

Appendix D

ESEM and SEM/EDS Data for Test #3, Day-30 Corrosion Products

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For ICET tests, one process of interest is the corrosion effect of metal and concrete coupons. One means of understanding the corrosion process is through direct examination of the corrosion products after the test is completed. For this purpose, corrosion products were collected when Test #3 was shut down (May 5, 2005). These corrosion products included (1) fine powders on a vertical piece of the submerged CPVC rack, (2) corrosion products on a submerged galvanized steel coupon, (3) corrosion products on a submerged copper coupon, (4) corrosion products on a submerged aluminum coupon, and (5) corrosion products on a submerged concrete coupon.

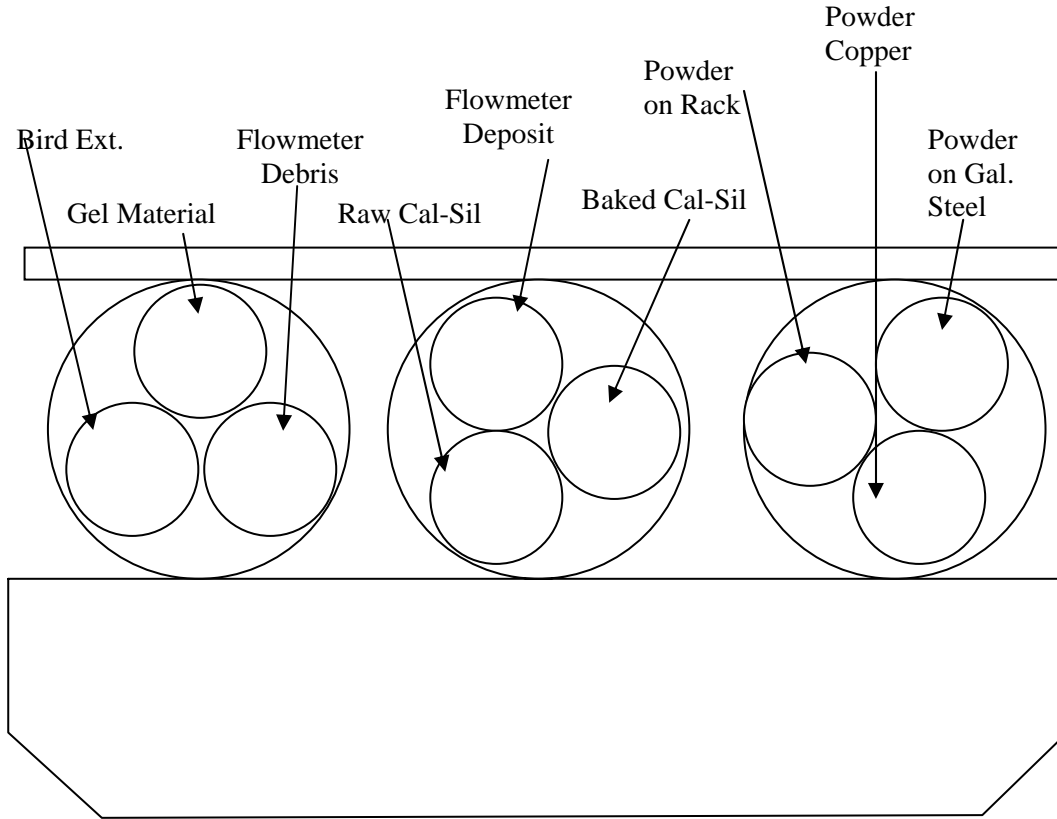
Corrosion products were collected by directly adhering the sample onto double-sided carbon tape suitable for SEM/EDS examination. After the samples were dried in air, an Au/Pd coating was applied to enhance the surface conductivity of the samples and to prevent possible charging problems during the SEM examination process. Based on EDS results, a semi-quantitative elemental analysis was performed after calibration of the x-ray signal using an internal standard of the microscopy. This appendix presents the SEM/EDS data that were generated on May 17, 2005. Available logbook entries for this laboratory session are included in this appendix as transcribed notes.

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Transcribed Laboratory Log

Laboratory session from May 9, 2005.

Test #3, Day-30 Powder Deposits



Powder on Rack

Image: T3~RackPowder013 200 ×

Figure D-1

EDS: T3RackPowder09

Powder on image 013

Figure D-2

Powder on Galvanized Steel

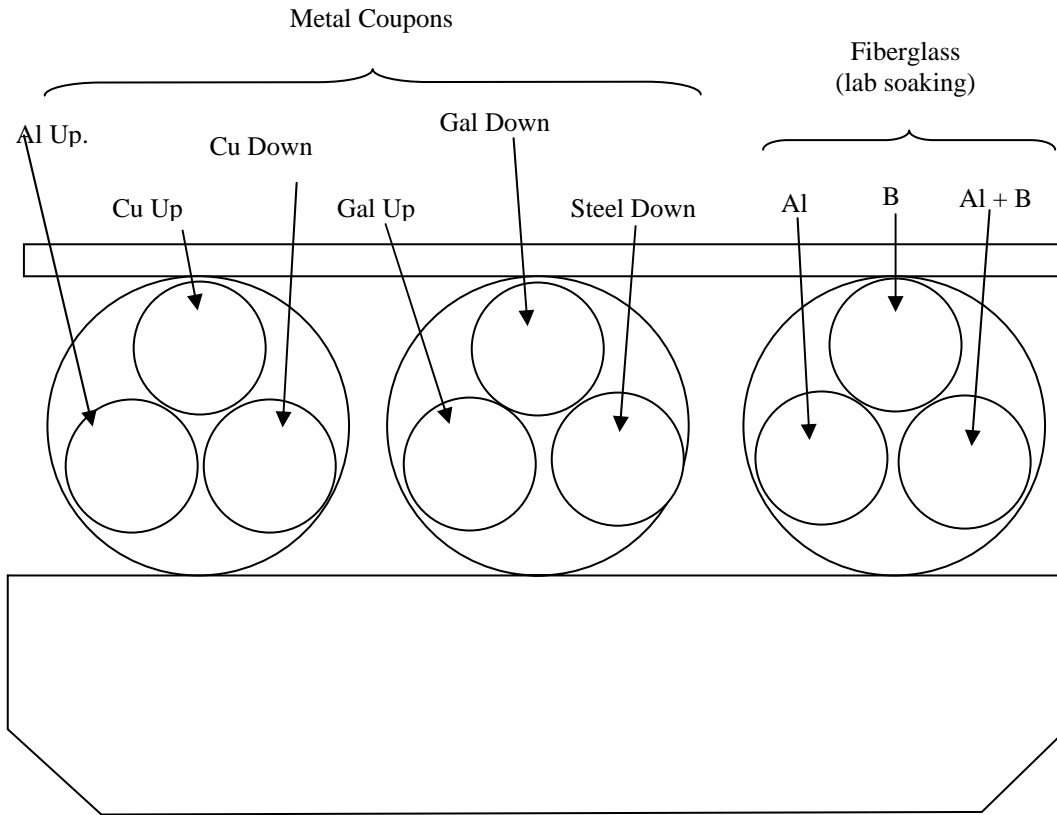
Image: T3~Gal~Steel~Powder014 500 × Figure D-3
 EDS: CorPdct~GalStel10 White powder on image 014 Figure D-4
 CorPdct~GalSteel11 Dark powder on image 014 Figure D-5

Powder on Copper

Image: T3~Copper~Powder015 500 × Figure D-6
 EDS: CorPrdct_cu12 Powder on image 015 Figure D-7

Transcribed Laboratory Log

Laboratory session from May 17, 2005.
 Test #3, Day-30 Metal Coupons



**Coat with Gold

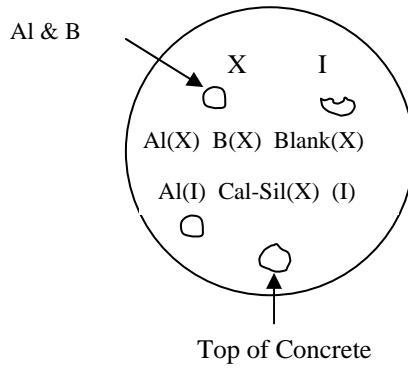
Corrosion Product on Submerged Aluminum

Image:	T3D30CorrPrdctSubmA1039	100 ×		Figure D-8
	T3D30CorrPrdctSubmA1040	100 ×	Backscattering	Figure D-9
EDS:	T3D30CorrPrdtA122		Particles on image 040	Figure D-10
Image:	T3D30CorrPrdctSubmA1041	1000 ×		Figure D-11

Transcribed Laboratory Log

Laboratory session from May 10, 2005.

Test #3, Day-30 ESEM.



Deposits on the Top of Concrete

Image:	T3Cont28	1000 ×		Figure D-12
	t3cont29	100 ×		Figure D-13
EDS:	t3cont30		Particles on image 29	Figure D-14

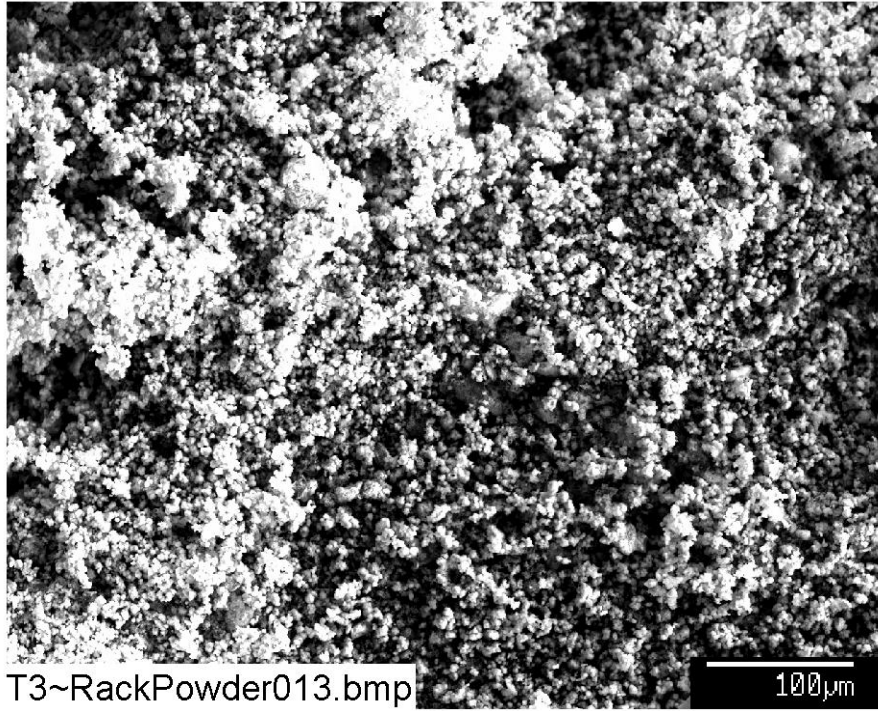


Figure D-1. SEM image magnified 200 times for a Test #3, Day-30 powder on the submerged rack. (T3~RackPowder013)

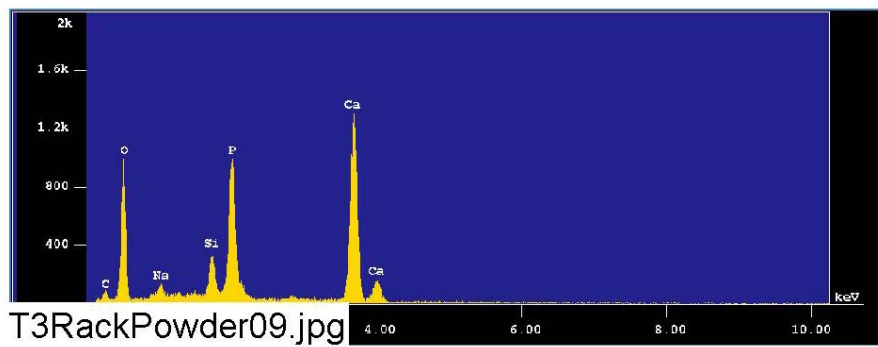


Figure D-2. EDS counting spectrum for the powder on the submerged rack shown in Figure D-1. (T3RackPowder09)

The results from the chemical composition analysis for T3RackPowder09 are given in Table D-1.

Table D-1. Chemical Compositions for T3RackPowder09, Figure D-2

May 9 2005

Group : NRC
 Sample : T3D30 ID# : 9
 Comment : Powder on submerged Rack
 Condition : Full Scale : 20KeV(10eV/ch,2Kch)
 Live Time : 60.000 sec Aperture # : 1
 Acc. Volt : 15.0 KV Probe Current : 1.608E-09 A
 Stage Point : X=23.811 Y=58.398 Z= 9.938
 Acq. Date : Mon May 9 15:02:46 2005

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
O K	Normal	0.25- 0.77	16.4417	0.0037	6188 / 66
Na K	Normal	0.81- 1.27	0.4147	0.0011	448 / 64
Si K	Normal	1.50- 2.05	1.8593	0.0006	2708 / 288
P K	Normal	1.75- 2.38	10.0274	0.0058	9012 / 160
Ca K	Normal	3.39- 4.30	22.3191	0.0043	15798 / 22
C K	Normal	0.09- 0.46	0.0345	0.0005	19 / 166

 Chi_square = 55.4587

Element	Mass%	Atomic%	ZAF	Z	A	F
O	48.147	67.3988	1.8951	0.9734	1.9469	1.0000
Na	0.977	0.9516	1.5243	1.0269	1.4843	1.0000
Si	3.302	2.6332	1.1493	0.9767	1.1837	0.9941
P	13.197	9.5423	0.8517	1.1722	0.7283	0.9977
Ca	34.174	19.0962	0.9909	0.9956	0.9953	1.0000
C	0.203	0.3778	3.7963	1.0208	3.7192	0.9999

 Total 100.000 100.0000
 Normalization factor = 1.5452
 Total 100.000 100.0000
 Normalization factor = 2.1120

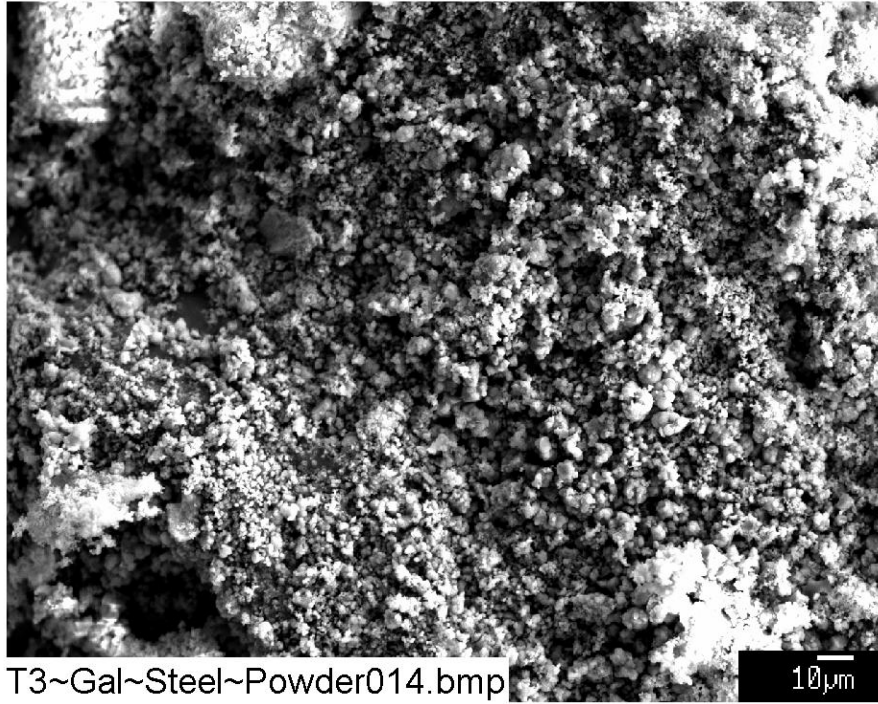


Figure D-3. SEM image magnified 500 times for a Test #3, Day-30 powder on a submerged galvanized steel coupon. (T3~Gal~Steel~Powder014)

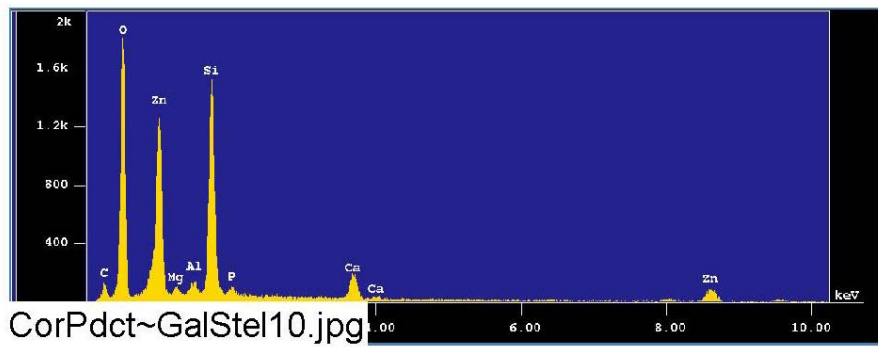


Figure D-4. EDS counting spectrum for the white powder on galvanized steel shown in Figure D-3. (CorPdct~GalStel10)

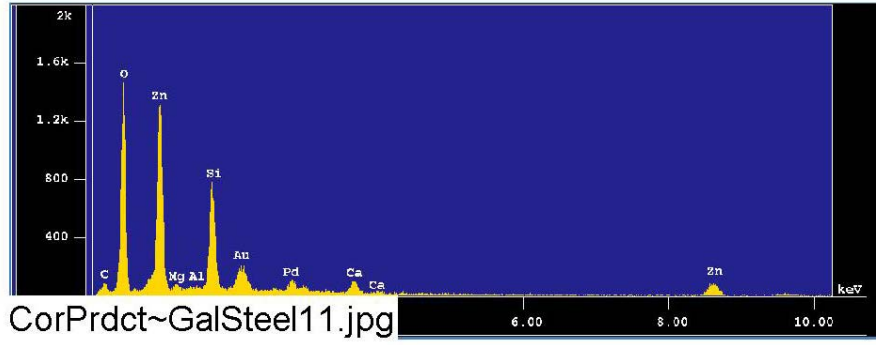


Figure D-5. EDS counting spectrum for the dark powder on galvanized steel shown in Figure D-3. (CorPrdct~GalSteel11)

The results from the chemical composition analysis for CorPrdct~GalSteel11 are given in Table D-2.

Table D-2. Chemical Compositions for CorPrdct~GalSteel11, Figure D-5

May 9 2005

Group : NRC
 Sample : T3D30 ID# : 11
 Comment : Corrosion product of Gal-Steel
 Condition : Full Scale : 20KeV(10eV/ch,2Kch)
 Live Time : 60.000 sec Aperture # : 1
 Acc. Volt : 15.0 KV Probe Current : 1.608E-09 A
 Stage Point : X=12.508 Y=58.337 Z= 9.938
 Acq. Date : Mon May 9 15:23:47 2005

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
O K	Normal	0.25- 0.77	24.6017	0.0044	9259 / 71
Mg K	Normal	0.97- 1.57	0.1342	0.0003	211 / 424
Si K	Normal	1.50- 2.05	4.3383	0.0008	6318 / 94
Ca K	Normal	3.39- 4.30	1.4823	0.0016	1049 / 28
Zn K	Normal	8.22-10.03	13.8053	0.0096	1501 / 6
Al K	Normal	1.19- 1.83	0.1257	0.0003	196 / 77
C K	Normal	0.09- 0.46	0.0000	0.0000	0 / 254

 Chi_square = 39.1864

Element	Mass%	Atomic%	ZAF	Z	A	F
O	47.383	72.4077	0.9119	0.9354	0.9750	1.0000
Mg	0.655	0.6591	2.3126	0.9284	2.4928	0.9993
Si	13.143	11.4404	1.4344	0.9377	1.5298	0.9999
Ca	3.059	1.8657	0.9770	0.9542	1.0247	0.9991
Zn	35.285	13.1966	1.2102	1.2129	0.9978	1.0000
Al	0.475	0.4304	1.7897	0.9594	1.8692	0.9979
C	0.000	0.0000	5.2279	0.9811	5.3287	1.0000

 Total 100.000 100.0000
 Normalization factor = 2.1120

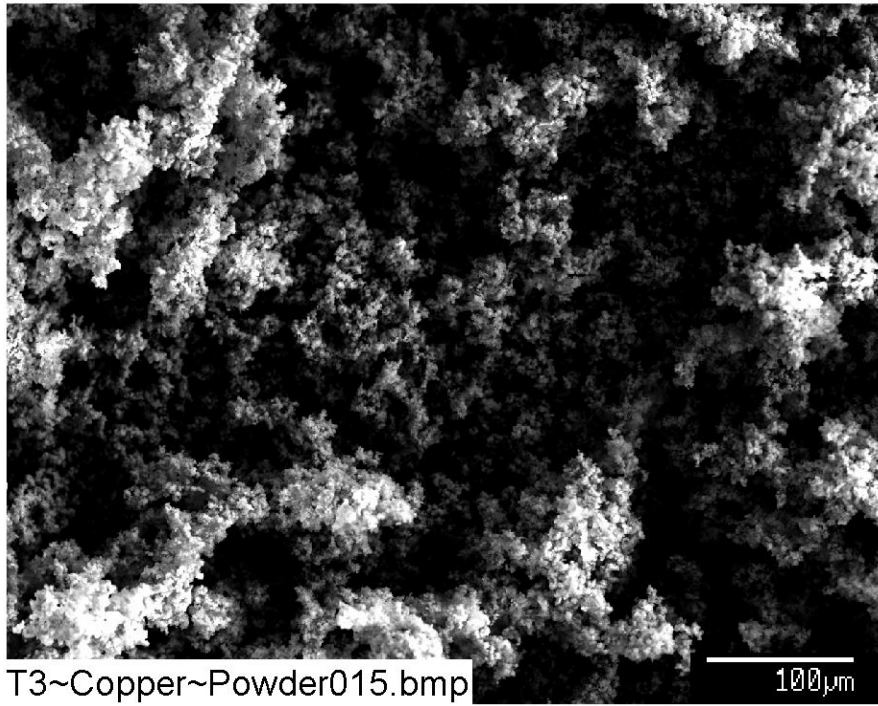


Figure D-6. SEM image magnified 500 times for a Test #3, Day-30 powder on a submerged copper coupon. (T3~Copper~Powder015)

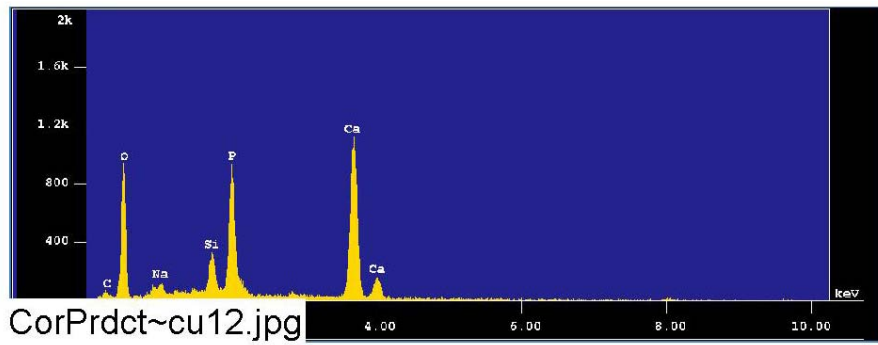


Figure D-7. EDS counting spectrum for the powder on copper shown in Figure D-6. (CorPrdct~cu12)

The results from the chemical composition analysis for CorPrdct~cu12 are given in Table D-3.

Table D-3. Chemical Compositions for CorPrdct~cu12, Figure D-7

May 9 2005

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Group      : NRC
Sample     : T3D30 ID# : 112
Comment    : Corrosion product of Copper
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec   Aperture #   : 1
             Acc. Volt  : 15.0 KV      Probe Current : 1.609E-09 A
             Stage Point: X=17.909 Y=70.722 Z= 9.938
             Acq. Date  : Mon May 9 15:34:51 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
O K	Normal	0.25- 0.77	16.9583	0.0036	6386 / 54
Na K	Normal	0.81- 1.27	0.3712	0.0011	402 / 46
Si K	Normal	1.50- 2.05	1.7009	0.0006	2479 / 254
P K	Normal	1.75- 2.38	8.6109	0.0054	7744 / 164
Ca K	Normal	3.39- 4.30	19.7450	0.0040	13984 / 28
C K	Normal	0.09- 0.46	0.0000	0.0000	0 / 156

 Chi_square = 59.8005

Element	Mass%	Atomic%	ZAF	Z	A	F
O	51.054	70.0693	1.8119	0.9751	1.8582	1.0000
Na	0.947	0.9045	1.5353	1.0287	1.4923	1.0000
Si	3.260	2.5484	1.1533	0.9785	1.1852	0.9945
P	12.216	8.6603	0.8538	1.1744	0.7286	0.9978
Ca	32.523	17.8176	0.9913	0.9976	0.9936	1.0000
C	0.000	0.0000	3.6900	1.0225	3.6090	0.9999

 Total 100.000 100.0000
 Normalization factor = 1.6616

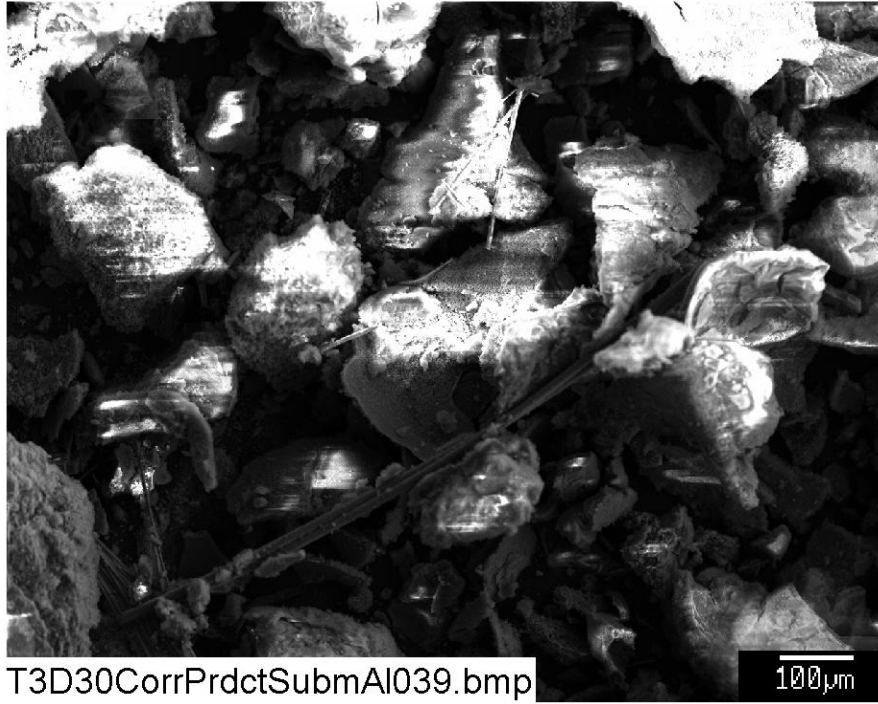


Figure D-8. SEM image magnified 100 times for Test #3, Day-30 corrosion products on a submerged aluminum coupon. (T3D30CorrPrdctSubmAl039)

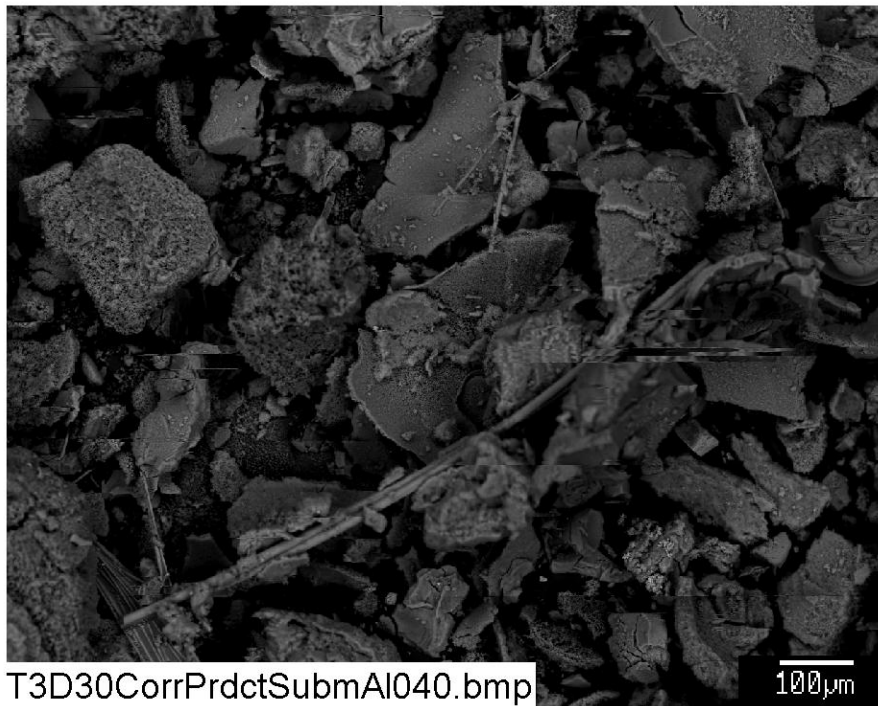


Figure D-9. Backscattered SEM image magnified 100 times for Test #3, Day-30 corrosion products on a submerged aluminum coupon. (T3D30CorrPrdct SubmAl040)

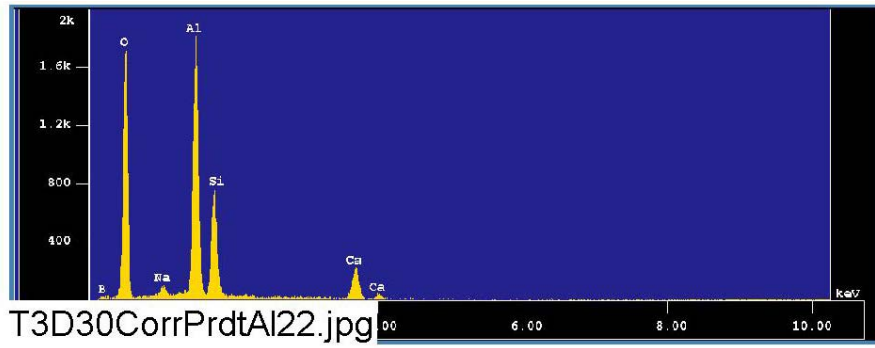


Figure D-10. EDS counting spectrum for the corrosion products (particles) shown in Figure D-9. (T3D30CorrPrdtAl22)

The results from the chemical composition analysis for T3D30CorrPrdtAl22 are given in Table D-4.

Table D-4. Chemical Compositions for T3D30CorrPrdtAl22, Figure D-10

May 17 2005

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Group      : NRC
Sample     : T3D30 ID# : 25
Comment    : Corr Prodct on Submerged Al
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec      Aperture #   : 2
             Acc. Volt  : 15.0 KV         Probe Current  : 7.686E-09 A
             Stage Point: X=17.100 Y=58.819 Z=11.000
             Acq. Date  : Tue May 17 16:07:30 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
O K	Normal	0.25- 0.77	43.5604	0.0044	10399 / 29
Na K	Normal	0.81- 1.27	0.7246	0.0010	497 / 45
Al K	Normal	1.26- 1.78	15.1592	0.0021	15016 / 184
Si K	Normal	1.50- 2.05	6.6963	0.0008	6185 / 674
Ca K	Normal	3.40- 4.30	4.2145	0.0082	1892 / 14
B K	Normal	0.00- 0.36	0.6943	0.0002	69 / 10

 Chi_square = 107.5732

Element	Mass%	Atomic%	ZAF	Z	A	F
O	52.728	58.8383	1.0170	0.9767	1.0413	1.0000
Na	1.120	0.8699	1.2989	1.0311	1.2612	0.9988
Al	19.542	12.9304	1.0831	0.9932	1.0934	0.9974
Si	10.480	6.6618	1.3149	0.9816	1.3397	0.9999
Ca	4.923	2.1928	0.9814	0.9916	0.9896	1.0001
B	11.207	18.5068	13.5610	1.1342	11.9568	1.0000

 Total 100.000 100.0000
 Normalization factor = 1.1902
 re 2.399 1.5375 0.9896 1.0503 1.0060 0.9366

 Total 100.000 100.0000
 Normalization factor = 3.2486

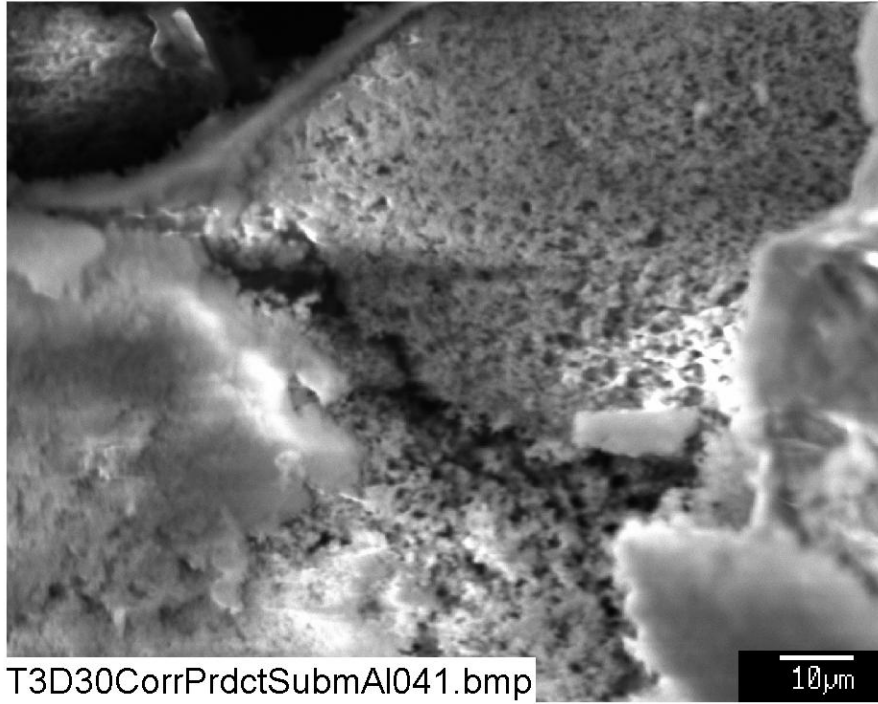


Figure D-11. SEM image magnified 1000 times for Test #3, Day-30 corrosion products on a submerged aluminum coupon. (T3D30CorrPrdctSubmAl041)

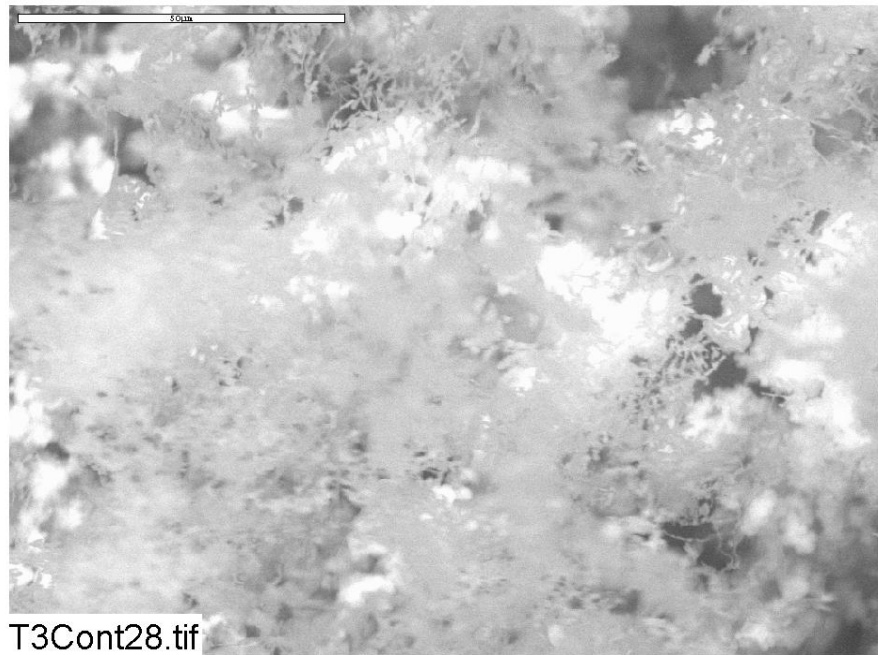


Figure D-12. ESEM image magnified 1000 times for Test #3, Day-30 corrosion products on a submerged concrete coupon. (T3cont28)

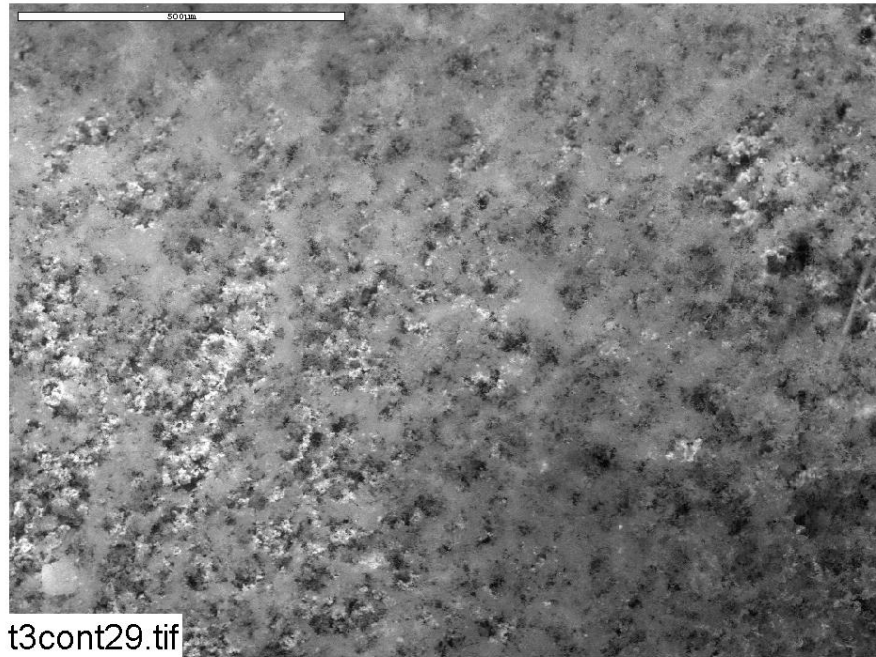


Figure D-13. ESEM image magnified 100 times for Test #3, Day-30 corrosion products on a submerged concrete coupon. (t3cont29)

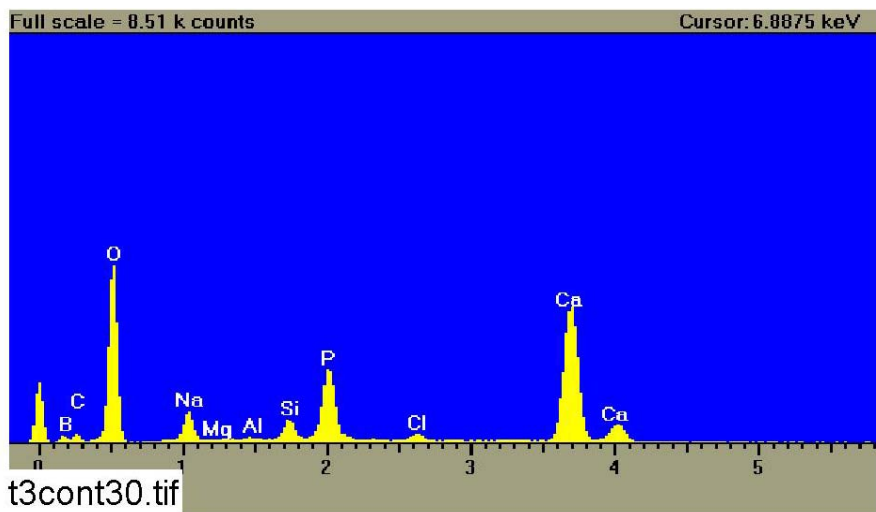


Figure D-14. EDS counting spectrum for the corrosion products (particles) shown in Figure D-13. (t3cont30)

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