APPENDIX A

Data for the line analysis on a particle chlorinated for 30 seconds as seen in Figures 17 and 18.

		O	Cl	Zr	V	Al	Si	Ti	Mg	Mn	Ca	K	Fe	Cr	Nb	Total
#	µm	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%
1	0	32.56	0.01	0.07	0.51	0.56	0.05	54.89	0.71	0.90	0.00	0.04	6.33	0.00	1.45	98.08
2	5	33.20	0.00	0.07	0.52	0.67	0.01	54.96	0.84	0.88	0.08	0.00	6.68	0.09	1.54	99.54
3	10	33.36	0.00	0.09	0.50	0.53	0.01	54.90	0.76	0.46	0.00	0.00	6.74	0.00	1.21	98.56
4	15	33.39	0.01	0.07	0.58	0.68	0.05	55.76	0.81	0.81	0.00	0.00	6.63	0.11	1.36	100.27
5	20	33.59	0.01	0.09	0.54	0.67	0.04	54.17	0.76	0.85	0.05	0.03	6.82	0.05	1.52	99.16
6	25	33.59	0.00	0.05	0.51	0.66	0.09	55.03	0.83	0.81	0.02	0.00	6.63	0.00	1.65	99.87
7	30	28.73	0.05	0.09	0.51	4.61	0.08	46.25	0.56	0.93	0.10	0.00	5.50	0.00	1.32	88.74
8	35	34.05	0.00	0.06	0.50	0.78	0.07	54.31	0.70	0.78	0.06	0.00	7.04	0.03	1.47	99.84
9	40	33.68	0.00	0.09	0.52	2.23	0.05	51.85	0.76	0.99	0.00	0.00	6.41	0.17	1.67	98.42
10	45	31.50	0.00	0.08	0.47	0.61	0.05	54.48	0.93	0.75	0.00	0.00	7.45	0.11	1.37	97.81
11	50	32.24	0.01	0.07	0.59	0.67	0.03	54.45	0.80	0.80	0.07	0.08	6.55	0.20	1.56	98.12
12	55	32.39	0.01	0.07	0.51	0.70	0.03	54.29	0.73	1.01	0.05	0.00	6.76	0.02	1.28	97.87
13	60	32.26	0.00	0.08	0.51	0.59	0.00	54.67	0.84	0.94	0.06	0.00	6.44	0.04	1.65	98.08
14	65	32.50	0.00	0.03	0.57	0.62	0.09	54.88	0.82	0.89	0.00	0.00	6.79	0.42	1.64	99.26
15	70	32.78	0.00	0.06	0.46	0.62	0.00	55.20	0.83	0.72	0.00	0.00	6.35	0.32	1.29	98.62
16	75	33.28	0.00	0.06	0.54	0.64	0.04	56.09	0.93	0.76	0.00	0.00	6.47	0.00	1.30	100.11
17	80	32.50	0.00	0.07	0.55	0.73	0.14	54.94	0.88	0.68	0.03	0.00	7.17	0.09	1.42	99.19
18	85	33.04	0.00	0.09	0.53	0.66	0.03	55.44	0.85	0.97	0.07	0.00	6.88	0.14	1.66	100.37
19	90	32.89	0.01	0.12	0.49	0.59	0.07	53.84	0.71	0.79	0.01	0.00	6.66	0.26	1.31	97.74
20	95	33.14	0.00	0.07	0.50	0.78	0.14	55.03	0.81	0.89	0.00	0.00	6.68	0.14	1.62	99.82
21	100	32.90	0.00	0.08	0.49	0.66	0.03	54.28	0.86	1.01	0.02	0.00	6.57	0.08	1.61	98.58
22	105	33.04	0.00	0.12	0.51	0.61	0.08	54.84	0.89	0.78	0.00	0.00	6.95	0.00	1.45	99.27
23	110	33.13	0.02	0.09	0.46	0.74	0.07	54.90	0.82	0.80	0.10	0.00	7.00	0.16	1.34	99.62
24	115	32.88	0.00	0.08	0.50	0.62	0.06	54.78	0.72	0.90	0.00	0.00	7.23	0.33	1.57	99.68
25	120	32.75	0.00	0.10	0.53	0.63	0.04	54.58	0.78	0.94	0.00	0.00	7.44	0.10	1.23	99.11
26	125	32.84	0.00	0.11	0.48	0.70	0.03	53.88	0.84	1.03	0.02	0.02	6.92	0.26	1.75	98.87
27	130	33.31	0.02	0.12	0.59	0.61	0.03	54.70	0.87	1.12	0.05	0.00	6.63	0.00	1.36	99.42
28	135	33.15	0.00	0.11	0.53	0.75	0.12	53.79	0.86	1.07	0.00	0.03	7.12	0.19	1.16	98.88
29	140	33.66	0.00	0.09	0.52	0.66	0.12	55.56	0.74	1.01	0.00	0.00	6.83	0.11	1.30	100.61
30	145	33.23	0.01	0.10	0.49	0.74	0.13	54.25	0.93	1.46	0.04	0.00	7.16	0.00	1.61	100.15
31	150	34.53	0.00	0.12	0.46	0.64	0.10	54.71	0.69	1.60	0.07	0.00	6.01	0.10	1.42	100.46
32	155	34.32	0.00	0.11	0.51	0.55	0.03	54.57	0.77	0.87	0.01	0.00	6.38	0.04	1.39	99.56
33	160	33.89	0.00	0.09	0.54	0.61	0.00	54.34	0.75	1.22	0.00	0.00	6.49	0.08	1.50	99.51
34	165	33.82	0.00	0.07	0.48	0.59	0.08	54.46	0.74	1.04	0.00	0.00	7.01	0.05	1.48	99.84
35	170	33.53	0.01	0.11	0.52	0.55	0.10	54.33	0.73	1.03	0.00	0.00	7.33	0.02	1.31	99.58
36	175	34.53	0.00	0.11	0.46	0.56	0.00	54.29	0.72	1.23	0.00	0.00	6.55	0.00	1.43	99.88
37	180	35.60	0.00	0.12	0.59	0.56	0.05	53.67	0.82	1.07	0.09	0.00	4.86	0.14	1.47	99.04
38	185	36.73	0.07	0.10	0.58	0.51	0.04	55.93	0.60	0.44	0.00	0.00	2.20	0.00	1.45	98.65
39	190	37.39	0.00	0.09	0.55	0.43	0.07	56.91	0.90	0.42	0.09	0.00	1.06	0.00	1.51	99.43
40	195	39.34	0.04	0.10	0.65	0.43	0.06	57.09	0.67	0.02	0.06	0.00	0.70	0.00	1.49	100.65
41	200	37.39	0.06	0.09	0.41	0.73	0.03	56.50	0.00	0.10	0.04	0.00	0.00	0.11	1.63	97.10
42	205	40.77	0.04	0.06	0.48	1.16	0.15	57.00	0.02	0.03	0.00	0.00	0.07	0.12	1.51	101.41
43	210	38.56	0.00	0.11	0.47	1.29	0.21	56.51	0.00	0.00	0.00	0.00	0.02	0.00	1.33	98.51
44	215	36.75	0.05	0.06	0.47	1.20	0.16	55.64	0.01	0.09	0.05	0.00	0.16	0.00	1.28	95.91
45	220	34.76	0.04	0.08	0.43	0.86	0.04	53.93	0.00	0.00	0.04	0.00	0.28	0.03	1.33	91.82
46	225	36.79	0.05	0.09	0.47	0.68	0.11	56.66	0.11	0.07	0.00	0.00	0.00	0.00	1.40	96.43
47	230	37.05	0.02	0.10	0.41	0.26	0.08	57.91	0.05	0.00	0.00	0.01	0.00	0.19	1.53	97.62
48	235	38.03	0.03	0.11	0.44	0.45	0.09	58.01	0.01	0.07	0.01	0.00	0.04	0.23	1.40	98.93

49	240	38.68	0.06	0.08	0.40	0.48	0.09	58.84	0.00	0.00	0.00	0.03	0.16	0.00	1.20	100.02
50	245	37.43	0.09	0.08	0.36	3.15	0.16	55.30	0.17	0.00	0.00	0.00	0.10	0.00	1.30	98.15
51	250	38.34	0.04	0.07	0.41	0.35	0.05	59.10	0.08	0.00	0.02	0.00	0.47	0.18	1.40	100.51
52	255	37.74	0.03	0.08	0.32	0.22	0.00	58.15	0.00	0.00	0.02	0.00	0.17	0.03	1.55	98.31
53	260	37.63	0.06	0.10	0.38	0.29	0.17	57.06	0.04	0.00	0.00	0.00	0.03	0.13	1.27	97.17
54	265	39.11	0.12	0.08	0.36	0.26	0.00	58.38	0.00	0.00	0.03	0.00	0.16	0.22	1.59	100.29

APPENDIX B

The following data are for the Figure 19 where the Cl_2/CO ratio was investigated. The experiments were done at 950 °C for 20 minutes each.

Exp. 1						
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
0	11.42	7.61	19.03	0	60	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	52.38		51.98	0.40	0.76	
TiO_2	44.95		44.82	0.13	0.29	
FeO	6.08		5.96	0.12	1.96	
MnO	0.94		0.91	0.03	3.52	
MgO	0.50		0.50	0.00	0.76	
Cr_2O_3	0.07		0.07	0.01	7.85	
SiO_2	0.93		0.84	0.09	9.73	
CaO	0.09		0.09	0.01	6.27	
Exp. 2						
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
1.9	9.52	7.61	19.03	10	50	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	52.28		44.05	8.23	15.74	
TiO_2	44.87		42.26	2.61	5.82	
FeO	6.07		0.19	5.88	96.84	
MnO	0.94		0.05	0.89	94.85	
MgO	0.50		0.10	0.40	79.81	
Cr_2O_3	0.07		0.04	0.04	51.85	
SiO_2	0.93		0.83	0.10	10.51	
CaO	0.09		0.08	0.01	15.74	

Exp. 3

Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
3.81	7.61	7.61	19.03	20	40	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	52.24		43.05	9.19	17.59	
TiO_2	44.83		41.27	3.56	7.95	
FeO	6.06		0.21	5.86	96.59	
MnO	0.94		0.05	0.89	94.51	
MgO	0.50		0.05	0.45	90.56	
Cr_2O_3	0.07		0.02	0.05	70.57	
SiO_2	0.92		0.85	0.07	7.81	
CaO	0.09		0.07	0.02	22.17	

Exp. 4

Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.71	5.71	7.61	19.03	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	51.35		42.30	9.05	17.62	
TiO_2	44.07		40.35	3.72	8.44	
FeO	5.96		0.17	5.8	97.1	
MnO	0.92		0.04	0.89	95.88	
MgO	0.49		0.05	0.45	90.56	
Cr_2O_3	0.07		0.01	0.06	88.23	
SiO_2	0.91		0.86	0.05	5.52	
CaO	0.09		0.07	0.02	22.19	

Exp. 5

Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
7.61	3.81	7.61	19.03	40	20	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	52.09		43.55	8.54	16.39	
TiO_2	44.70		41.56	3.14	7.03	
FeO	6.05		0.24	5.8	96.0	
MnO	0.94		0.04	0.89	95.36	
MgO	0.50		0.06	0.44	87.81	
Cr_2O_3	0.07		0.01	0.06	88.06	
SiO_2	0.92		0.90	0.02	2.70	
CaO	0.09		0.07	0.02	21.04	

Exp. 6

Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
9.52	1.9	7.61	19.03	50	10	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	51.20		44.04	7.16	13.98	
TiO_2	43.94		41.97	1.97	4.47	
FeO	5.94		0.32	5.6	94.6	
MnO	0.92		0.06	0.86	93.79	
MgO	0.49		0.12	0.37	75.81	
Cr_2O_3	0.07		0.01	0.06	87.71	
SiO_2	0.91		0.80	0.10	11.55	
CaO	0.09		0.06	0.03	33.09	

Exp. 7						
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
11.42	0.01	7.61	19.04	60	0	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	G	%	
Total	50.88		45.04	5.84	11.48	
TiO_2	43.67		42.64	1.03	2.36	
FeO	5.91		0.36	5.6	94.0	
MnO	0.92		0.06	0.86	93.61	
MgO	0.49		0.21	0.28	57.59	
Cr_2O_3	0.07		0.02	0.05	74.71	
SiO_2	0.90		0.86	0.04	3.98	
CaO	0.09		0.07	0.02	21.32	

APPENDIX C

The following data are for Figure 24 where the influence of the CO partial pressure was investigated. The experiments were done at 950°C.

Exp 1	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	13.43	0	19.19	30	70	0
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.32		39.30	11.02	21.90	
TiO_2	43.50		37.91	5.59	12.86	
FeO	5.99		0.20	5.80	96.73	
MnO	0.78		0.02	0.76	97.66	
MgO	0.53		0.03	0.50	94.30	
Cr_2O_3	0.08		0.02	0.07	81.26	
SiO_2	0.69		0.68	0.01	0.96	
CaO	0.07		0.06	0.01	19.32	
Exp 2	Time =	25	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	13.43	0	19.19	30	70	0
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.51		33.35	17.16	33.98	
TiO_2	43.66		32.23	11.43	26.18	
FeO	6.02		0.13	5.88	97.78	
MnO	0.78		0.01	0.78	99.15	
MgO	0.54		0.00	0.54	100.00	
Cr_2O_3	0.08		0.00	0.08	100.00	
SiO_2	0.69		0.65	0.04	5.75	
CaO	0.07		0.06	0.02	24.89	

Exp 3	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	9.6	3.84	19.2	30	50	20
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.93		40.63	10.30	20.22	
TiO_2	44.03		39.26	4.76	10.82	
FeO	6.07		0.27	5.80	95.55	
MnO	0.79		0.03	0.76	96.28	
MgO	0.54		0.00	0.54	100.00	
Cr_2O_3	0.08		0.01	0.07	83.83	
SiO_2	0.70		0.68	0.02	2.18	
CaO	0.08		0.06	0.01	18.45	
Exp 4	Time =	25	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	9.6	3.84	19.2	30	50	20
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.95		37.35	13.60	26.69	
TiO_2	44.05		36.08	7.97	18.10	
FeO	6.07		0.19	5.9	96.9	
MnO	0.79		0.02	0.77	97.47	
MgO	0.54		0.00	0.54	100.00	
Cr_2O_3	0.08		0.00	0.08	100.00	
SiO_2	0.70		0.72	-0.02	-3.00	
CaO	0.08		0.06	0.01	14.15	

Exp 5	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.41		41.77	8.64	17.14	
TiO_2	43.58		40.31	3.27	7.50	
FeO	6.01		0.30	5.7	95.0	
MnO	0.78		0.03	0.75	95.89	
MgO	0.54		0.01	0.53	98.40	
Cr_2O_3	0.08		0.02	0.06	75.17	
SiO_2	0.69		0.64	0.04	6.43	
CaO	0.07		0.06	0.01	17.06	

Exp 6	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.41		41.42	8.99	17.83	
TiO_2	43.58		40.05	3.52	8.08	
FeO	6.01		0.30	5.7	95.0	
MnO	0.78		0.03	0.75	96.13	
MgO	0.54		0.02	0.51	95.99	
Cr_2O_3	0.08		0.00	0.08	100.00	
SiO_2	0.69		0.64	0.05	7.77	
CaO	0.07		0.05	0.02	30.22	

Exp 7	Time =	14	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.36		41.12	9.25	18.36	
TiO_2	43.54		39.53	4.00	9.20	
FeO	6.00		0.25	5.7	95.8	
MnO	0.78		0.02	0.76	97.36	
MgO	0.53		0.00	0.53	100.00	
Cr_2O_3	0.08		0.01	0.07	88.04	
SiO_2	0.69		0.62	0.06	9.28	
CaO	0.07		0.06	0.02	21.90	
Exp 8	Time =	20	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.29		39.42	10.87	21.62	
TiO_2	43.48		38.25	5.22	12.01	
FeO	5.99		0.21	5.8	96.6	
MnO	0.78		0.01	0.77	98.13	
MgO	0.53		0.00	0.53	100.00	
Cr_2O_3	0.08		0.00	0.08	99.95	
SiO_2	0.69		0.66	0.03	3.89	
CaO	0.07		0.05	0.02	31.44	

APPENDIX D

The following data are for Figure 27 where the influence of the Cl_2 partial pressure was investigated. The experiments were done at 950°C.

Exp 1	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
1.92	5.75	11.52	19.19	10	30	60
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.87		43.37	7.50	14.74	
TiO_2	43.97		41.46	2.51	5.71	
FeO	6.06		0.33	5.73	94.48	
MnO	0.79		0.04	0.75	95.50	
MgO	0.54		0.10	0.44	80.59	
Cr_2O_3	0.08		0.05	0.04	44.11	
SiO_2	0.70		0.67	0.03	4.20	
CaO	0.07		0.07	0.00	4.82	
Exp 2	Time =	25	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
1.92	5.75	11.52	19.19	10	30	60
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.90		41.52	9.38	18.43	
TiO_2	44.01		39.83	4.18	9.50	
FeO	6.07		0.24	5.8	96.0	
MnO	0.79		0.03	0.76	96.64	
MgO	0.54		0.04	0.50	92.10	
Cr_2O_3	0.08		0.02	0.06	70.41	
SiO_2	0.70		0.69	0.00	0.45	
CaO	0.07		0.07	0.00	3.75	

Exp 3	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.41		41.77	8.64	17.14	
TiO_2	43.58		40.31	3.27	7.50	
FeO	6.01		0.30	5.7	95.0	
MnO	0.78		0.03	0.75	95.89	
MgO	0.54		0.01	0.53	98.40	
Cr_2O_3	0.08		0.02	0.06	75.17	
SiO_2	0.69		0.64	0.04	6.43	
CaO	0.07		0.06	0.01	17.06	
Exp 4	Time =	10	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.41		41.42	8.99	17.83	
TiO_2	43.58		40.05	3.52	8.08	
FeO	6.01		0.30	5.7	95.0	
MnO	0.78		0.03	0.75	96.13	
MgO	0.54		0.02	0.51	95.99	
Cr_2O_3	0.08		0.00	0.08	100.00	
SiO_2	0.69		0.64	0.05	7.77	
CaO	0.07		0.05	0.02	30.22	

Exp 5	Time =	14	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.36		41.12	9.25	18.36	
TiO_2	43.54		39.53	4.00	9.20	
FeO	6.00		0.25	5.7	95.8	
MnO	0.78		0.02	0.76	97.36	
MgO	0.53		0.00	0.53	100.00	
Cr_2O_3	0.08		0.01	0.07	88.04	
SiO_2	0.69		0.62	0.06	9.28	
CaO	0.07		0.06	0.02	21.90	

Exp 6	Time =	20	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.29		39.42	10.87	21.62	
TiO_2	43.48		38.25	5.22	12.01	
FeO	5.99		0.21	5.8	96.6	
MnO	0.78		0.01	0.77	98.13	
MgO	0.53		0.00	0.53	100.00	
Cr_2O_3	0.08		0.00	0.08	99.95	
SiO_2	0.69		0.66	0.03	3.89	
CaO	0.07		0.05	0.02	31.44	

APPENDIX E

The following data are for Figure 30 where the influence of the initial particle size was investigated. The experiments were done at 950°C.

Exp 1	Time =	10	min		dp =	215	µm
Cl_2	CO	N_2	Total	Cl_2	CO	N_2	
l/min	l/min	l/min	l/min	%	%	%	
5.76	5.76	7.68	19.2	30	30	40	
	Mass In		Mass Out	Mass loss	Conversion		
	g		g	g	%		
Total	50.24		40.43	9.81	19.53		
TiO_2	43.43		38.61	4.82	11.10		
FeO	5.99		0.30	5.7	95.0		
MnO	0.78		0.04	0.74	95.28		
MgO	0.53		0.01	0.52	98.41		
Cr_2O_3	0.08		0.01	0.07	83.99		
Exp 2	Time =	20	min		dp =	215	µm
Cl_2	CO	N_2	Total	Cl_2	CO	N_2	
l/min	l/min	l/min	l/min	%	%	%	
5.76	5.76	7.68	19.2	30	30	40	
	Mass In		Mass Out	Mass loss	Conversion		
	g		g	g	%		
Total	50.38		38.78	11.60	23.02		
TiO_2	43.55		37.45	6.10	14.01		
FeO	6.00		0.21	5.8	96.5		
MnO	0.78		0.02	0.77	97.89		
MgO	0.53		0.00	0.53	100.00		
Cr_2O_3	0.08		0.00	0.08	100.00		

Exp 3	Time =	10	min		dp =	513	µm
Cl_2	CO	N_2	Total	Cl_2	CO	N_2	
l/min	l/min	l/min	l/min	%	%	%	
5.76	5.76	7.68	19.2	30	30	40	
	Mass In		Mass Out	Mass loss	Conversion		
	g		g	g	%		
Total	50.74		42.79	7.95	15.66		
TiO_2	43.86		41.19	2.67	6.08		
FeO	6.04		0.29	5.8	95.3		
MnO	0.79		0.03	0.75	95.62		
MgO	0.54		0.00	0.54	100.00		
Cr_2O_3	0.08		0.02	0.06	76.04		
Exp 4	Time =	20	min		dp =	513	µm
Cl_2	CO	N_2	Total	Cl_2	CO	N_2	
l/min	l/min	l/min	l/min	%	%	%	
5.76	5.76	7.68	19.2	30	30	40	
	Mass In		Mass Out	Mass loss	Conversion		
	g		g	g	%		
Total	50.49		41.29	9.20	18.22		
TiO_2	43.65		39.87	3.78	8.66		
FeO	6.02		0.26	5.8	95.7		
MnO	0.78		0.03	0.76	96.50		
MgO	0.54		0.02	0.51	95.90		
Cr_2O_3	0.08		0.00	0.08	98.03		

APPENDIX F

The following data are for Figure 22 where the influence of the bed temperature was investigated. The experiments were done at 910 and 950°C.

Exp 1	Time =	10	min	Temp =	910	°C
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.46		42.68	7.78	15.41	
TiO_2	43.62		40.71	2.91	6.67	
FeO	6.01		0.32	5.7	94.7	
MnO	0.78		0.04	0.74	94.97	
MgO	0.54		0.10	0.43	81.09	
Cr_2O_3	0.08		0.03	0.05	64.14	
SiO_2	0.69		0.66	0.03	4.61	
CaO	0.07		0.07	0.01	7.47	
Exp 2	Time =	23	min	Temp =	910	°C
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.26		40.14	10.12	20.14	
TiO_2	43.45		38.38	5.07	11.67	
FeO	5.99		0.22	5.8	96.4	
MnO	0.78		0.03	0.75	96.53	
MgO	0.53		0.09	0.45	83.98	
Cr_2O_3	0.08		0.01	0.07	87.06	
SiO_2	0.69		0.69	0.00	0.07	
CaO	0.07		0.07	0.01	9.56	

Exp 3	Time =	10	min	Temp =	950	°C
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.41		41.77	8.64	17.14	
TiO_2	43.58		40.31	3.27	7.50	
FeO	6.01		0.30	5.7	95.0	
MnO	0.78		0.03	0.75	95.89	
MgO	0.54		0.01	0.53	98.40	
Cr_2O_3	0.08		0.02	0.06	75.17	
SiO_2	0.69		0.64	0.04	6.43	
CaO	0.07		0.06	0.01	17.06	

Exp 4	Time =	10	min	Temp =	950	°C
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.41		41.42	8.99	17.83	
TiO_2	43.58		40.05	3.52	8.08	
FeO	6.01		0.30	5.7	95.0	
MnO	0.78		0.03	0.75	96.13	
MgO	0.54		0.02	0.51	95.99	
Cr_2O_3	0.08		0.00	0.08	100.00	
SiO_2	0.69		0.64	0.05	7.77	
CaO	0.07		0.05	0.02	30.22	

Exp 5	Time =	14	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.36		41.12	9.25	18.36	
TiO_2	43.54		39.53	4.00	9.20	
FeO	6.00		0.25	5.7	95.8	
MnO	0.78		0.02	0.76	97.36	
MgO	0.53		0.00	0.53	100.00	
Cr_2O_3	0.08		0.01	0.07	88.04	
SiO_2	0.69		0.62	0.06	9.28	
CaO	0.07		0.06	0.02	21.90	
Exp 6	Time =	20	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.29		39.42	10.87	21.62	
TiO_2	43.48		38.25	5.22	12.01	
FeO	5.99		0.21	5.8	96.6	
MnO	0.78		0.01	0.77	98.13	
MgO	0.53		0.00	0.53	100.00	
Cr_2O_3	0.08		0.00	0.08	99.95	
SiO_2	0.69		0.66	0.03	3.89	
CaO	0.07		0.05	0.02	31.44	

APPENDIX G

The following data are for Figure 37 where the slag B was chlorinated to evaluate the kinetic model. The experiments were done at 950°C.

Exp 1	Time =	5	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	50.79		43.98	6.81	13.41	
TiO_2	45.39		42.38	3.02	6.64	
FeO	4.89		0.16	4.7	96.8	
MnO	0.59		0.02	0.58	97.18	
MgO	0.53		0.07	0.46	86.73	
Cr_2O_3	0.02		0.01	0.01	33.46	
SiO_2	0.80		0.69	0.10	12.96	
CaO	0.15		0.11	0.04	27.62	
Exp 2	Time =	7.75	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	51.10		44.12	6.98	13.66	
TiO_2	45.68		42.65	3.03	6.63	
FeO	4.92		0.16	4.8	96.7	
MnO	0.60		0.01	0.58	97.54	
MgO	0.54		0.10	0.44	81.80	
Cr_2O_3	0.02		0.01	0.01	37.90	
SiO_2	0.80		0.71	0.09	11.63	
CaO	0.15		0.10	0.04	29.24	

Exp 3	Time =	21	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	51.27		43.21	8.06	15.72	
TiO_2	45.82		41.78	4.04	8.81	
FeO	4.93		0.06	4.9	98.7	
MnO	0.60		0.00	0.60	100.00	
MgO	0.54		0.01	0.53	98.23	
Cr_2O_3	0.02		0.00	0.02	100.00	
SiO_2	0.80		0.69	0.12	14.42	
CaO	0.15		0.10	0.05	30.61	
Exp 4	Time =	30	min			
Cl_2	CO	N_2	Total	Cl_2	CO	N_2
l/min	l/min	l/min	l/min	%	%	%
5.76	5.76	7.68	19.2	30	30	40
	Mass In		Mass Out	Mass loss	Conversion	
	g		g	g	%	
Total	52.09		43.36	8.73	16.76	
TiO_2	46.55		41.98	4.57	9.82	
FeO	5.01		0.14	4.9	97.2	
MnO	0.61		0.01	0.60	98.03	
MgO	0.55		0.03	0.51	93.80	
Cr_2O_3	0.02		0.00	0.02	100.00	
SiO_2	0.82		0.70	0.12	14.59	
CaO	0.15		0.10	0.05	31.31	

APPENDIX H

The following data are for Figure 39 where an experiment was done on rutile to compare it to a kinetic model found in the literature. The experiment was done at 950°C.

Exp 1	Time =	30	min		dp =	200	µm
Cl_2	CO	N_2	Total	Cl_2	CO	N_2	
l/min	l/min	l/min	l/min	%	%	%	
5.76	5.76	7.68	19.2	30	30	40	
	Mass In		Mass Out	Mass loss	Conversion		
	g		g	g	%		
Total	50.24		48.70	1.53	3.05		
TiO_2	48.96		47.27	1.69	3.46		
FeO	0.23		0.09	0.1	61.1		
Cr_2O_3	0.05		0.03	0.02	39.71		

REFERENCES

Battle, T.P., Nguyen, D., Reeves, J.W., (1993) *The Processing of Titanium-Containing Ores*, The Paul E.Queneau International Symposium, pp 925 - 934.

Bergholm, A., (1961) *Chlorination of Rutile*, Transactions of the Metallurgical Society of AIME, **221**, pp 1121 - 1129.

Bessinger, D., Du Plooy, H., Pistorius, P.C., Visser, C., (1997) *Characteristics of Some High Titania Slags,* Heavy Minerals 1997. Proceedings of a Conference held in Durban, South Africa, October 1997. South African Institute of Mining and Metallurgy, pp 151 – 156.

Desrosiers, R., Ajersch, F., & Grau, A., (1980*) Electrical Conductivity of Industrial Slags of High Titanium Content,* 19th Annual Conference of Metallurgists*,* 24-27 August 1980, Halifax, Nova Scotia.

Dunn, W.E., Jr. (1960), *High Temperature Chlorination of TiO_2 Bearing Minerals*, Trans. AIME, pp 218, 6-12.

F*A*C*T Thermochemical Database, http://www.crct.polymtl.ca/fact/fact.htm

Fisher, J.R., (1997) *Developments in the TiO_2 Pigments Industry which will drive demand for TiO_2 mineral feedstocks*, Heavy Minerals 1997. Proceedings of a Conference held in Durban, South Africa, October 1997. South African Institute of Mining and Metallurgy, Johannesburg, pp 207 – 217.

Geldenhuis, J.M.A. & Pistorius, P.C., (1999) *The use of commercial oxygen probes during the production of high titania slags*, Journal of the South African Institute of Mining and Metallurgy, **99**, (1), pp 41-47.

Kahn, J.A., (1984) *Non-Rutile Feedstocks for the Production of Titanium*, Journal of Metals, July, pp 33 – 38.

Kubaschewski, O., Alcock, C.B. & Spencer, P.J. (1993) *Materials Thermochemistry*, 6th edition, Pergamon, Oxford.

Mackey, T.S., (1994) *Upgrading Ilmenite into a High-Grade Synthetic Rutile*, JOM, **63**, April, pp 59 – 64.

Macpherson, R.D., (1982) *Mineral Processing at Richards Bay Minerals*, Proceedings, 12th CMMI Congress. H.W. Glen (editor), Johannesburg, S. Afr. Inst. Min. Metall., pp 835 – 839.

Minkler, W.W. and Baroch, E. F. (1981), *The Production of Titanium, Zirconium and Hafnium*, in JK Tien & JF Elliot (eds.) Metallurgical Treatises, Metallurgical Society of the AIME, pp 171 – 182.

Morris, A.J. & Jensen, R.F., (1976) *Fluidised-Bed Chlorination Rates of Australian Rutile*, Metallurgical Transactions, **7B**, pp 89 - 93.

Nienow, A.W., Rowe, P.N. and Cheung, L.Y.-L., (1978) *A Quantitative Analysis of the Mixing of Two Segregating Powders of Different Density in a Gas-Fluidised Bed*, Powder Technology, **20**, pp 89 – 97.

Pesl, J., & Eric, R.H., (1997) *Metal-slag Equilibrium Pertinent to the Smelting Reduction of Ilmenite: Significance for Industrial Processes*, Heavy Minerals 1997. Proceedings of a Conference held in Durban, South Africa, October 1997. South African Institute of Mining and Metallurgy, pp 143-150.

Perry, R.H. & Green, D. (1984) *Perry's Chemical Engineers' Handbook*, 6th edition, McGraw-Hill Book Company.

Rao, Y.K., and Chadwick, B.K., (1988), *Chlorination of Rutile (TiO_2) with CO-Cl_2-He gas mixtures*, Trans. Inst. Min. Metall., Sect. C, **97**, pp 167 - 179.

Reeves, J.W. and Reeves, R.G., (1997) *Misconceptions About Titanium Ore Chlorination*, Heavy Minerals 1997. Proceedings of a Conference held in Durban, South Africa, October 1997. South African Institute of Mining and Metallurgy, pp 203-206.

Sohn, H.Y., and Szekeley, J., (1972) *A structural Model for Gas-Solid Reactions with a Moving Boundary – III. A Generalised Dimensionless Representation of the Irreversible Reaction between a Porous Solid and a Reactant Gas*, Chem. Eng. Sci., **27**, pp 763 – 778.

Sohn, H.Y., Zhou, L., (1998) *The Kinetics of Carbochlorination of Titania Slag*, The Canadian Journal of Chemical Engineering, **76**, pp 1078 - 1082.

Sohn, H.Y., Zhou, L., & Cho, K., (1998) *Intrinsic Kinetics and Mechanism of Rutile Chlorination by CO + Cl_2 Mixtures*, Ind. Eng. Chem. Res., **37**, (10), pp 3800 - 3805

Stanaway, K.J., (1994), *Overview of Titanium Dioxide Feedstocks*, Mining Engineering, **46**, (12), pp 1367 - 1370.

Stickler, H., (1984) *Varianten des Elred-Verfahrens*, Stahl und Eisen, 104, 11, pp 539-541.

Szekely, J., Evans, J., and Sohn, H.Y., (1976) *Gas-Solid Reactions*, Academic Press, New York, NY.

Szekely, J. & Themelis, N. J., (1971) *Rate Phenomena in Process Metallurgy*, Wiley & Sons, New York, pp 639 - 650.

Van Dyk, J.P., & Pistorius, P.C., (1999) *Evaluation of a Process that uses Phosphate Additions to Upgrade Titania Slag*, Metallurgical and Materials Transactions, **30B**, pp 823 – 826.

Yang, F. & Hlavacek, V., (1998) *Carbochlorination Kinetics of Titanium Dioxide with Carbon and Carbon Monoxide as Reductant*, Metallurgical & Materials Transactions, **29B**, pp 1297 – 1307.

Zhou, L., Sohn, H. Y., Whiting, G.K. and Leary, K.J., (1996) *Microstructural Changes in Several Titaniferous Materials during Chlorination Reaction*, Ind. Eng. Chem. Res., **35**, pp 954 – 962.

Zhou, L. (1994) *Fluidized Bed Chlorination of Several Titaniferous Materials – Kinetics, Morphological Changes and Mathematical Modeling*, A dissertation submitted to the faculty of The University of Utah in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June 1994, p 111.