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Supplemental Material

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TABLE S1. SELECTED MICROPROBE ANALYSES FOR GARNET-BEARING AMPHIBOLITE SAMPLES

Sample LZ15-09																	
Mineral	g-r1	g-r2	g-m3	g-m4	g-c5	g-c6	pl-1	pl-4	ab-1	ab-2	hb-1	hb-2	hb-3	mu-1	mu-2	ep-1	ep-2
SiO2	37.87	38.21	37.91	37.95	37.80	37.67	63.24	63.18	67.90	67.94	36.54	37.79	36.93	47.95	49.19	38.48	38.36
TiO2	0.08	0.02	0.08	0.09	0.01	0.00	0.00	0.00	0.03	0.00	0.08	1.50	0.17	0.32	0.38	0.00	0.00
Al2O3	20.62	20.87	21.04	20.94	21.10	21.06	22.10	22.29	20.06	19.94	19.92	14.04	14.54	30.33	30.12	26.46	27.98
Cr2O3	0.00	0.03	0.00	0.04	0.02	0.00	0.02	0.00	0.01	0.00	0.02	0.02	0.62	0.21	0.29	0.03	0.06
Fe2O3	2.00	0.90	2.07	1.53	2.86	2.81	0.00	0.04	0.01	0.27	8.90	4.98	0.00	0.00	0.00	9.46	5.67
FeO	25.22	26.31	25.00	25.13	24.54	24.36	0.00	0.00	0.00	0.00	18.30	12.02	18.27	3.12	3.57	0.66	1.97
MnO	1.39	1.38	1.43	1.37	1.28	1.17	0.00	0.01	0.00	0.04	1.43	0.13	0.56	0.00	0.02	0.00	0.00
MgO	4.69	4.64	4.95	4.93	5.20	5.18	0.00	0.00	0.00	0.00	4.88	8.66	5.44	1.80	1.89	0.04	0.06
CaO	8.02	7.59	7.80	7.82	7.85	7.94	3.50	3.20	0.42	1.03	7.55	10.41	10.80	0.00	0.00	24.30	24.76
Na2O	0.02	0.00	0.03	0.03	0.01	0.02	8.91	9.68	11.03	11.00	0.03	1.90	4.57	2.70	2.92	0.02	0.02
K2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.11	0.06	9.35	9.21	0.00	0.00
Total	99.71	99.87	100.1	99.67	100.38	99.93	97.78	98.41	99.47	100.29	96.77	91.06	91.96	95.79	97.60	98.50	98.31
Oxygens	12.00	12.00	12.00	12.00	12.00	12.00	8.00	8.00	8.00	8.00	23.00	23.00	23.00	11.00	11.00	12.50	12.50
Si	2.98	3.00	2.97	2.98	2.98	2.95	2.84	2.83	2.98	2.97	5.587	6.02	6.05	3.21	3.24	2.99	2.98
Ti	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.009	0.18	0.02	0.02	0.02	0.00	0.00
Al	1.91	1.93	1.94	1.94	2.56	1.94	1.17	1.18	1.04	1.03	3.591	2.64	2.81	2.40	2.34	2.42	2.56
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00	0.08	0.01	0.02	0.00	0.00
Fe3	0.12	0.05	0.12	0.09	0.33	0.17	0.00	0.00	0.00	0.01	1.024	0.60	0.00	0.00	0.00	0.55	0.33
Fe2	1.66	1.73	1.64	1.65	0.13	1.59	0.00	0.00	0.00	0.00	2.341	1.60	2.50	0.18	0.20	0.04	0.13
Mn	0.09	0.09	0.10	0.09	0.00	0.08	0.00	0.00	0.00	0.00	0.185	0.02	0.08	0.00	0.00	0.00	0.00
Mg	0.55	0.54	0.58	0.58	0.01	0.60	0.00	0.00	0.00	0.00	1.112	2.06	1.33	0.18	0.19	0.01	0.01
Ca	0.68	0.64	0.65	0.66	2.06	0.67	0.17	0.15	0.02	0.05	1.237	1.78	1.90	0.00	0.00	2.02	2.06
Na	0.00	0.00	0.01	0.01	0.00	0.00	0.78	0.84	0.94	0.93	0.009	0.59	1.45	0.35	0.37	0.00	0.00

K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.02	0.01	0.80	0.77	0.00	0.00
Sum	8.00	8.00	8.00	8.00	8.00	8.00	5.00	5.00	4.97	5.00	15.44	15.69	16.22	7.14	7.14	8.03	8.07
Mn/(Mg+Mn+Fe+Ca)	0.03	0.03	0.03	0.03	0.03	0.03											
Fe/(Mg+Mn+Fe+Ca)	0.56	0.58	0.55	0.55	0.54	0.54											
Mg/(Mg+Mn+Fe+Ca)	0.18	0.18	0.19	0.19	0.21	0.21											
Ca/(Mg+Mn+Fe+Ca)	0.23	0.21	0.22	0.22	0.22	0.23											
X(phase)							0.18	0.15	0.02	0.05	0.59	0.33	0.43				
Y(phase)							0.82	0.85	0.98	0.95				0.79	0.76		

Notes: Major oxides are given in wt%, and cations are reported per formula unit (pfu); $X(pl/ab) = Ca/(Ca + Na + K)$; $Y(pl/ab) = Na/(Ca + Na + K)$; $X(hb) = AlM2$; $Y(mu) = AlM2A$.

TABLE S2. BULK COMPOSITIONS OF GARNET-BEARING AMPHIBOLITE FOR PHASE EQUILIBRIA MODELLING

Sample	ICP-OES whole-rock compositions (wt.%)										
	SiO ₂	TiO ₂	Al ₂ O ₃	TFe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	LOL
LZ15-09	49.35	0.93	17.60	12.40	0.20	4.71	9.31	3.14	0.94	0.14	0.89
Sample	Normalized molar proportion (mol.%)										
	H ₂ O	SiO ₂	Al ₂ O ₃	CaO	MgO	FeO	K ₂ O	Na ₂ O	TiO ₂	O	Total
LZ15-09	4.30	52.22	10.97	10.37	7.43	9.87	0.64	3.22	0.74	0.24	100.00

TABLE S3. TH-U-PB DATA OF METAMORPHIC ZIRCONS OF GARNET-BEARING AMPHIBOLITE SAMPLES

Sample spot	U	Th	Th/U	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	$\pm\sigma$	ρ	Conc.	Age (Ma)					
	(ppm)	(ppm)			%		%		%		%	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	$\pm\sigma$
Sample LZ15-09 SIMS Th-U-Pb data																	
1	194	77	0.40	0.04871	2.48	0.09332	2.71	0.0139	1.11	0.40821	95	134.0	57.2	90.6	2.4	89.0	1.0
2	525	317	0.60	0.04840	1.18	0.09228	1.70	0.0138	1.22	0.71969	96	119.0	27.5	89.6	1.5	88.5	1.1
3	351	187	0.53	0.04914	1.34	0.09390	1.76	0.0139	1.14	0.65072	96	154.4	31.0	91.1	1.5	88.7	1.0
4	944	517	0.55	0.04876	0.83	0.09570	1.75	0.0142	1.54	0.88097	97	136.1	19.3	92.8	1.5	91.1	1.4
5	226	109	0.48	0.05035	1.64	0.09780	2.34	0.0141	1.67	0.71318	99	211.1	37.5	94.7	2.1	90.2	1.5
6	270	116	0.43	0.04913	2.02	0.09517	2.20	0.0140	0.87	0.39504	99	153.9	46.6	92.3	1.9	89.9	0.8
7	321	214	0.67	0.04979	2.21	0.09625	2.58	0.0140	1.32	0.51382	100	185.2	50.7	93.3	2.3	89.8	1.2
8	245	85	0.35	0.04972	1.62	0.09619	1.85	0.0140	0.89	0.48280	96	182.1	37.2	93.3	1.6	89.8	0.8
9	847	399	0.47	0.04935	0.89	0.09591	1.30	0.0141	0.94	0.72656	84	164.4	20.7	93.0	1.2	90.2	0.8
10	219	72	0.33	0.04935	1.76	0.09620	1.97	0.0141	0.87	0.44191	96	164.5	40.7	93.3	1.8	90.5	0.8
11	273	140	0.51	0.04894	1.82	0.09533	2.70	0.0141	2.00	0.73933	97	144.8	42.2	92.5	2.4	90.4	1.8
12	420	250	0.59	0.04955	1.38	0.09560	1.64	0.0140	0.88	0.53437	98	174.0	32.0	92.7	1.5	89.6	0.8
13	326	182	0.56	0.04863	1.72	0.09367	2.22	0.0140	1.41	0.63195	83	129.8	40.0	90.9	1.9	89.4	1.2
14	406	179	0.44	0.04854	1.60	0.09375	1.83	0.0140	0.87	0.47731	99	125.6	37.3	91.0	1.6	89.7	0.8
15	440	325	0.74	0.04917	1.27	0.09519	1.55	0.0140	0.88	0.57143	97	155.9	29.5	92.3	1.4	89.9	0.8
16	305	156	0.51	0.05031	1.52	0.09625	1.99	0.0139	1.29	0.64466	95	209.3	35.0	93.3	1.8	88.8	1.1

TABLE S3. (Continued.)

Sample spot	U	Th	Th/U	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	$\pm\sigma$	ρ	Conc.	Age (Ma)						
	(ppm)	(ppm)											$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	$\pm\sigma$
													%	%	%	%	%	%
Sample LZ15-09 LA-ICPMS Th-U-Pb data																		
17	131	39	0.29	0.05512	15.50	0.09031	11.30	0.0134	3.06	0.27112	98	416.7	349.0	87.8	9.5	85.7	2.6	
18	217	80	0.37	0.04677	11.27	0.09250	10.46	0.0144	2.47	0.23608	98	39.0	248.1	89.8	9.0	91.9	2.3	
19	215	63	0.29	0.05452	6.67	0.09646	6.43	0.0132	1.64	0.03103	92	-209.6	357.4	91.9	11.3	84.4	2.8	
20	278	137	0.49	0.04789	6.04	0.09043	5.76	0.0140	1.61	0.00613	97	-50.2	293.0	86.7	9.7	89.5	2.9	
21	206	66	0.32	0.04852	7.88	0.09243	7.64	0.0138	1.49	0.12370	99	-443.5	390.4	87.7	12.8	88.6	2.6	
22	195	55	0.28	0.04395	7.45	0.08435	7.69	0.0133	1.53	0.10974	94	-224.0	351.6	80.4	12.0	85.2	2.6	
23	236	90	0.38	0.05101	7.04	0.09280	6.82	0.0133	1.42	0.05703	94	-125.7	371.0	90.2	12.0	84.8	2.4	
24	240	128	0.53	0.04421	7.02	0.08341	7.04	0.0137	1.77	0.00565	91	-221.0	320.4	79.9	10.8	87.5	3.1	
25	227	74	0.33	0.04680	6.50	0.08677	6.60	0.0134	1.66	0.07459	97	-242.9	342.7	83.1	10.6	85.7	2.8	
26	309	267	0.87	0.04946	5.15	0.09364	5.00	0.0142	1.45	0.01583	99	-103.6	267.3	90.0	8.6	90.8	2.6	
27	308	132	0.43	0.05164	4.95	0.09422	4.80	0.0133	1.24	0.06842	94	91.1	220.5	90.6	8.4	85.2	2.1	
28	259	226	0.87	0.05250	5.44	0.09522	5.40	0.0134	1.73	0.07617	94	-2.9	327.1	91.2	9.5	86.0	3.0	
29	612	293	0.48	0.04749	3.85	0.08715	3.81	0.0135	0.96	0.06612	98	-14.1	174.9	84.4	6.2	86.2	1.6	
30	368	148	0.40	0.04874	5.01	0.09314	5.03	0.0137	1.22	0.02737	98	-14.4	227.9	89.5	8.6	87.8	2.1	
31	404	171	0.42	0.05431	5.49	0.10055	5.24	0.0135	1.19	0.07042	89	-58.2	304.1	96.1	9.7	86.2	2.0	
32	227	154	0.68	0.04520	6.76	0.08271	6.77	0.0130	1.52	0.00158	97	-445.0	369.6	80.9	10.8	83.4	2.5	
33	428	389	0.91	0.04579	4.57	0.09060	4.97	0.0139	1.14	0.07624	98	-201.0	240.1	87.2	8.3	89.2	2.0	
34	396	213	0.54	0.04693	5.18	0.08719	5.14	0.0135	1.26	0.18787	97	-235.8	288.6	84.0	8.3	86.4	2.2	
35	379	434	1.15	0.04849	5.47	0.09121	5.47	0.0136	1.22	0.02251	100	71.8	218.4	87.6	9.2	87.3	2.1	
36	360	153	0.43	0.05002	5.08	0.09458	5.05	0.0137	1.17	0.16696	97	109.4	220.5	90.8	8.8	87.9	2.0	

TABLE S3. (Continued.)

Sample spot	U	Th	Th/U	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	$\pm\sigma$	ρ	Conc.	Age (Ma)					
	(ppm)	(ppm)										$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	$\pm\sigma$
Sample LZ15-10 SIMS Th-U-Pb data																	
1	365	200	0.55	0.04856	1.50	0.09412	2.16	0.0141	1.56	0.72099	99	126.7	34.9	91.3	1.9	90.0	1.4
2	285	148	0.52	0.05133	2.22	0.09944	2.77	0.0141	1.66	0.59788	93	255.5	50.2	96.3	2.5	90.0	1.5
3	397	204	0.51	0.04683	4.62	0.08650	4.88	0.0134	1.57	0.32184	98	40.5	107.0	84.2	4.0	85.8	1.3
4	344	172	0.50	0.04860	2.16	0.09353	2.71	0.0140	1.64	0.60443	98	128.6	50.1	90.8	2.4	89.4	1.5
5	320	154	0.48	0.04732	2.70	0.09047	3.12	0.0139	1.56	0.49919	99	65.7	63.1	87.9	2.6	88.8	1.4
6	317	161	0.51	0.04779	3.10	0.09058	3.49	0.0137	1.61	0.46211	100	88.8	71.8	88.0	2.9	88.0	1.4
7	424	189	0.45	0.04812	1.37	0.09092	2.37	0.0137	1.93	0.81572	99	105.1	32.1	88.4	2.0	87.7	1.7
8	605	158	0.26	0.04879	1.27	0.09121	2.15	0.0136	1.74	0.80908	98	137.5	29.5	88.6	1.8	86.8	1.5
9	384	175	0.46	0.04782	2.34	0.09154	2.85	0.0139	1.62	0.56933	100	90.6	54.5	88.9	2.4	88.9	1.4
10	377	221	0.59	0.04567	2.08	0.08583	2.59	0.0136	1.54	0.59666	96	-19.5	49.5	83.6	2.1	87.3	1.3
11	380	197	0.52	0.04864	1.51	0.09443	2.17	0.0141	1.57	0.72032	98	130.3	35.1	91.6	1.9	90.1	1.4
12	127	152	0.39	0.05128	3.36	0.08933	3.79	0.0126	1.75	0.46276	93	253.4	75.4	86.9	3.2	80.9	1.4
13	74	69	0.23	0.05306	3.94	0.09338	4.32	0.0128	1.77	0.41062	90	331.2	87.0	90.6	3.8	81.8	1.4
14	72	45	0.22	0.05138	3.34	0.09086	3.75	0.0128	1.71	0.45498	93	258.1	74.9	88.3	3.2	82.1	1.4

Notes: ρ = concordance defined as $[(^{206}\text{Pb}/^{238}\text{U age})/(^{207}\text{Pb}/^{206}\text{Pb age})]$; Conc. % denotes degree of concordance.

TABLE S4. REE CONTENTS (PPM) IN ZIRCON OF GARNET-BEARING AMPHIBOLITE SAMPLE

Sample spot	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th	U	REE
Sample LZ15-09																		
1	49	0.00	4.33	0.02	0.28	0.48	0.27	2.50	0.59	5.50	1.30	4.27	0.69	4.73	0.73	48	158	26
2	103	0.01	7.10	0.07	1.59	2.89	1.12	10.23	2.16	14.47	3.13	8.65	1.14	8.34	1.33	122	245	62
3	43	0.01	2.46	0.00	0.18	0.35	0.14	1.32	0.43	3.93	1.32	4.62	0.77	6.05	1.19	39	131	23
4	91	0.01	5.29	0.05	0.77	1.31	0.73	6.93	1.52	11.42	2.53	7.73	1.09	8.54	1.33	80	217	49
5	46	0.00	5.58	0.02	0.20	0.64	0.31	2.67	0.67	5.43	1.36	4.12	0.58	4.44	0.68	63	215	27
6	125	0.00	8.04	0.07	1.36	3.32	1.09	11.36	2.54	16.61	3.67	10.54	1.52	10.39	1.46	137	278	72
7	57	0.00	5.56	0.00	0.35	0.72	0.33	3.54	0.89	6.86	1.50	5.11	0.70	5.09	0.74	66	206	31
8	71	0.00	5.20	0.01	0.31	0.50	0.25	3.08	0.77	7.06	1.94	7.74	1.35	10.82	2.01	55	195	41
9	35	0.00	3.26	0.00	0.00	0.19	0.16	1.35	0.40	3.69	1.08	3.71	0.60	4.77	0.91	90	236	20
10	143	0.00	7.48	0.05	1.22	3.14	1.30	11.76	2.56	19.77	4.07	12.43	1.87	12.41	1.79	128	240	80
11	103	0.00	7.76	0.02	0.61	1.45	0.58	6.71	1.69	12.97	3.14	9.57	1.33	9.25	1.22	74	227	56
12	137	0.01	4.94	0.00	0.17	0.29	0.20	1.99	0.68	9.17	3.96	21.33	5.34	63.56	16.46	158	333	128
13	120	0.01	4.91	0.00	0.16	0.07	0.18	1.68	0.76	8.32	3.50	18.58	4.65	48.77	13.34	201	388	105
14	185	0.00	4.07	0.00	0.11	0.25	0.22	2.77	0.94	12.99	5.58	28.19	7.35	85.57	21.50	122	241	170
15	170	0.01	3.77	0.02	0.06	0.17	0.29	2.40	0.88	12.23	5.22	26.80	6.96	77.49	20.12	130	267	156
16	362	0.01	6.07	0.03	0.54	1.91	1.01	7.20	2.31	28.71	11.50	55.08	13.26	139.70	33.87	296	369	301
17	154	0.00	4.18	0.01	0.23	0.14	0.11	1.78	0.76	9.48	4.31	25.69	6.51	80.88	22.03	110	313	156
18	134	0.00	4.40	0.00	0.06	0.40	0.18	1.90	0.66	9.25	4.16	22.24	5.58	62.50	16.08	117	276	127
19	147	0.00	4.83	0.01	0.12	0.37	0.29	1.99	0.71	10.61	4.70	24.30	6.23	67.06	18.26	145	307	139
20	86.1	0.01	3.10	0.00	0.00	0.07	0.09	1.10	0.39	5.40	2.44	14.09	3.88	43.14	12.00	95.4	239	86
21	138	0.00	4.69	0.00	0.29	0.20	0.20	1.87	0.69	9.96	4.56	21.94	5.66	67.21	17.38	146	341	135
22	308	0.00	6.39	0.01	0.26	0.89	0.40	4.75	1.71	23.23	9.84	47.35	11.47	127.38	31.76	247	371	265

23	129	0.01	4.23	0.00	0.12	0.17	0.10	1.50	0.67	9.64	4.01	21.10	5.13	63.20	16.37	116	294	126
24	563	0.02	9.48	0.02	0.92	1.63	0.82	8.37	3.03	39.25	17.18	91.72	22.03	244.07	62.78	509	1007	501
25	308	0.00	6.38	0.03	0.34	0.57	0.38	4.45	1.64	21.96	9.05	50.07	13.01	149.30	38.81	246	562	296
26	272	0.00	6.53	0.02	0.36	0.70	0.52	4.07	1.53	20.59	8.46	44.87	10.94	117.28	29.46	267	309	245
27	134	0.00	4.60	0.00	0.07	0.20	0.15	1.74	0.60	8.63	3.96	23.08	5.71	64.56	16.60	132	308	130
28	224	0.00	8.37	0.00	0.12	0.46	0.22	2.72	1.09	15.64	6.67	36.95	9.19	101.21	25.70	226	259	208
29	590	0.00	17.34	0.00	0.44	0.97	0.45	7.41	2.80	40.83	17.64	99.50	25.02	281.66	71.85	293	612	566
30	122	0.00	3.98	0.01	0.00	0.21	0.11	1.40	0.56	8.02	3.34	19.69	5.10	59.43	15.23	148	368	117
31	185	0.00	5.96	0.00	0.09	0.49	0.23	2.40	0.98	12.96	5.44	32.91	7.70	84.53	21.48	171	404	175
32	329	0.00	4.78	0.00	0.29	0.88	0.66	5.40	1.89	24.54	10.17	52.38	12.15	126.15	30.66	154	227	270
33	265	0.00	6.07	0.02	0.25	0.53	0.32	3.75	1.33	18.22	7.95	44.97	10.91	119.64	31.04	389	428	245
34	229	0.00	5.24	0.00	0.16	0.31	0.32	2.97	1.07	15.35	7.11	39.64	9.85	114.45	31.31	213	396	228
35	637	0.00	14.71	0.02	0.42	1.05	0.53	8.81	3.10	44.54	18.87	106.04	26.37	297.04	75.54	434	379	597
36	173	0.00	5.06	0.00	0.15	0.22	0.22	2.43	0.95	12.29	5.07	28.75	7.22	79.19	20.78	153	360	162
