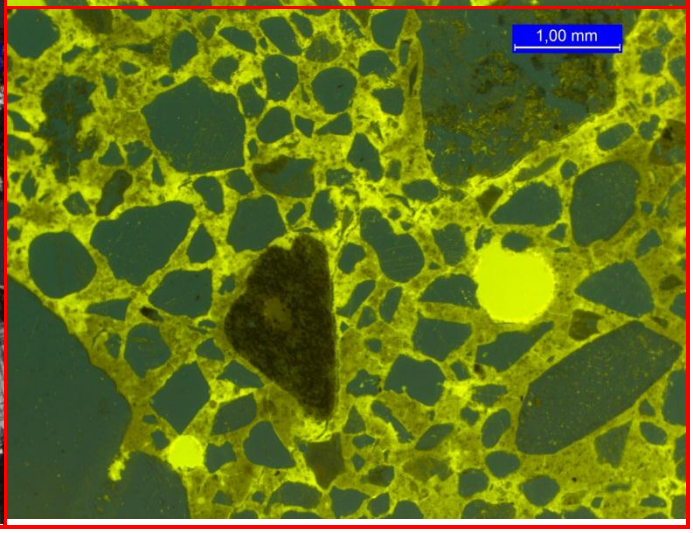


Micro-observations

Micro-structural zoning through concrete:

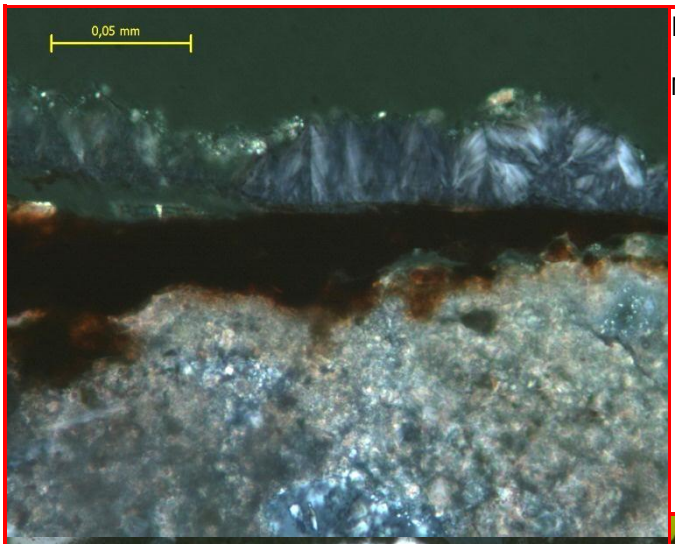
1. Surface is deteriorated and not intact
2. 0-0.8mm: Weak popcorn carbonation
3. 0.8-45mm: Leached paste containing very large CH crystals in voids spaces, air voids and fine paste cracks. Highly porous zones penetrate the concrete. Paste appears inhomogeneous (patchy).

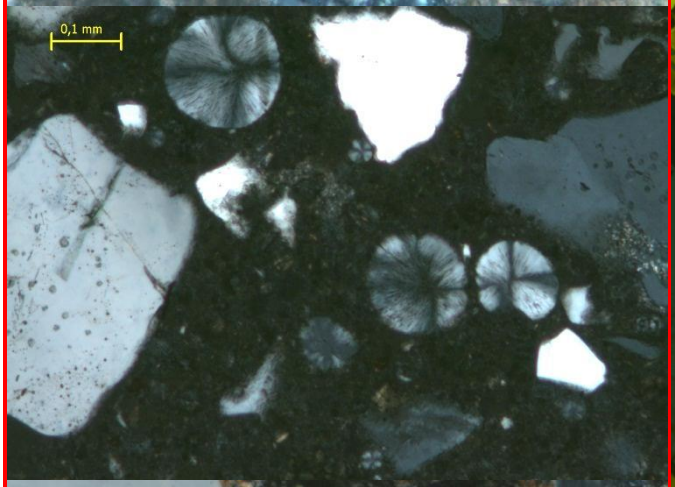


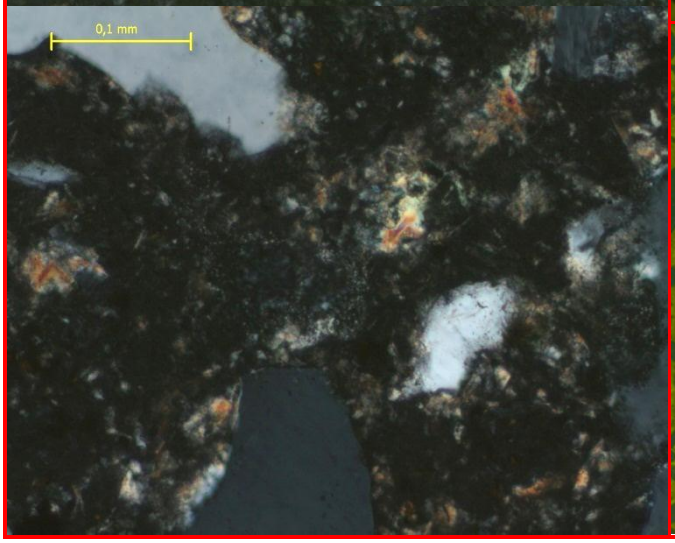


Hadsundbroen **Pylon, below sea level** **Age: 1974-76**

Info		Comments
Cement type	PC (A)	Core taken in 1996
Fly ash	-	Cement: 355 kg/m3
Microsilica	-	W/C = 0.47 (mix)
Slag	-	Granite aggregate, few porous flint in sand (minor ASR)
W/C, apparent	0.45	
Air %	2	
		UHJ section (rap196)



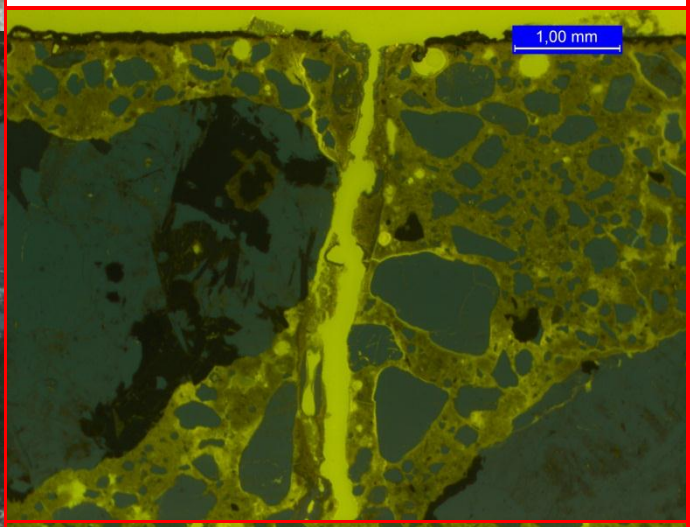


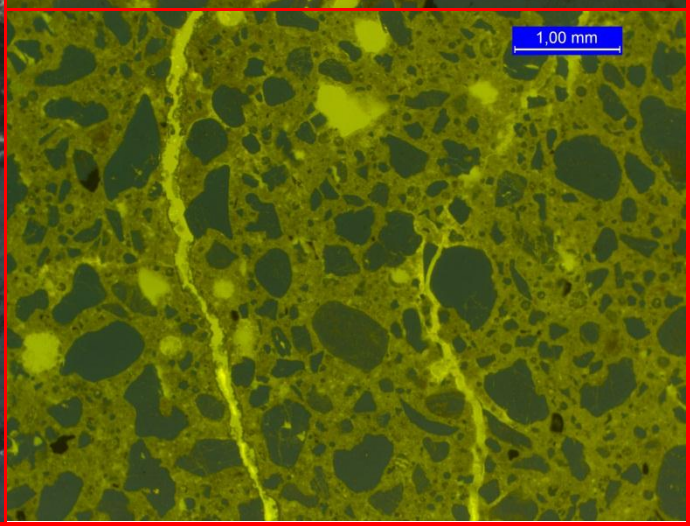


Micro-observations

Micro-structural zoning through concrete:

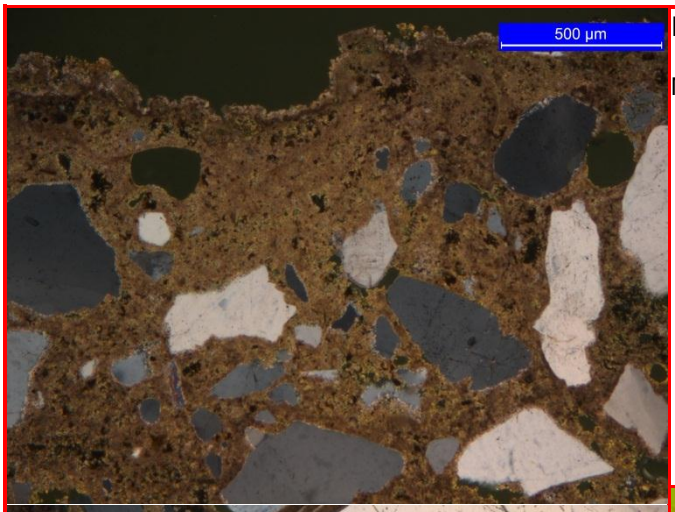
1. Relatively straight surface occasionally covered by calcite and brucite. No exposed aggregate. A thin rusty zone appears at interface to concrete.
2. 0-2mm: Distinct carbonated zone with a fine crack through concrete. The crack divides with depth. Carbonated paste along crack; brucite and calcite in crack.
3. 2-45mm: Paste rich in large CH crystals. Towards the crack the paste becomes totally leached (black) with massive ettringite in air voids. Popcorn carbonation is also observed close to crack.

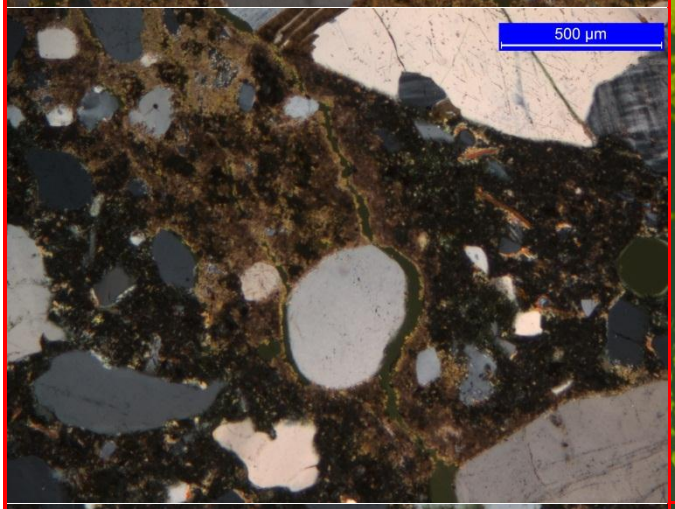


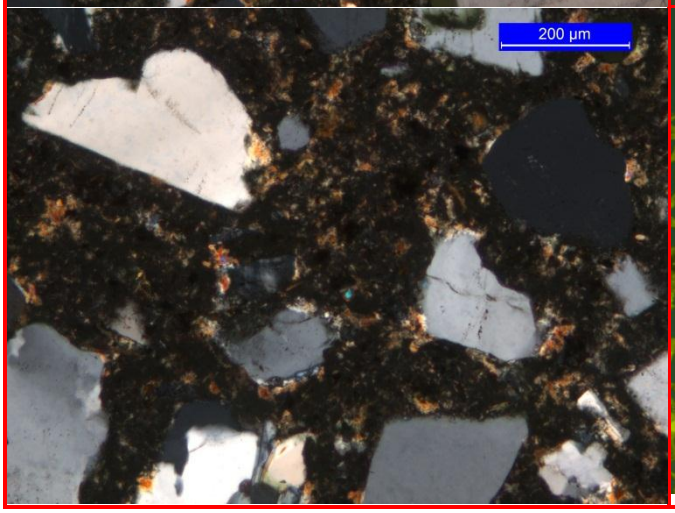


Hadsundbroen **Pylon, above sea water** **Age: 1974-76**

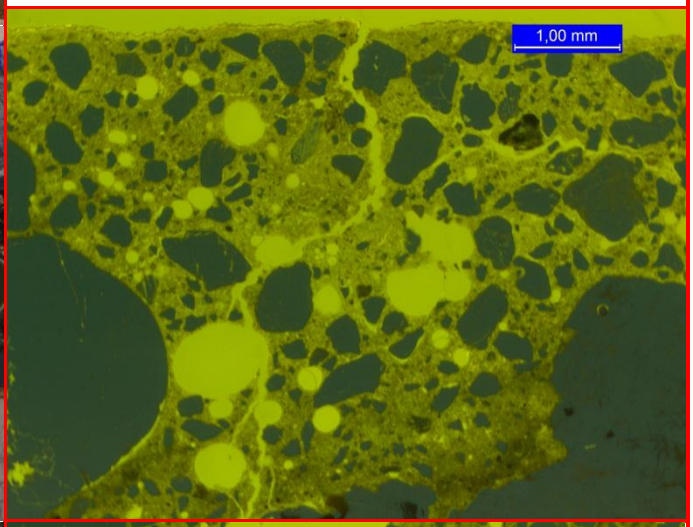
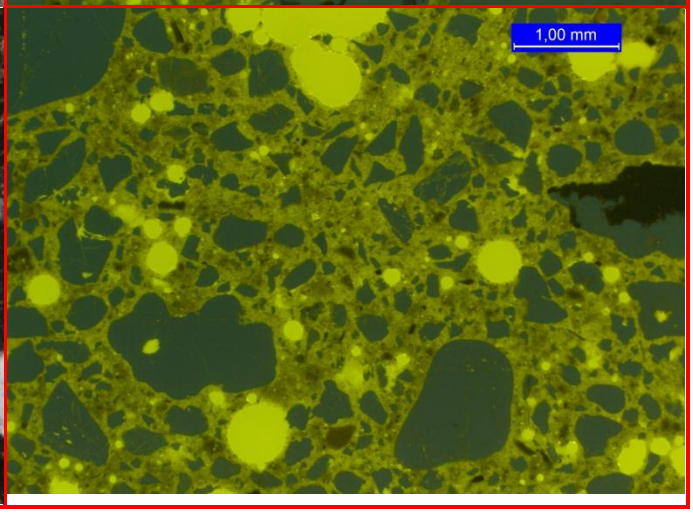
Info		**Comments**
Cement type	PC (A)	Core taken in 1996
Fly ash	-	Porous flint in both aggregate fractions (Fill concrete). ASR
Microsilica	-	
Slag	-	
W/C, apparent	0.45	
Air %		
		UHJ section (rap223)







Micro-observations

Micro-structural zoning through concrete:

1. Wavy surface, no exposure of aggregate. Occasionally calcite crust.
2. 0-12mm: Distinct carbonated surface, very irregular front. Soft crack appears through concrete, paste is carbonated along this to 35mm depth.
3. 12-45mm: Paste containing very large CH crystals in voids spaces and air voids. The paste appears leached (black) towards the crack with massive ettringite in air voids. Some popcorn carbonation near crack.