TABLE 1. ANALYSIS TECHNIQUES AND DATA (ppm) FOR ANALYZED ZIRCON IN FIGURE 1.

Sample: BOGGY PLAIN (d = diorite; a = aplite) [1]

Analysis	d-1	d-2	d-3	d-4	d-5	d-6	a-1	a-2
La	0.03	0.05	0.02	0.07	0.03	0.03	0.09	0.06
Ce	3.6	5.7	4.4	8.3	6.3	5.2	15	16
Pr	0.01	0.09	0.01	0.13	0.08	0.04	0.14	0.11
Nd	0.4	2.6	0.5	3.8	2.6	1.3	0.9	1.0
Sm	0.9	5	1.2	6	5	2.6	2.1	2.2
Eu	0.2	0.7	0.3	1.0	0.8	0.5	0.6	0.4
Gd	6.3	21	8.2	30	23	15	14	12
Tb	2.1	6.2	2.4	9.5	6.9	4.6	4.7	4.1
Dy	25	67	29	108	73	52	50	41
Ho	10	26	11	46	28	21	20	16
Er	51	127	55	218	127	102	107	83
Tm	11	26	12	44	26	21	21	16
Yb	122	270	125	462	269	231	225	174
Lu	27	59	27	100	55	49	53	39
HfO_2		2.36	2.37	2.28		2.72	2.83	3.42
$(Yb/Sm)_N$	125	50	96	71	49	82	98	73
$(Yb/Gd)_N$	24	16	19	19	14	19	20	18
$(Sm/La)_N$	48	160	96	137	267	139	37	59
Eu/Eu*	0.26	0.21	0.29	0.23	0.23	0.24	0.34	0.24
Ce/Ce*	50	21	75	21	31	36	32	48

Sample: BLIND GABBRO [2]

Analysis	a-3	a-4	1	2	3	4	5	6
P			996	428	350	449	708	635
Y			8514	3316	3045	4288	3737	6016
La	0.06	0.23	0.1	3.6	0.8	0.1	4.1	0.1
Ce	19	22	49	46	28	35	41	38
Pr	0.16	0.12	1.0	2.1	0.7	0.6	1.4	0.8
Nd	1.5	2.0	13	13	8	9	11	11
Sm	4.1	3.2	24	16	10	15	17	17
Eu	0.5	1.1	2.9	2.0	1.1	1.3	1.5	1.9
Gd	31	18	148	73	47	63	64	83
Tb	12.9	6.6	54	24	18	25	24	32
Dy	149	71	744	290	237	336	300	450
Ho	63	31	284	112	94	132	119	187
Er	346	177	1134	457	416	558	509	785
Tm	70	38	217	89	84	110	99	149
Yb	773	452	1515	656	619	788	735	1068
Lu	177	113	235	109	106	130	118	173
HfO_2	3.98		1.54	1.58	1.72	1.66	1.71	1.53
$(Yb/Sm)_N$	173	130	58	38	57	48	40	58
$(Yb/Gd)_N$	31	31	13	11	16	15	14	16
$(Sm/La)_N$	109	22	384	7.1	20	240	6.6	272
Eu/Eu*	0.14	0.44	0.15	0.18	0.15	0.13	0.14	0.15
Ce/Ce*	47	32	37	4.0	9.1	35	4.1	33

Sample: MAWSON IGNEOUS CHARNOCKITE [3]

Analysis	7	8	1	2	3	4	5	6
P	429	876	31	34	48	60	61	52
Y	4406	8150	649	732	757	1170	1127	639
La	1.2	0.14	0.03	0.03	0.11	0.04	0.20	0.02
Ce	40	56	24	26	28	36	34	24
Pr	1.3	1.1	0.12	0.09	0.28	0.21	0.61	0.10
Nd	11	15	0.9	1.1	1.2	2.0	5.0	0.8
Sm	14	24	1.7	2.5	3.6	5.0	5.9	1.7
Eu	1.6	2.7	0.50	0.55	0.60	0.68	0.77	0.44
Gd	69	144	9.0	12	16	27	24	9.0
Tb	21	53	4.2	3.9	5.2	8.0	7.1	3.6
Dy	325	723	58	66	69	111	89	57
Ho	145	286	24	27	28	46	35	22
Er	639	1166	104	120	127	192	146	110
Tm	118	224	23	28	27	40	29	25
Yb	909	1594	178	227	211	288	232	199
Lu	153	274	34	43	39	55	41	38
HfO_2	1.73	1.61	2.08	2.13	2.19	2.13	1.76	2.01
$(Yb/Sm)_N$	60	61	96	83	54	53	36	108
$(Yb/Gd)_N$	16	14	24	23	16	13	12	27
$(Sm/La)_N$	19	275	91	133	52	200	47	136
Eu/Eu*	0.16	0.14	0.39	0.31	0.24	0.18	0.20	0.34
Ce/Ce*	7.7	35	97	121	39	95	24	130

Sample: SYROS OPHIOLITE [4]

Analysis	7	8	9	1	2	3	4	5
P	72	67	77	1394	628	797	646	657
Y	1490	1769	2151	7185	4518	6290	5752	4563
La	0.04	0.02	0.08	0.03	0.01	0.04	0.12	0.14
Ce	37	42	46	53	8.8	12	11	11
Pr	0.4	0.4	0.7	0.29	0.27	0.41	0.51	0.45
Nd	4.9	4.9	8.1	5.1	4.6	7.8	9.1	6.4
Sm	9.8	11	14	12	10	19	19	12
Eu	0.9	0.7	1.5	2.5	2.5	4.5	4.0	2.6
Gd	42	49	53	67	52	87	86	60
Tb	11	13	13	40	28	45	43	32
Dy	157	189	224	561	360	552	514	394
Ho	60	69	84	236	151	213	201	159
Er	231	283	339	1178	737	974	912	725
Tm	48	54	68	254	154	192	179	152
Yb	353	394	464	2099	1266	1569	1459	1218
Lu	63	71	84	414	250	298	281	239
HfO_2	2.22	1.89	2.34	1.59	1.19	1.15	1.24	1.28
$(Yb/Sm)_N$	33	33	30	161	116	76	71	93
$(Yb/Gd)_N$	10	10	11	39	30	22	21	25
$(Sm/La)_N$	392	881	280	641	1601	761	254	137
Eu/Eu*	0.14	0.09	0.17	0.27	0.33	0.34	0.30	0.30
Ce/Ce*	71	114	47	137	41	23	11	11

				Sample: MANILLA PLAGIOGRANITE [5]				
Analysis	6	7	8	1	2	3	4	5
P	305	890	1021	25	39	23	59	37
Y	1175	2295	3714	3506	1820	881	2514	1486
La	0.06	0.01	0.01	0.11	0.13	0.20	0.13	0.19
Ce	3.7	22	30	32	13	6	20	14
Pr	0.05	0.06	0.14	0.56	0.18	0.11	0.24	0.16
Nd	0.8	1.5	2.3	4.8	0.9	0.4	1.9	0.7
Sm	2.0	3.5	5.9	24	6.0	2.1	8.9	5.8
Eu	0.43	0.90	1.3	14	2.0	1.4	5.5	4.0
Gd	9.4	20	37	86	27	9	37	23
Tb	5.7	12	20					
Dy	84	168	276	326	135	66	201	124
Ho	37	72	117					
Er	187	374	587	556	276	153	423	231
Tm	41	83	125					
Yb	384	721	1068	1298	685	427	1057	560
Lu	73	146	244	235	137	86	211	111
HfO_2	1.28	1.54	1.44	0.75	0.86	1.09	0.83	0.90
$(Yb/Sm)_N$	176	189	166	50	105	187	109	89
$(Yb/Gd)_N$	50	45	36	19	31	59	35	30
$(Sm/La)_N$	53	560	945	349	74	17	110	49
Eu/Eu*	0.30	0.33	0.27	0.94	0.48	0.98	0.92	1.06
Ce/Ce*	16	217	194	31	21	10	27	19

			Sample: PHALABO-RWA CARB-ONATITE [6]	Sample: MUD TANK CARBONATITE [7]				
Analysis	6	7		1	2	3	4	5
P	32	29		122	80	48	35	22
Y	699	397	1000	41	43	35	28	29
La	0.26	0.22	0.04	0.03	0.03	0.05	0.04	0.05
Ce	20	6.5	14	0.55	0.51	0.51	0.46	0.49
Pr	0.26	0.15	0.12	0.03	0.02	0.04	0.02	0.02
Nd	0.8	0.23	1.9	0.16	0.15	0.21	0.21	0.15
Sm	4.0	1.8	4	0.27	0.27	0.24	0.20	0.25
Eu	1.7	1.3	1.1	0.16	0.17	0.18	0.14	0.12
Gd	12	6.2	22	1.2	1.3	1.1	1.0	0.9
Dy	59	29	68	4.7	4.8	3.9	3.3	3.2
Ho			25					
Er	110	65	98	6.1	6.1	5.2	4.0	3.9
Tm			21	1.1	1.1	0.9	0.8	0.7
Yb	258	194	185	8.6	8.4	7.5	5.8	5.7
Lu	48	43	39	1.5	1.5	1.3	1.0	1.0
HfO_2	0.81	0.99	0.26					
$(Yb/Sm)_N$	59	99	43	29	29	29	27	21
$(Yb/Gd)_N$	27	39	10	8.9	8.0	8.4	7.2	7.8
$(Sm/La)_N$	25	13	160	14	14	7.7	8.0	8.0
Eu/Eu*	0.75	1.19	0.36	0.86	0.87	1.07	0.95	0.77
Ce/Ce*	19	8.7	49	4.4	5.0	2.8	3.9	3.7

Analysis	6	7	8	9	10	11	12	13
P	<91	<81	<77	72	60	54	<72	<144
Y	28	34	29	28	25	31	27	33
La	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.05
Ce	0.46	0.52	0.44	0.43	0.47	0.52	0.51	0.62
Pr	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Nd	0.19	0.17	0.13	0.17	0.15	0.12	0.18	0.24
Sm	0.22	0.23	0.23	0.16	0.22	0.26	0.18	0.2
Eu	0.12	0.16	0.17	0.15	0.17	0.12	0.14	0.25
Gd	0.82	1.1	0.99	0.91	0.78	0.96	0.74	0.84
Dy	3.3	4.2	3.0	3.2	3.0	3.2	3.0	3.8
Er	3.9	4.9	4.0	3.9	3.6	4.5	4.0	4.5
Tm	0.76	0.98	0.79	0.70	0.64	0.77	0.70	0.83
Yb	5.5	7.3	6.5	5.8	4.8	6.1	5.5	6.6
Lu	1.0	1.2	1.0	1.0	0.9	1.0	1.0	1.2
$(Yb/Sm)_N$	23	29	26	33	20	22	28	30
$(Yb/Gd)_N$	8.3	8.2	8.1	7.9	7.6	7.9	9.2	9.7
$(Sm/La)_N$	8.8	12	9.2	6.4	8.8	10	9.6	6.4
Eu/Eu*	0.86	0.97	1.09	1.20	1.25	0.73	1.17	1.86
Ce/Ce*	3.9	4.2	3.1	3.0	3.3	3.6	4.1	3.9

Analysis	14	15	16	17	18	19	20	Sample: JWANENG Kimberlite [8]
P	<97	<97	<94	<106	47	<56	54	58
Y	40	45	43	17	34	21	16	32
La	<0.04	0.04	0.04	<0.04	0.01	<0.04	0.009	0.02
Ce	0.48	0.57	0.55	0.52	0.53	0.58	0.49	1.8
Pr	0.02	0.04	0.04	<0.04	<0.04	0.02	0.008	0.04
Nd	0.22	0.24	0.23	<0.2	0.07	0.22	0.04	0.2
Sm	0.30	0.21	0.39	0.33	0.14	0.17	0.13	0.7
Eu	0.14	0.18	0.16	0.10	0.18	0.08	0.05	0.5
Gd	1.1	1.5	1.4	0.53	1.1	0.56	0.51	2
Tb								0.5
Dy	4.5	5.1	5.0	2.0	4.1	2.2	1.9	3
Ho								0.5
Er	5.7	6.1	6.2	2.5	4.8	2.5	2.3	2.2
Tm	1.0	1.3	1.1	0.51	0.89	0.50	0.43	0.4
Yb	7.8	9.6	9.2	3.8	6.9	3.7	3.4	2.3
Lu	1.4	1.6	1.7	0.7	1.3	0.59	0.60	0.5
HfO_2								0.76
$(Yb/Sm)_N$	24	42	22	11	45	20	24	3.0
$(Yb/Gd)_N$	8.8	7.9	8.1	8.9	7.8	8.2	8.2	1.4
$(Sm/La)_N$		8.4	16		22		23	56
Eu/Eu*	0.74	0.98	0.66	0.73	1.40	0.79	0.59	1.29
Ce/Ce*		3.4	3.3				14	15

				Sample: SRI LANKA HIGH-GRADE METAMORPHIC [9]				
Analysis	2	3	4	1	2	3	4	5
P	30	32	41					
Y	21	20	29	1612	1665	164	1665	1688
La	0.04	0.02	0.03	0.03	0.02	0.02	0.03	0.02
Ce	1.5	1.6	1.6	43	44	45	41	41
Pr	0.03	0.03	0.04	0.5	0.3	0.3	0.5	0.4
Nd	0.4	0.4	0.4	4.1	3.8	4.0	4.1	3.9
Sm	0.6	0.5	0.7	5.8	6.4	6.1	6.8	7.3
Eu	0.5	0.2	0.4	0.32	0.31	0.06	0.26	0.33
Gd	2.2	1.8	2.3	28	29	29	29	31
Tb	0.5	0.5	0.4	8.8	9.2	8.9	9.7	9.5
Dy		3.1	3.5	116	118	118	118	121
Ho	0.9	0.6	0.8	49	52	50	52	54
Er		1.7	1.9	236	245	243	251	249
Tm	0.6	0.3	0.3	58	60	60	60	62
Yb		1.4	1.4	660	644	644	676	692
Lu	0.4	0.3	0.3	175	172	173	177	182
HfO_2	0.39	0.87	0.80	3.42	3.51	3.50	3.48	3.63
$(Yb/Sm)_N$		2.6	1.8	105	93	97	91	87
$(Yb/Gd)_N$		1.0	0.8	29	27	27	29	28
$(Sm/La)_N$	24	40	37	310	512	488	363	584
Eu/Eu*	1.33	0.64	0.96	0.08	0.07	0.01	0.06	0.07
Ce/Ce*	10	16	11	85	137	141	81	111

Analysis	6	7	8	9	10	11	12	13
Y		1572	1592	1696	1537	1399	1954	2434
La	0.05	0.06	0.05	0.04	0.02	0.05	0.05	0.05
Ce	23	43	39	36	39	36	51	33
Pr	0.18	0.33	0.33	0.29	0.44	0.26	0.50	0.44
Nd	2.8	4.8	4.1	4.4	3.6	3.8	4.8	6.9
Sm	4.2	6.8	6.0	5.4	5.9	5.3	6.6	9.9
Eu	0.20	0.18	0.32	0.41	0.09	0.13	0.04	0.28
Gd	22	28	24	24	27	24	28	38
Tb	6.7	8.4	7.5	7.4	8.6	7.0	8.5	13
Dy	72	111	100	83	108	93	130	159
Ho	29	44	42	35	46	42	63	72
Er	155	220	196	163	216	204	300	343
Tm	36	58	49	40	54	48	74	80
Yb	404	480	406	338	447	390	639	645
Lu	100	95	89	74	91	78	130	130
HfO_2		3.36	2.68	3.03	3.52	3.59	1.35	2.67
$(Yb/Sm)_N$	88	65	62	58	70	68	89	60
$(Yb/Gd)_N$	23	21	21	17	20	20	28	21
$(Sm/La)_N$	135	181	192	216	472	170	211	317
Eu/Eu*	0.06	0.04	0.08	0.11	0.02	0.04	0.01	0.04
Ce/Ce*	59	74	73	81	101	76	78	54

Sample:	JUNCTION CREEK HIGH-GRADE METAMORPHIC [10]					STATFJORD FORMATION [11]		
Analysis	1	2	3	4	5	1	2	3
P	53	145	146	142	126	435	214	225
Y	370	587	613	537	664	1878	737	1314
La	0.73	0.36	2	0.4	1	0.1	0.01	0.01
Ce	4.5	3.9	7.3	7.7	10	17	6.6	24
Pr	0.47	0.20	0.73	0.23	0.88	0.50	0.08	0.14
Nd	2.9	1.3	3.0	1.3	4.8	7.0	1.0	2.2
Sm	2.9	0.91	1.6	1.1	5.1	10	2.0	5
Eu	0.43	0.06	0.14	0.07	0.64	3.0	0.07	0.12
Gd	7.5	3.9	6.5	5.0	13	35	9	22
Tb	1.7	2.0	2.3	2.1	4.5	16	4.2	9.2
Dy	26	37	39	34	56	175	55	114
Ho	12	20	20	19	24	61	24	45
Er	73	107	111	100	111	258	102	211
Tm	21	28	31	26	27	52	22	44
Yb	216	262	304	261	247	412	183	359
Lu	58	57	65	59	57	92	44	81
HfO_2	2.3	2.0	2.2	2.1	2.4	1.29	1.43	1.58
$(Yb/Sm)_N$	68	265	175	218	45	38	84	66
$(Yb/Gd)_N$	36	83	58	65	23	15	25	20
$(Sm/La)_N$	6.4	4.0	1.3	4.4	8.2	160	320	801
Eu/Eu*	0.28	0.10	0.13	0.09	0.24	0.49	0.05	0.03
Ce/Ce*	1.9	3.5	1.5	6.1	2.6	18	56	155

Analysis	4	5	6	7	8	9
P	97	<200	301	225	225	211
Y	343	2355	1117	819	929	474
La	0.03	<0.05	0.1	0.02	0.03	0.009
Ce	1.90	<20	10	27	15	17
Pr	0.08	<0.2	0.17	0.09	0.08	0.11
Nd	0.69	<2	2.6	1.3	1.2	1.8
Sm	0.74	<3	2.9	2.3	2.5	3.2
Eu	0.22	2.8	1.3	0.47	0.32	1.0
Gd	4.1	41	17	13	12	11
Tb	2.9	17	7.9	5.8	5.5	4.0
Dy	31	201	100	68	72	43
Ho	11	77	38	28	30	16
Er	53	344	172	120	150	70
Tm	12	75	36	28	35	15
Yb	94	627	315	226	286	130
Lu	25	137	68	53	70	30
HfO_2	2.07	1062	1.86	1.74	1.44	1.57
$(Yb/Sm)_N$	117		100	90	105	37
$(Yb/Gd)_N$	28	19	23	21	29	15
$(Sm/La)_N$	40		46	184	133	569
Eu/Eu*	0.39		0.56	0.26	0.18	0.51
Ce/Ce*	9.4		19	154	74	131

Notes: 1—Values for HfO_2 are given as wt% oxide.

2—The subscript "N" denotes the elemental abundances have been chondrite normalised. Chondrite values from McDonough and Sun, 1995.

Techniques: Zircon crystals were separated from rock samples by conventional heavy liquid and magnetic techniques. Crystals were mounted in epoxy resin and sectioned to their mid-point parallel to their long axes, and documented using optical microscopy, reflected light photography and cathodoluminescence. REE compositions were analyzed by SIMS and laser ablation (LA) ICP-MS according to the methodology of Hoskin (1998). Analyses were performed in twelve separate analytical sessions over a two year period. Early analytical sessions were performed by SIMS prior to LA–ICP-MS facilities coming on-line at the Australian National University. Zircons from the Mud Tank carbonatite and Boggy Plain zoned pluton were analysed by both techniques to monitor reproducibility of results. SIMS analyses were done on the SHRIMP I ion microprobe using a 30 μm diameter spot size on the sample. Data were reduced by normalizing to $^{30}Si^{+}$ in zircon. LA–ICP-MS analyses were done using a Fisons VG PlasmaQuad PQ2-XR ICP-MS, custom built sample cell and transport system (Eggins et al., 1998), and Excimer ArF laser. For analyses of Sri Lanka zircon a 40 μm diameter laser beam was used for analysis, and for analysis of Mud Tank carbonatite zircon an 85 μm diameter beam was necessary due to lower REE abundances. Data were reduced by normalizing to $^{178}Hf^{+}$ in zircon. External standardization for both SIMS and LA–ICP-MS was by analysis of and normalization to the reference glass NIST SRM 610 (preferred values from Norman et al., 1996).

All zircons were imaged by cathodoluminescence microscopy, backscattered electron microscopy, and reflected light photography. Data presented here represents analyses on structurally discrete areas within individual crystals and do not represent analyses of cores or obvious secondary features. Most analyses in Table 1 represent a single analysis of a single crystal except for the Mud Tank carbonatite analyses which were all done on a single crystal. Fine-scale (1–10 μm) oscillatory zoning was observed in most crystals. Such zoning probably represents local variations in the abundance of the REE and other trace elements (Hoskin, 2000). Because it was not possible to preform analyses within individual zones, our analyses represent therefore a 30–85 μm average of local variations.

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Sample details and source: [1] Boggy Plain zoned pluton; Hoskin et al., 2000. [2] Blind Gabbro; 148°44'E 36°36'S, Snowy River region, New South Wales; supplied by Sonia Cousins. [3] Mawson igneous charnockite; Young and Black, 1991; supplied by Lance Black. [4] Syros ophiolite; Baldwin, 1996; supplied by Sue Keay. [5] Manilla plagiogranite; Aitchison and Ireland, 1995; supplied by Jonathan Aitchison. [6] Phalaborwa Complex carbonatite; Eriksson, 1989; supplied by Wayne Taylor. [7] Mud Tank carbonatite; Currie et al., 1992; supplied by Bruce Watson. [8] Jwaneng kimberlite, Kinny et al., 1989; supplied by John Bristow. [9] Sri Lanka high-grade metamorphic zircon; derived from Sri Lankain gem gravels, analysed by TIMS by R. Maas (see Hoskin, 1998); supplied by Ian Williams. [10] Junction Creek high-grade metamorphic zircon; Hoskin and Black, 2000; supplied by Lance Black. [11] Statfjord Formation zircon; Morton et al., 1996; supplied by Andrew Morton and Jonathan Clauoé-Long.

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