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## **Data Repository**

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**APPENDIX 1: LOCATIONS FOR WALDEN CREEK GROUP SAMPLES**

Sample	Formation	Lithology	Latitude	Longitude	UTM		Mineral Analyzed
5-1-2	Wilhite	poorly-sorted arkosic sandstone	35 10' 28"	-84 25' 59"	17S 187330.89mE	3897788.56mN	monazite
5-2-1A	Wilhite	quartz-pebble conglomerate	35 19' 30"	-84 17' 54"	17S 200161.21mE	3914078.74mN	monazite, zircon
Carter 5.1	Wilhite	subarkosic sandstone	35 36' 08"	-84 02' 58"	17S 223744.89mE	3944112.65mN	monazite, zircon
FL7	Wilhite	quartz-rich sandstone	35 30' 04"	-84 06' 51"	17S 217524.82mE	3933077.21mN	monazite, zircon
KS12-2C	Wilhite	very poorly sorted subarkosic sandstone with shale clasts	35 44' 20"	-83 45' 38"	17S 250349.17mE	3958502.47mN	zircon
PF12-1	Shields	poorly sorted feldspathic sandstone	35 45' 40"	-83 37' 18"	17S 262978.42mE	3960623.05mN	zircon, monazite
WC12-2A	Shields	quartz-rich poorly sorted angular sandstone	35 42' 59"	-83 40' 19"	17S 258296.57mE	3955784.02mN	zircon
WCK12-1	Sandsuck	quartz-pebble conglomerate	35 48' 13"	-83 39' 13"	17S 260217.49mE	3965416.13mN	zircon, monazite

## APPENDIX 2. SIMS Th-Pb MONAZITE GEOCHRONOLOGY

Analysis	Age (Ma)			
	208Pb/ 232Th	± (Ma)	208*/ 232Th	± %
<b>5-2-1A Wilhite Fm.</b>				
2013_09_26Sep\ Big_mnz@45.ais	983	19	0.049841	1.9
2013_09_26Sep\ Big_mnz@46.ais	1013	22	0.051395	2.1
2013_09_26Sep\ Big_mnz@47.ais	1011	21	0.051291	2.0
2013_09_27Sep\ small_mnz@43.ais	1021	20	0.051812	1.9
2013_09_27Sep\ small_mnz@45.ais	979	19	0.049602	1.9
2013_09_27Sep\ small_mnz@46.ais	1172	23	0.059699	1.9
2013_09_27Sep\ small_mnz@47.ais	1152	22	0.058651	1.8
2013_09_27Sep\ small_mnz@48.ais	1132	22	0.057604	1.9
<b>5-1-2 Wilhite Fm.</b>				
2013_09_26Sep\ Big_mnz@78.ais	477	9	0.023880	1.9
2013_09_26Sep\ Big_mnz@81.ais	472	9	0.023627	1.9
2013_09_26Sep\ Big_mnz@85.ais	487	13	0.024367	2.6
2013_09_26Sep\ Big_mnz@86.ais	479	10	0.023956	2.0
2013_09_26Sep\ Big_mnz@95.ais	493	12	0.024666	2.3
2013_09_27Sep\ small_mnz@25.ais	514	16	0.025741	3.1
2013_09_27Sep\ small_mnz@28.ais	1031	21	0.052332	1.9
<b>Carter 5.1 Wilhite Fm.</b>				
2013_09_26Sep\ Big_mnz@55.ais	486	15	0.024336	3.0
2013_09_26Sep\ Big_mnz@56.ais	513	16	0.025690	3.2
2013_09_26Sep\ Big_mnz@58.ais	452	8	0.022599	1.9
2013_09_26Sep\ Big_mnz@61.ais	543	19	0.027219	3.4
2013_09_26Sep\ Big_mnz@62.ais	456	9	0.022832	1.9
2013_09_26Sep\ Big_mnz@65.ais	454	9	0.022731	1.9
2013_09_26Sep\ Big_mnz@66.ais	516	17	0.025863	3.3
2013_09_26Sep\ Big_mnz@69.ais	431	8	0.021563	1.9
2013_09_26Sep\ Big_mnz@70.ais	465	9	0.023267	1.9
2013_09_26Sep\ Big_mnz@71.ais	507	15	0.025381	3.0
2013_09_26Sep\ Big_mnz@72.ais	450	9	0.022503	1.9
2013_09_27Sep\ small_mnz@31.ais	448	8	0.022432	1.8
2013_09_27Sep\ small_mnz@35.ais	456	8	0.022837	1.7
2013_09_27Sep\ small_mnz@36.ais	458	8	0.022918	1.7
2013_09_27Sep\ small_mnz@37.ais	1054	20	0.053530	1.8
2013_09_27Sep\ small_mnz@38.ais	462	9	0.023105	1.9
2013_09_27Sep\ small_mnz@41.ais	458	8	0.022938	1.7
<b>FL7 Wilhite Fm.</b>				
2013_09_26Sep\ Big_mnz@1.ais	1018	18.5	0.051655	1.8
2013_09_26Sep\ Big_mnz@10.ais	992.6	21.3	0.050335	2.1
2013_09_26Sep\ Big_mnz@11.ais	1028	22.4	0.052176	2.1
2013_09_26Sep\ Big_mnz@2.ais	1122	21	0.057081	1.8
2013_09_26Sep\ Big_mnz@3.ais	1019	23.1	0.051707	2.2

2013_09_26Sep\	Big_mnz@4.ais	1063	23.2	0.053999	2.1
2013_09_26Sep\	Big_mnz@5.ais	1126	23.8	0.057290	2.1
2013_09_26Sep\	Big_mnz@6.ais	921.4	20.2	0.046641	2.1
2013_09_26Sep\	Big_mnz@7.ais	1017	19.4	0.051603	1.9
2013_09_26Sep\	Big_mnz@8.ais	1164	24.7	0.059279	2.1
2013_09_26Sep\	Big_mnz@9.ais	1062	22.7	0.053947	2.1
2013_09_27Sep\	small_mnz@1.ais	1041.0	16.6	0.052853	1.6
2013_09_27Sep\	small_mnz@10.ais	1089.0	22.1	0.055356	2.0
2013_09_27Sep\	small_mnz@11.ais	1067.0	23.4	0.054208	2.1
2013_09_27Sep\	small_mnz@12.ais	1146.0	20.6	0.058337	1.7
2013_09_27Sep\	small_mnz@13.ais	1106.0	20.6	0.056244	1.8
2013_09_27Sep\	small_mnz@14.ais	1162.0	25.0	0.059175	2.1
2013_09_27Sep\	small_mnz@15.ais	1036.0	19.8	0.052592	1.9
2013_09_27Sep\	small_mnz@16.ais	971.4	19.7	0.049234	2.0
2013_09_27Sep\	small_mnz@18.ais	991.6	16.5	0.050283	1.6
2013_09_27Sep\	small_mnz@19.ais	1061.0	22.4	0.053895	2.1
2013_09_27Sep\	small_mnz@2.ais	1100.0	18.1	0.055931	1.6
2013_09_27Sep\	small_mnz@3.ais	1147.0	23.3	0.058389	2.0
2013_09_27Sep\	small_mnz@4.ais	1019.0	20.3	0.051707	1.9
2013_09_27Sep\	small_mnz@5.ais	1043.0	21.4	0.052957	2.0
2013_09_27Sep\	small_mnz@6.ais	942.5	13.8	0.047734	1.4
2013_09_27Sep\	small_mnz@8.ais	1141.0	21.8	0.058075	1.9
2013_09_27Sep\	small_mnz@9.ais	1002.0	19.2	0.050823	1.9

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**PF 12-1 Shields Fm.**

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2013_09_26Sep\	Big_mnz@12.ais	1000	19.3	0.050719	1.9
2013_09_26Sep\	Big_mnz@13.ais	998.5	22.9	0.050641	2.2
2013_09_26Sep\	Big_mnz@24.ais	999.6	21.5	0.050699	2.1
2013_09_26Sep\	Big_mnz@27.ais	1050	22.9	0.053322	2.1
2013_09_26Sep\	Big_mnz@29.ais	1001	19.9	0.050771	1.9
2013_09_26Sep\	Big_mnz@30.ais	1132	19.9	0.057604	1.7
2013_09_26Sep\	Big_mnz@31.ais	1024	20.8	0.051968	2.0
2013_09_27Sep\	small_mnz@51.ais	1061.0	22.2	0.053895	2.0
2013_09_27Sep\	small_mnz@52.ais	1003.0	19.1	0.050875	1.9
2013_09_27Sep\	small_mnz@54.ais	1039.0	19.4	0.052749	1.8
2013_09_27Sep\	small_mnz@55.ais	977.2	16.7	0.049535	1.7
2013_09_27Sep\	small_mnz@56.ais	1203.0	21.4	0.061325	1.7

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**WCK12-1 Sandsuck Fm.**

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2013_09_26Sep\	Big_mnz@34.ais	1013	19	0.051395	1.8
2013_09_26Sep\	Big_mnz@35.ais	1061	29.5	0.053895	2.7
2013_09_26Sep\	Big_mnz@39.ais	1212	46.4	0.061798	3.7
2013_09_27Sep\	small_mnz@60.ais	1030.0	19.2	0.052280	1.8
2013_09_27Sep\	small_mnz@63.ais	1023.0	20.9	0.051916	2.0
2013_09_27Sep\	small_mnz@64.ais	974.3	18.4	0.049384	1.8
2013_09_27Sep\	small_mnz@65.ais	1031.0	17.9	0.052332	1.7

5-1-2																													
SAMPLE	m1 hi Th	m1 low Th lower	m1 low Th upper	m3 low Y left	m3 hi Y right	m3 higher Th	m3 hi Th rim upper left	m4 higher Th	m4 low Th left	m6 hi Th right	m6 low Th left	5-1-2 m2	5-1-2 m7	5-1-2 m8 upper right	5-1-2 m9	m10 upper left	m11	m12	m14 higher Th lower left	m14 upper	m15 upper	m16 hi Th middle	m16 lower Th right	m16 lower	m17 hi Th core	m17 low Th	m17 hi Th rim left	m8 hi Th rim upper right	m10 hi Th rim left
n																													
U WT%	0.036	0.021	0.098	0.061	0.055	0.018	0.021	0.043	0.022	0.050	0.022	0.047	0.026	0.054	0.060	0.033	0.049	0.067	0.042	0.043	0.038	0.030	0.040	0.052	0.038	0.022	0.045	0.030	0.038
Th WT%	5.90	0.69	1.38	0.02	1.70	5.37	1.51	6.41	2.70	4.64	1.67	3.18	0.29	1.88	1.56	2.00	7.75	2.80	2.61	1.38	2.38	7.71	3.77	3.10	4.16	0.43	1.63	1.73	2.37
Pb WT%	0.132	0.014	0.036	0.004	0.044	0.121	0.025	0.147	0.055	0.103	0.039	0.080	0.009	0.048	0.038	0.048	0.180	0.067	0.056	0.034	0.051	0.174	0.091	0.069	0.090	0.011	0.036	0.037	0.053
U PPM	361	206	984	613	545	175	208	425	221	502	224	473	255	543	597	330	492	672	420	429	382	295	397	516	379	219	450	299	380
Th PPM	58985	6943	13833	166	16952	53683	15122	64085	26996	46440	16731	31810	2926	18781	15608	20005	77465	28044	26090	13843	23830	77135	37675	30952	41626	4262	16273	17318	23699
Pb PPM	1316	137	362	44	436	1208	250	1473	553	1033	387	798	87	480	382	482	1797	673	564	336	514	1737	914	695	900	113	361	369	527
%Pb(Th) <sup>1</sup>	98.1	90.6	75.4	7.7	81.4	98.9	95.8	97.8	97.4	96.5	95.7	93.0	77.1	90.8	88.9	94.9	98.0	92.2	94.6	90.6	94.8	98.8	96.7	94.8	97.1	85.2	90.5	94.6	95.0
%Pb(U) <sup>1</sup>	1.9	9.4	24.5	92.3	18.5	1.1	4.2	2.2	2.6	3.5	4.2	7.0	22.9	9.2	11.1	5.1	2.0	7.8	5.4	9.3	5.2	1.2	3.3	5.2	2.9	14.8	9.5	5.4	5.0
Age (m.y.) <sup>2</sup>	488	449	508	454	520	492	356	502	441	477	490	539	512	518	486	508	506	495	453	492	453	495	521	478	468	506	455	448	471
Std. Dev. (m.y.)	17	9	24	58	18	21	18	21	21	11	30	27	26	24	28	11	6	17	34	42	36	21	24	15	9	14	6	20	43
UO <sub>2</sub>	0.041	0.023	0.112	0.070	0.062	0.020	0.024	0.048	0.025	0.057	0.025	0.054	0.029	0.062	0.068	0.037	0.056	0.076	0.048	0.049	0.043	0.033	0.045	0.058	0.043	0.025	0.051	0.034	0.043
K <sub>2</sub> O	0.01	0.05	0.02	0.01	0.01	0.01	0.05	0.05	0.06	0.01	0.00	0.01	0.01	0.02	0.05	0.01	0.01	0.01	0.03	0.01	0.04	0.00	0.01	0.01	0.00	0.01	0.04	0.07	0.07
ThO <sub>2</sub>	6.71	0.79	1.57	0.02	1.93	6.11	1.72	7.29	3.07	5.28	1.90	3.62	0.33	2.14	1.78	2.28	8.81	3.19	2.97	1.58	2.71	8.78	4.29	3.52	4.74	0.49	1.85	1.97	2.70
CaO	1.05	0.34	0.46	0.05	0.49	1.02	0.20	1.05	0.41	0.99	0.49	0.74	0.27	0.52	0.43	0.59	1.51	0.66	0.62	0.53	0.63	1.42	1.02	0.71	0.98	0.29	0.29	0.28	0.37
SO <sub>3</sub>	0.27	0.42	0.30	0.07	0.19	0.15	0.02	0.19	0.01	0.23	0.42	0.34	0.38	0.19	0.25	0.46	0.23	0.28	0.32	0.26	0.29	0.25	0.76	0.25	0.36	0.37	0.04	0.02	0.02
P <sub>2</sub> O <sub>5</sub>	27.17	29.23	28.08	30.24	29.06	26.40	30.48	29.05	29.38	28.47	29.46	28.22	30.01	29.21	29.69	29.31	24.64	29.44	29.48	29.60	28.95	24.36	25.56	29.73	27.66	30.00	29.94	26.85	29.71
Y <sub>2</sub> O <sub>3</sub>	0.44	0.26	0.69	0.42	0.69	0.46	0.23	0.41	0.33	0.63	0.29	0.46	0.25	0.77	0.52	0.39	0.55	0.58	0.46	0.86	0.57	0.51	0.34	0.76	0.64	0.27	0.46	0.23	0.43
SrO	0.44	0.26	0.17	0.02	0.20	0.28	0.07	0.48	0.04	0.45	0.34	0.50	0.20	0.27	0.19	0.39	0.56	0.30	0.27	0.30	0.32	0.54	0.71	0.42	0.46	0.22	0.07	0.10	0.08
SiO <sub>2</sub>	0.21	0.07	0.06	0.05	0.07	0.18	0.12	0.23	0.23	0.11	0.04	0.17	0.05	0.07	0.08	0.05	0.28	0.15	0.12	0.08	0.10	0.34	0.10	0.09	0.14	0.02	0.12	0.22	0.29
PbO	0.142	0.015	0.039	0.005	0.047	0.130	0.027	0.159	0.060	0.111	0.042	0.086	0.009	0.052	0.041	0.052	0.194	0.072	0.061	0.036	0.055	0.187	0.098	0.075	0.097	0.012	0.039	0.040	0.057
La <sub>2</sub> O <sub>3</sub>	8.56	19.99	10.12	11.30	6.91	4.32	14.02	10.76	13.68	8.42	12.10	9.97	15.39	9.82	13.32	11.95	6.88	8.69	10.38	7.15	12.54	6.16	9.09	12.18	6.67	14.41	13.07	14.36	13.73
Ce <sub>2</sub> O <sub>3</sub>	28.76	33.25	32.13	34.05	27.59	21.80	29.17	29.79	26.88	27.94	33.68	30.89	35.37	30.30	31.64	33.49	25.89	30.69	29.52	28.21	30.56	25.79	31.55	31.70	27.11	35.90	28.30	28.61	27.47
Nd <sub>2</sub> O <sub>3</sub>	16.68	10.30	17.39	17.77	22.00	23.86	16.26	14.22	15.93	17.99	15.64	17.35	13.65	18.89	15.22	15.32	18.23	18.63	18.16	22.41	16.60	19.34	18.69	15.30	20.75	14.60	16.86	15.82	15.90
Pr <sub>2</sub> O <sub>3</sub>	3.83	2.93	4.12	4.16	4.39	4.10	3.46	3.54	3.24	3.87	3.91	4.00	3.65	4.01	3.53	3.80	3.82	4.11	3.88	4.38	3.66	3.94	4.26	3.63	4.29	3.92	3.56	3.39	3.30
Eu <sub>2</sub> O <sub>3</sub>	0.43	0.25	0.51	0.50	0.79	1.02	0.73	0.36	0.66	0.53	0.37	0.48	0.34	0.64	0.53	0.38	0.55	0.51	0.62	0.73	0.48	0.56	0.51	0.45	0.64	0.24	0.71	0.72	0.69
Sm <sub>2</sub> O <sub>3</sub>	2.27	1.10	2.55	2.51	3.86	5.46	3.72	1.86	3.91	2.77	1.84	2.36	1.50	3.09	2.67	1.81	2.98	2.72	3.15	3.91	2.47	3.03	2.58	2.24	3.42	1.58	3.94	3.62	3.94
Dy <sub>2</sub> O <sub>3</sub>	0.13	0.05	0.17	0.12	0.31	0.25	0.15	0.08	0.24	0.20	0.07	0.11	0.05	0.23	0.19	0.10	0.20	0.13	0.19	0.23	0.12	0.11	0.11	0.15	0.21	0.00	0.29	0.17	0.27
Er <sub>2</sub> O <sub>3</sub>	0.03	0.03	0.09	0.05	0.03	bd	0.00	0.04	0.02	0.07	0.02	0.06	0.02	0.09	0.04	0.03	0.08	0.05	0.03	0.07	0.02	0.04	0.04	0.04	0.03	0.01	0.03	bd	0.04
Gd <sub>2</sub> O <sub>3</sub>	0.61	0.28	0.77	0.70	1.44	2.18	1.81	0.55	1.89	0.88	0.43	0.70	0.35	1.05	1.15	0.50	1.00	0.78	1.22	1.23	0.73	0.85	0.68	0.71	1.01	0.38	2.01	1.90	2.13
Total	97.79	99.64	99.36	102.11	100.06	97.75	102.26	100.17	100.08	99.02	101.10	100.11	101.85	101.41	101.38	100.93	96.48	101.06	101.51	101.61	100.88	96.23	100.45	102.02	99.24	102.74	101.68	98.40	101.23

SAMPLE	38Q6																
	m2 hi Th lower	m2 mid Th left side	m2 low Th right	m3 middle	m3 upper left	m3 lower	m3 hi Th rim lower	m4 middle	m4 upper area	m1 lower	m1 lower	m6 area 1	m6 area 2	m6 area 3	m7 area 1	m7 area 2	m7 area 3
n																	
U WT%	0.029	0.205	0.055	0.161	0.128	0.076	0.028	0.622	0.558	0.122	0.124	0.066	0.049	0.040	0.079	0.057	0.052
Th WT%	8.01	1.60	0.85	1.29	0.91	0.93	2.72	7.56	6.86	3.38	3.23	2.12	2.40	1.60	1.55	1.66	1.50
Pb WT%	0.165	0.047	0.019	0.041	0.028	0.025	0.059	0.457	0.413	0.189	0.196	0.054	0.056	0.039	0.037	0.039	0.034
U PPM	294	2052	554	1612	1281	757	282	6225	5580	1215	1238	665	486	401	794	565	517
Th PPM	80059	16037	8523	12868	9058	9338	27242	75566	68574	33775	32295	21218	23959	15957	15499	16567	15006
Pb PPM	1653	466	187	408	280	251	593	4566	4126	1891	1958	537	561	391	370	388	343
%Pb(Th) <sup>1</sup>	98.8	70.5	82.5	70.9	67.7	79.1	96.5	78.1	78.3	89.0	88.3	87.1	93.6	91.8	85.7	89.9	89.7
%Pb(U) <sup>1</sup>	1.2	29.5	17.5	29.1	32.3	20.9	3.5	21.9	21.7	11.0	11.7	12.9	6.4	8.2	14.2	10.1	10.2
Age (m.y.) <sup>2</sup>	455	458	406	502	472	473	468	1036	1034	1094	1173	509	491	498	454	467	455
Std. Dev. (m.y.)	24	18	35	25	32	38	15	14	20	11	23	24	10	19	21	23	31
UO <sub>2</sub>	0.033	0.233	0.063	0.183	0.145	0.086	0.032	0.706	0.633	0.138	0.140	0.075	0.055	0.046	0.090	0.064	0.059
K <sub>2</sub> O	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.04	0.04	0.03	0.02	0.03	0.03
ThO <sub>2</sub>	9.11	1.82	0.97	1.46	1.03	1.06	3.10	8.60	7.80	3.84	3.67	2.41	2.73	1.82	1.76	1.89	1.71
CaO	0.54	0.29	0.25	0.17	0.16	0.05	0.21	0.73	0.68	0.11	0.10	0.13	0.23	0.21	0.18	0.13	0.12
SO <sub>3</sub>	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01
P <sub>2</sub> O <sub>5</sub>	27.19	29.42	29.66	29.78	29.52	29.99	29.38	27.61	28.11	28.08	28.52	29.25	29.57	30.09	30.01	30.06	29.99
Y <sub>2</sub> O <sub>3</sub>	0.28	0.79	0.79	0.75	0.81	0.68	0.33	1.28	1.22	1.32	1.36	0.54	0.54	0.53	0.55	0.44	0.41
SrO	1.95	0.65	0.52	0.50	0.42	0.22	0.75	0.01	0.01	0.01	bd	0.52	0.65	0.70	0.41	0.48	0.44
SiO <sub>2</sub>	0.33	0.07	0.06	0.05	0.05	0.03	0.11	1.09	0.98	0.75	0.82	0.11	0.13	0.11	0.07	0.07	0.09
PbO	0.178	0.050	0.020	0.044	0.030	0.027	0.064	0.492	0.444	0.204	0.211	0.058	0.060	0.042	0.040	0.042	0.037
La <sub>2</sub> O <sub>3</sub>	9.49	4.79	5.07	9.09	9.89	9.25	11.28	12.04	12.45	9.73	9.71	9.69	8.73	11.62	7.43	12.07	10.83
Ce <sub>2</sub> O <sub>3</sub>	30.68	25.11	26.25	32.32	32.69	33.41	34.34	28.16	28.51	29.10	28.84	33.30	32.64	34.92	31.24	34.65	34.63
Nd <sub>2</sub> O <sub>3</sub>	13.80	25.96	25.60	19.03	17.95	18.89	14.88	12.31	12.16	18.04	18.09	17.34	18.67	15.35	21.33	15.10	16.58
Pr <sub>2</sub> O <sub>3</sub>	3.67	4.72	4.71	4.36	4.11	4.38	3.87	3.12	3.07	3.98	3.86	4.15	4.35	3.96	4.63	3.87	4.20
Eu <sub>2</sub> O <sub>3</sub>	0.22	0.68	0.64	0.41	0.37	0.36	0.26	0.07	0.12	0.13	0.14	0.33	0.38	0.26	0.44	0.30	0.28
Sm <sub>2</sub> O <sub>3</sub>	1.21	4.40	4.06	2.42	2.16	2.19	1.33	2.14	2.09	2.63	2.57	1.82	2.06	1.44	2.62	1.52	1.63
Dy <sub>2</sub> O <sub>3</sub>	0.08	0.42	0.39	0.35	0.35	0.26	0.13	0.40	0.38	0.50	0.52	0.24	0.24	0.20	0.22	0.21	0.16
Er <sub>2</sub> O <sub>3</sub>	0.00	0.06	0.06	0.06	0.03	0.04	0.00	0.08	0.05	0.06	0.08	0.05	0.04	0.03	0.06	0.01	0.03
Gd <sub>2</sub> O <sub>3</sub>	0.27	1.67	1.41	0.71	0.67	0.59	0.34	1.32	1.27	1.73	1.68	0.50	0.50	0.39	0.70	0.50	0.38
Total	99.08	101.14	100.55	101.71	100.39	101.52	100.45	100.17	100.00	100.39	100.34	100.58	101.62	101.77	101.83	101.48	101.62